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Upregulating Positive Affect Through Imaginal Recounting in Anhedonia

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Upregulating Positive Affect Through Imaginal Recounting in Anhedonia

A dissertation submitted in partial satisfaction of the requirements for the degree

Doctor of Philosophy in Psychology

by

Christina Sandman

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ABSTRACT OF THE DISSERTATION

Upregulating Positive Affect Through Imaginal Recounting in Anhedonia

by

Christina Sandman

Doctor of Philosophy in Psychology

University of California, Los Angeles, 2023

Professor Michelle Craske, Chair

Anhedonia, a loss of interest or pleasure in activities, characterizes many individuals suffering from depression. The majority of therapeutic interventions are designed to decrease negative affect and are largely ineffective for reducing anhedonia. Treatments can be improved by targeting processes thought to underlie anhedonia, such as diminished positive affect, overgeneral autobiographical memory, less detailed mental imagery, and bias for use of third- vs. first-person perspective when recalling events. To this aim, Positive Affect Treatment (PAT; Study 1) and Mobile Virtual Reality-Reward Training (MVR-RT; Study 2) include autobiographical memory specificity training via “imaginal recounting,” which involves guided visualization of pleasant experiences with a focus on specific positive sensations, thoughts, and emotions using first-person perspective and present tense. The primary aim of this dissertation was to investigate features of imaginal recounting that enhance positive affect. Drawing from trials of PAT and MVR-RT, Studies 1 and 2 used linguistic analysis of treatment sessions to examine whether features of imaginal recounting (emotional tone, first-person perspective, perception words, episodic detail) changed across sessions and whether changes corresponded with symptom improvements. In PAT, there were no changes in linguistic features across sessions, whereas in MVR-RT, emotional tone became increasingly positive and contained more perception words. The relationship between linguistic features and clinical outcomes was mixed and varied between treatments. Because the first two studies were correlational in nature, a third experimental study compared the impact of experiential processing (focusing on sensations) versus analytical processing (thinking conceptually) among participants with anhedonia who were asked to recall positive autobiographical memories and imagine future events. In addition to positive and negative affect, additional outcomes included dampening appraisals (which serve to diminish positive affect) and meaning. Compared to analytical processing, experiential processing led to greater positive affect, less negative affect, less dampening, and marginally greater meaning. Overall, these studies suggest that clinical interventions that encourage experiential savoring of pleasant sensations can enhance positive affect for individuals with anhedonia.

The dissertation of Christina Sandman is approved.

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University of California, Los Angeles

2023

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SELECTED CONFERENCE PRESENTATIONS

Sandman, C.F., Chen, K., Young, K.S., Costello, A., Hovhannisyan, E. & Craske, M.G. Virtual reality reward training for anhedonia. (2021, January). In S. Hofmann (Chair), *The role of positive affect in emotional disorders* [Symposium]. Annual Conference of the Anxiety and Depression Association of America (virtual due to COVID-19).

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GENERAL INTRODUCTION

What is Anhedonia?

Anhedonia is a core symptom of depression, defined as diminished interest or pleasure in one's activities in the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013). Anhedonia is a multifaceted symptom characterized by deficits in positive affect, which can be further understood through impairments in the reward system (Treadway & Zald, 2011). Up to 75% of individuals with major depressive disorder report anhedonia (Franken et al., 2007). Anhedonia is a transdiagnostic symptom, in that it extends beyond major depression to social anxiety disorder and generalized anxiety disorder (Kashdan et al., 2011), and is also relevant to substance use disorder and negative symptoms of schizophrenia (Thomsen et al., 2015). Thus, anhedonia represents a dimension of psychopathology that crosses diagnostic boundaries. This dissertation focuses on anhedonia primarily in the context of depression and affective disorders.

Anhedonia as a Marker of Psychopathology

Anhedonia, assessed via low positive emotionality, prospectively predicts both depression and anxiety, even when controlling for baseline symptoms (Kendall et al., 2015; Khazanov & Ruscio, 2016). Once disorders emerge, anhedonia predicts of poorer longitudinal course of major depression (Morris et al., 2009). Further, anhedonia predicts poor psychosocial functioning after improvements in depressed mood (Vinckier et al., 2017) and recurrence of depression (Wichers et al., 2010). Moreover, anhedonia is a substantial predictor of suicide ideation and attempt (Ducasse et al., 2018; Spijker et al., 2010; Winer et al., 2014). In over 2,500 outpatients with mood disorders, those with anhedonia had a 1.4-fold higher risk of suicidal ideation in the next three years (Ducasse et al., 2020). The predictive effects upon suicidal ideation or attempt persist when controlling for other cognitive and affective symptoms of depression (Ballard et al., 2017; Fawcett et al., 1990) as well as other risk factors such as history of suicide attempts, childhood trauma, marital status, sex, and age (Ducasse et al., 2020). Finally, anhedonia statistically accounts for the relation between depression and suicidality (Zielinski et al., 2017).

Traditional Treatments are Ineffective for Anhedonia

Extant treatment approaches are largely ineffective in improving anhedonia, highlighting an unmet therapeutic need. Specifically, pharmacological treatments have little effect, with some antidepressant medications even worsening anhedonia (Landén et al., 2005; McCabe et al., 2010). For example, after treatment with selective-serotonin reuptake inhibitors, anhedonia was one of the most prevalent residual disturbances (Price et al., 2009).

Regarding psychological treatments, the majority of therapies are designed to decrease negative affect and do not directly focus on increasing positive affect (Dunn, 2012). Evidence-based psychotherapies (primarily cognitive–behavioral therapy) have limited effects upon positive affect (Boumparis et al., 2016). For example, whereas cognitive therapy and antidepressant medication normalized elevations in negative affect on the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) to adult population norms, positive affect levels remained lower than typical for general adult populations (Dunn, German, et al., 2019).

In contrast to traditional cognitive behavioral therapy, behavioral activation therapy is designed to increase response contingent positive reinforcement through engagement in activities (Manos et al., 2010). However, very few studies report the effect of behavioral activation upon positive affect, and the ones that do show limited effects for improving in self-reported anhedonia and positive affect (Boumparis et al., 2016; Dichter et al., 2009; Moore et al., 2013). This is perhaps not surprising since relatively little attention has been given to how to conduct behavioral activation in a manner that maximizes positive emotional experience (Dunn, 2012; Forbes, 2020). The efficacy of interventions that target positive affect may be bolstered by an increased focus on processes thought to underlie anhedonia, including various cognitive and mental imagery deficits described below.

Mental Imagery Deficits in Depression

Individuals with depression demonstrate overgeneral autobiographical memory, less detailed positive mental imagery, and a bias for observer (vs. field) perspective (Holmes, Blackwell, Burnett Heyes, Renner, & Raes, 2016). Not only do individuals with depression tend to have excess negative mental imagery, but they also exhibit deficits in generating vivid past and future-oriented positive mental images and prospections (Stober, 2000; Werner-Seidler & Moulds, 2011; Yang et al., 2018). The effects described below have been tested primarily in relation to depressive symptomatology in general; when possible, specific links with anhedonia are highlighted.

Overgeneral Autobiographical Memory. Individuals with depression are more likely to display overgeneral autobiographical memory (OGM), characterized by a failure to generate specific memories that take place within the span of a single event or day (Williams et al., 2007). Instead, depressed individuals tend to provide memories that extend over longer periods of time, are abstractions of various experiences, or are categorical in nature. Overgeneral memory – or reduced memory specificity – is assessed via the Autobiographical Memory Task (Williams & Broadbent, 1986), in which participants recall memories in response to cue words of different valences, which are subsequently coded as either specific (within 24 hours) or non-specific (general/categorical). Specificity is then calculated as the proportion of specific to non-specific memories. As supported by meta-analyses, overgeneral autobiographical memory predicts onset and poorer course of depression (Hallford, Rusanov, Yeow, & Barry, 2020; Sumner, Griffith, & Mineka, 2010), and often remains even after depressed mood has improved (Raes et al., 2006).

Detail. Memory specificity and level of detail are related but separate constructs (Hallford et al., 2021; Kyung et al., 2016). Whereas specificity refers to an event that temporally occurs within a 24 hour window, episodic detail refers to the number of contextual details provided within a given event (for a discussion see Hallford, Austin, Takano, & Raes, 2018). The Autobiographical Interview Scoring Manual (Levine et al., 2002) is commonly used to code number of details across two main categories: 1) episodic detail (referred to as internal detail: event unfoldings/actions, place, time, perception, emotion/thought), and 2) non-episodic detail (external: semantic knowledge, repetitions, and 'other' details including editorializations or meta-cognitive statements). In addition, episodic richness is rated based on the overall sense of re-experiencing evoked by the details of an event.

Using this metric, severely depressed patients recalled fewer episodic, but not non-episodic, details compared to healthy controls, which was driven by healthy participants recalling more event, emotion/thought, and time details (Söderlund et al., 2014). Across a number of studies, similar patterns emerge when individuals with depression imagine future positive events (Hallford, Barry, et al., 2020; King, MacDougall, Ferris, Herdman, & McKinnon, 2011; Parlar et al., 2016). Further, individuals with social anhedonia generated less rich prospections of future positive events, which corresponded to less anticipatory pleasure (Yang et al., 2018).

Imagery Perspective. Imagery perspective, or the vantage point through which one perceives mental images, can impact affective experience. When using field perspective, individuals remember an event as if they are viewing it from their own eyes, and thus field perspective is associated with heightened emotionality, including physical sensations and affective reactions (Mcisaac & Eich, 2002). On the other hand, in observer perspective, individuals remember events as if they are watching themselves from the outside, which is associated with decreased intensity of emotions (Williams & Moulds, 2008). Indeed, instructed use of field perspective when imagining positive experiences can cause a boost in positive mood, whereas use of observer perspective leads to diminished positivity (Holmes, Coughtrey, & Connor, 2008).

When recalling negative memories, depressed individuals show a bias for observer versus field perspective (Kuyken & Howell, 2006; Kuyken & Moulds, 2009; Williams & Moulds, 2007) theorized to serve as a cognitive avoidance strategy. This bias for observer perspective extends to positive memories in currently (Lemogne et al., 2006) and formerly (Bergouignan et al., 2008) depressed individuals (cf. Werner-Seidler & Moulds, 2011). In a student sample, dysphoric individuals were more likely to use observer perspective when recalling positive versus neutral memories, whereas this bias was not evident in non-dysphoric participants (Nelis et al., 2013). Further, after positive memory enhancement training, a single session intervention that trains memory recall using field perspective, individuals with major depressive disorder effectively repaired positive and negative affect after a negative mood induction (Arditte Hall et al., 2018). Depressed individuals also simulated future positive events with less use of self-rated first-person perspective, which in turn was associated with less vividness and anticipatory pleasure (Hallford, Barry, et al., 2020). Guided episodic thinking of past and future events through field perspective increased mental imagery, vividness, anticipatory pleasure, and behavioral intention to engage in activities in healthy controls (Hallford, Farrell, & Lynch, 2020).

Memory Specificity Interventions

In recent years, several interventions have been developed to target deficits in memory and mental imagery in an emerging field of “memory therapeutics” (Dalgleish & Werner-Seidler, 2014; Holmes et al., 2016). To address overgeneral autobiographical memory, Memory Specificity Training (MeST) involves psychoeducation and generation of specific (<24 hours) negative, neutral, and positive autobiographical memories, with standard delivery in a group format over 4 weeks (Raes et al., 2009). According to a recent meta-analysis, memory specificity interventions for emotional disorders lead to short-term significant improvements in overgeneral memory, depression, hopelessness, and problem solving (Barry et al., 2019).

With relevance for anhedonia, more recent approaches involve training exclusively on positive scenarios (Pictet et al., 2016), positive memories (Arditte Hall et al., 2018; McMakin et al., 2011) and future positive events (Hallford, Sharma, & Austin, 2020; Hallford, Rusanov, et al., 2020), which lead to improvements in state mood repair after a sad mood induction, depressive symptoms, anticipatory pleasure, and behavioral intention to engage in activities. However, these studies have been limited to single sessions or brief interventions with limited follow-up periods (<2 weeks) and have not focused on anhedonic samples.

Positive Affect Interventions for Anhedonia

Techniques to enhance positive mental imagery and memory are starting to be incorporated into larger treatment packages for anhedonia (Sandman & Craske, 2022). One application aims to enhance the effectiveness of behavioral activation on positive affect through savoring practices (e.g., Dunn, Widnall, et al., 2019; Nagy et al., 2020). Towards this aim, two novel treatments for anhedonia from our lab include Positive Affect Treatment (PAT, Study 1; Craske, Treanor, Dour, Meuret, & Ritz, 2019) and Mobile Virtual Reality-Reward Training

(MVR-RT, Study 2), which each include positive memory specificity training via “imaginal recounting” as a treatment component. Imaginal recounting involves guided visualization of pleasant experiences with a focus on recalling specific positive sensations (sounds, smells, sights), thoughts, emotions, and situational details, using first person perspective while re-living the memories in the present tense. Imaginal recounting can be conducted on pleasant activities from behavioral activation, pleasant VR scenes, or positive autobiographical memories (please refer to studies 1 & 2 for details of each intervention). The current studies examined whether features (field perspective, detail, episodic richness) during imaginal recounting change across the course of treatment, and whether changes relate to symptom outcomes.

Affect Labeling

In addition to features of mental imagery and memory, the current studies examined the use of emotion words on affective experience during imaginal recounting. I took a theory-driven approach to linguistic analysis by investigating two opposing theories: 1) disruption theory, and 2) the label-feedback hypothesis.

Disruption theory. The “disruption theory” of language and emotion posits that verbal linguistic processes dampen affective experience (Lieberman, 2011). By recruiting the ventrolateral prefrontal cortex, affect labeling down-regulates subjective, physiological, and neural correlates of affect (Lieberman et al., 2007; Torre & Lieberman, 2018). Most studies have examined labeling effects on negative affect; however, some find dampening effects regardless of valence. For example, labeling pleasant stimuli can also dampen positive affect (Constantinou et al., 2014, 2015; Lieberman et al., 2011).

Notably, the majority of experimental studies involve presenting images either with and without emotionally-evocative labels (e.g., participants select between two experimenterprovided labels such as ‘anguish’ and ‘bomb’ when viewing negatively valanced images) rather than instructing participants to generate labels that describe one’s own emotional experience. Being provided labels, rather than self-generating affect labels was more effective in reducing amygdala and increasing ventrolateral prefrontal cortex activity (Torre, 2016, unpublished dissertation). However, in a clinical context, affect labeling during exposure (generating labels for both one’s own emotions and emotional adjectives for feared stimuli) reduced negative affect and enhanced clinical outcomes in individuals with spider phobia (Kircanski et al., 2012) and social anxiety (Niles et al., 2015). The effect of labeling one’s own positive emotional states in a clinical context has been relatively understudied. Based on disruption theory, labeling of positive emotions may serve to diminish positive affective experience during imaginal recounting.

Reward activation through positive affect labeling. In contrast, I offer a different possibility, in which labeling positive emotions enhances positive affect in the moment by increasing the ability to notice, shift attention to, and savor positive aspects in the long-term. This process is informed by a psychological constructionist perspective, which views language as an ingredient rather than result of emotional experience (Barrett, 2006; Lindquist, 2013). Within this perspective, the label-feedback hypothesis posits that the emotional label shapes the ongoing emotional experience through top-down shaping of sensations (Lindquist, 2017; Lindquist et al., 2015). Therefore, labeling specific positive emotions has the potential to increase upregulation of these emotions.

The label-feedback hypothesis is supported by experimental evidence that demonstrates emotion labels can cause discrete emotions to occur. For example, exposure to the label ‘fear’ before listening to unpleasant music lead participants to engage in behaviors specific to fear (risk aversion) compared to those exposed to the label of anger (Lindquist & Barrett, 2008). Further, impairing people's access to emotion word concepts (through a satiation procedure that involves repeating a word for 30 seconds to separate phonetics from meaning) also impairs ability to perceive emotional faces (Gendron et al., 2012; Lindquist et al., 2006). However, this work is limited in that it focuses predominately on 1) negative valence, and 2) relies upon provided labels rather than having individuals generate and attend to their own emotional labels.

Emotional Language Use in Affective Disorders. Positive emotion word use may reflect an individual's attention and internal state (Tausczik & Pennebaker, 2010). Relatedly, anhedonia and depression severity are associated with fewer positive and greater negative words recalled in an emotional memory task (Liu et al., 2012). Increases in positive emotion words across an expressive writing intervention predicted improvements in depression in women with a history of childhood sexual abuse (Pulverman et al., 2015). However, expressive writing involves writing about stressful or traumatic experiences. To date, only one study has examined emotion word use when writing about explicitly positive experiences, and found no change in positive emotion words across three writing sessions in a non-clinical college sample, despite benefits on positive mood and reduced health center visits (Burton & King, 2004). The limited research on positive emotion word use in clinical populations highlights the need for future work in this area, especially during interventions that seek to enhance positive affect.

"Text Mining" in Therapeutic Change Process Research

Therapeutic change process research (TCPR) aims to identify potential mechanisms through which treatment brings about beneficial change (Greenberg, 1991). This field has historically analyzed "products" of therapy (e.g., transcripts, homework, diaries) using predominantly qualitative methods, with recent calls for "text mining" using quantitative approaches to linguistic analysis (Smink et al., 2019). Language can reflect an individual's attention, thoughts, internal states, and priorities (Tausczik & Pennebaker, 2010). One commonly used quantitative tool is Linguistic Inquiry Word Count (LIWC; Pennebaker, Francis, & Booth, 2001), a computerized text analysis program that uses a dictionary-based method to classify words into different categories, including linguistic (e.g., pronouns), content (e.g., emotion words), and psychological processes (e.g., insight, causal thinking). LIWC has been used widely in social psychology and the expressive writing literature, in which people write about stressful life experiences such as coping with cancer (Merz et al., 2014). However, LIWC has been relatively underutilized to study session-by-session changes in psychotherapy, which could lead to a better understanding of clinically meaningful process that change with treatment.

Study Aims

The overarching aim of this dissertation was to investigate strategies that enhance positive emotions during imaginal recounting. Understanding the ways in which language affects positive emotional experience can directly inform and optimize interventions for anhedonia. The first two studies involved linguistic analysis of imaginal recounting in two clinical trials of novel treatments for anhedonia (Positive Affect Treatment, and Mobile Virtual Reality-Reward Training). Specifically, clients' language was analyzed using both automated text analysis with Linguistic Inquiry Word Count (LIWC; Pennebaker, Francis & Booth, 2001) and coding using the Autobiographical Interview (AI; Levine et al., 2002). In particular, LIWC assessed positive and negative emotion words, emotional tone, perception words, and first-person pronouns as an index of field perspective, since prior studies have established a causal link between experimentally induced field perspective and greater use of first-person pronouns (Mcisaac & Eich, 2002). The AI was used to code for internal (episodic) detail, external detail (non-episodic) detail and episodic richness. In both PAT and MVR-RT, I tested whether 1) whether linguistic features during imaginal recounting change across the course of treatment, and 2) whether treatment-related changes in these features correspond with clinical outcomes. I hypothesized that positive emotion words, emotional tone, perception words, first-person pronouns, episodic detail, and episodic richness would increase across the course of treatment, and that greater increases in these variables would relate to greater clinical improvement. I predicted that negative emotion words and non-episodic detail would decrease across treatment, the extent to which would relate to greater clinical improvement.

As the first two studies were correlational in nature and cannot speak to causality, the third study involved an experimental manipulation of different methods of imaginal recounting in an anhedonic sample. Specifically, I investigated the effect of experiential (concrete/imagery-based) versus analytical (abstract/verbal) processing of positive autobiographical memories and a positive future event on affective and cognitive experience. Dampening appraisals, or thoughts which serve to diminish positive experience, and positive meaning were explored as potential mediators of processing mode on affective experience (for a more in-depth review of processing mode and dampening see Study 3: Introduction). I hypothesized that compared to analytical processing, experiential processing of positive memories would lead to greater positive affect and positive meaning, and less negative affect and dampening appraisals.

STUDY 1

Imaginal Recounting of Pleasant Events in Positive Affect Treatment

Introduction

The current study sought to investigate potential change in language use during therapist-guided imaginal recounting of pleasant activities and their relationship to symptom change during Positive Affect Treatment (PAT). Drawing from affective neuroscience, PAT was developed to address the unmet therapeutic need for treating anhedonia by targeting deficits in reward processing (Craske, Meuret, Ritz, Treanor, & Dour, 2016). In a randomized controlled trial, PAT resulted in greater improvements in positive affect at six-month follow-up in comparison to cognitive behavioral therapy focused solely upon reductions in negative affect (Craske et al., 2019). Participants in PAT also reported greater improvements and less negative affect, and lower symptoms of depression, anxiety, stress, and suicidality at six-month follow-up. A second randomized control trial replicated these effects and demonstrated that changes in reward-anticipation and reward-attainment corresponded with clinical improvement (Craske et al., accepted).

PAT is a 15-session treatment that consists of three modules: 1) behavioral activation augmented with imaginal recounting (sessions 2-7), 2) attending to the positive through cognitive exercises (sessions 8-10), and 3) cultivating the positive through gratitude, loving-kindness, appreciative joy, and generosity (sessions 11-14). Session 1 includes psychoeducation, introduction to a positive emotion word bank, and pleasant activity scheduling, and Session 15 consists of relapse prevention. The current study focused only on augmented behavioral activation, which combines engagement in pleasurable activities with subsequent in-session imaginal recounting. Imaginal recounting involves therapist-guided visualization and reimagining of pleasant activities, including specific sensations, thoughts, emotions, and situational details, through first-person perspective, and in the present tense. This strategy aims to enhance memory and attention to positive aspects in order to consolidate reward processing experienced during pleasant activities.

The current study investigated three research questions with the following aims. First, do linguistic features during in-session imaginal recounting (positive and negative emotion words, emotional tone, first person pronouns, perception words, internal detail, proportion of episodic detail, external detail, episodic richness) change across treatment? I hypothesized that positive emotion words, emotional tone, first-person pronouns, perceptions words, episodic detail, and episodic richness would increase across sessions. Negative emotions words and external detail were hypothesized to decrease across sessions, as an index of less retrieval of negative aspects of memory and less non-episodic detail, respectively. Secondly, the current study investigated whether changes linguistic features during in-session imaginal recounting relate to symptom improvement. I hypothesized that increases in positive emotion words, emotional tone, first-person pronouns, perception words, internal detail, proportion of episodic detail, episodic richness would correlate with and predict improvements in positive affect. Negative affect and total symptoms (depression, anxiety, stress) were tested as secondary outcomes. Decreases in negative emotion words and external detail were hypothesized to relate to symptom improvements across the outcomes. Thirdly, I investigated whether the extent to which positive mood changes from before to after imaginal recounting related to symptom improvement. Greater increases in positive mood from before to after imaginal recounting were hypothesized to predict symptom improvement.

Method

Full details regarding method and clinical outcomes are reported elsewhere, as data in the current study were collected as part of two randomized control trials of the Treatment of Affective Dimensions Study (TAD) comparing Positive Affect Treatment and Negative Affect Treatment, referred to here as TAD 1.0 (Craske et al., 2019) and TAD 2.0 (Craske et al., accepted).

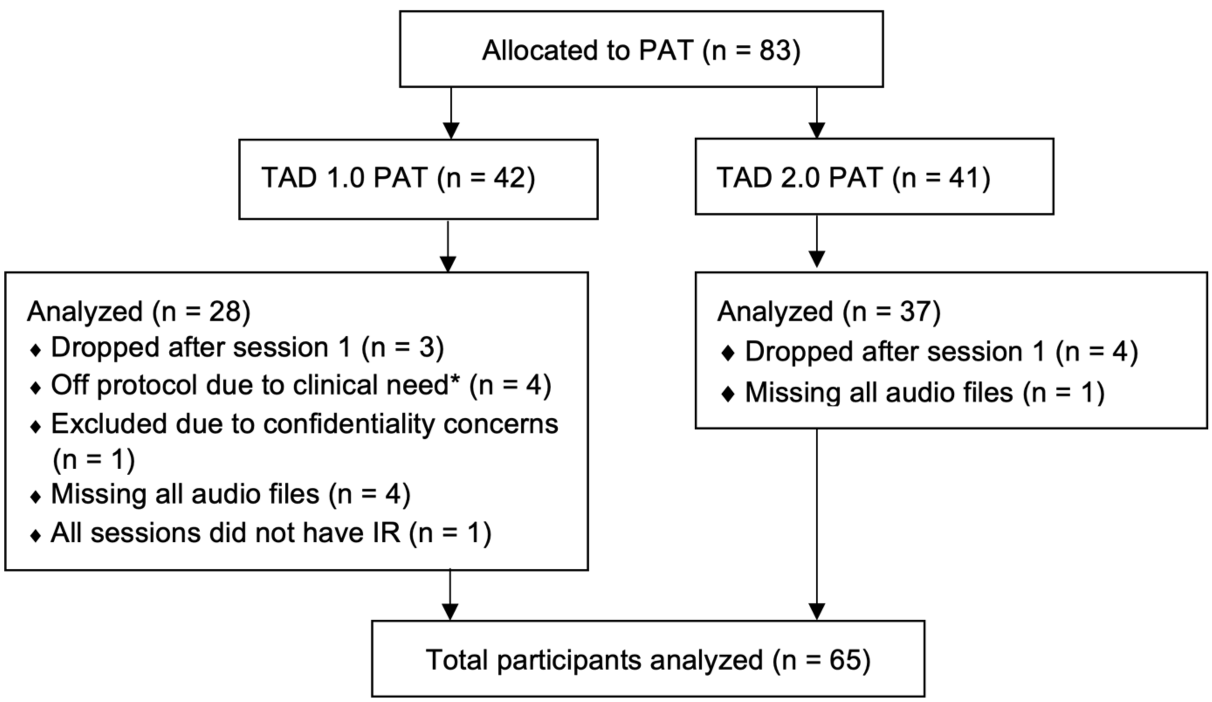
Participants

For both TAD 1.0 and 2.0, participants were recruited from the community were enrolled across two sites (University of California, Los Angeles and Southern Methodist University) to receive psychological treatment for symptoms of stress, anxiety, or depression. Eligibility criteria included: between ages of 18-65, stabilized on psychotropic medications or medication-free, willing to refrain from other psychotherapy during the trial, and English-speaking. Further, participants met for elevated depression or anxiety, as defined as scoring above dimensional cutoffs on at least one subscale of the Depression Anxiety Stress Scales (≥11 for depression, ≥6 for anxiety, and ≥10 for stress; DASS-21; Brown, 1997), as well as clinical impairment (≥5 on three Sheehan Disability subscales; Sheehan, Harnett-Sheehan, & Raj, 1996). For TAD 2.0, an additional inclusion criterion was low positive affect (≤24 on the Positive and Negative Affect Schedule – Positive Affect Subscale (PANAS-P), which is 1 SD below population mean and <18th percentile compared to a nonclinical reference sample; Crawford & Henry, 2004). Exclusion criteria included: serious medical conditions, history of Bipolar I or II disorder, cyclothymic disorder, schizophrenia-spectrum disorder, history of suicide attempt, active suicidal ideation or self-harm within the past year, intellectual disability or organic brain damage, substance use disorder within the last 6 months, and current pregnancy.

For the purpose of the current study, only participants who were randomly assigned to the PAT condition and who had at least one audio-recorded session that contained imaginal recounting were included, resulting in a total of 65 individuals (Figure 1; TAD 1.0 n = 28, with 16 from UCLA and 12 from SMU; TAD 2.0 n = 37, with 20 from UCLA and 17 from SMU). Sociodemographic characteristics and baseline clinical scores are reported in Tables 1 and 2.

Figure 1

Participant Flowchart and Reasons for Exclusion



Note. IR = imaginal recounting. *Reasons for changes in protocol due to different primary clinical need included severe choking phobia (n = 1), marijuana use (n = 1), and participant's request for a different treatment (n = 1).

Table 1

Sociodemographic Characteristics of Participants

	TAD 1.0		TAD 2.0		Full sample	
	n	%	n	%	n	%
Gender						
Female	21	75.0	28	75.7	49	75.4
Male	7	25.0	9	34.3	16	24.6
Transgender	0	0	0	0.0	0	0.0
Cisgender	28	100	37	100	65	100
Sexual Orientation						
Asexual	0	0	2	5.4	2	3.1
Bisexual	2	7.1	3	8.1	5	7.7
Homosexual	2	7.1	3	8.1	5	7.7
Heterosexual	17	60.7	27	72.9	44	67.7
Queer	0	0	1	2.7	1	1.5
Questioning	0	0	1	2.7	1	1.5
Other	1	3.7	0	0	1	1.5
Race						
Native American	0	0	1	2.7	1	1.5
Black	2	7.1	1	2.7	3	4.6
Asian	3	10.7	8	21.6	11	16.9
Pacific Islander	0	0	0	0	0	0
White	16	57.1	24	64	40	61.5
Latino non-white	5	17.8	-	-	5	7.7
Multiracial	1	3.7	2	5.4	3	4.6
Other	0	0	1	2.7	1	1.5
Prefer not to answer	1	3.7	0	0	1	1.5
Ethnicity						
Hispanic/Latinx	-	-	-	7	18.9	-
Non-Hispanic/Latinx	-	-	-	30	81.0	-

Note. The question assessing Hispanic/Latinx identity was posed in different ways for TAD 1.0 (which was included as an item under Race) versus TAD 2.0 which was assessed as a separate item.

Table 2

Participant Demographics and Baseline Clinical Variables

	TAD 1.0		TAD 2.0		Full sample	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age	34.25	13.63	32.57	11.86	33.41	12.75
DASS-D	22.07	10.96	23.74	11.16	23.06	10.93
DASS-A	19.11	10.70	10.74	8.07	14.12	10.02
DASS-S	25.63	9.18	20.95	9.88	22.87	9.73
DASS-tot	66.81	24.91	55.42	23.45	60.06	24.36
PANAS-P	24.78	8.31	20.24	7.15	22.12	7.92
PANAS-N	31.52	7.21	29.61	8.46	30.21	7.93

Note. DASS-D = Depression Anxiety and Stress Scales - Depression Subscale; DASS-A = Depression Anxiety and Stress Scales - Anxiety Subscale; DASS-S = Depression Anxiety and Stress Scales - Stress Subscale; DASS-tot = Depression Anxiety and Stress Scales – Total; PANAS-P = Positive and Negative Affect Scale – Positive Affect Subscale; PANAS-N = Positive and Negative Affect Scale – Negative Affect Subscale.

Approach

Imaginal recounting procedure. During sessions 2-7 of PAT, each session consisted of 1) homework review of pleasant activities completed as part of behavioral activation, 2) in-session imaginal recounting of one or more of the pleasant activities, and 3) homework assignment of pleasant activities to complete in the coming week. During the in-session imaginal recounting, the client was invited to close their eyes and slowly walk through the event aloud by describing the positive aspects of the experience in detail, while speaking in the first-person and in present-tense. Throughout the recounting, the therapist provided guidance (e.g., reminders to speak in present tense, instructing clients to identify specific positive emotions, asking how the emotions feel in their body, encouraging elaboration, providing praise and reflective statements, and redirecting attention away from negative aspects). Before and after the imaginal recounting, the therapist asked the client to rate their mood from 0 – 10 (0 = worst mood, 10 = best mood). In the case that behavioral activation homework was not completed, imaginal recounting was either not completed or was completed on the most positive moment from the past week.

Audio transcription. Audio-recordings from therapy sessions 2-7 were transcribed into text using a commercial software which can be used through a HIPAA compliant workflow to produce acceptable or better accuracy rates (Miner et al., 2020; Ziman et al., 2018). Session transcriptions were reviewed by the first author and research assistants to identify the relevant portion during which imaginal recounting took place, and to segment text spoken by clients versus therapists. For the purposes of this study, only text spoken by clients was analyzed.

Text analysis. Data was analyzed using Linguistic Inquiry Word Count software 2015 (LIWC; Pennebaker et al., 2001), a text analysis program that counts the total number of words in a given text and calculates the percentage of words that corresponds to various categories (Tausczik & Pennebaker, 2010). We focused on linguistic variables relevant to the study's primary hypotheses: first-person singular pronouns (e.g., I, me, my), positive emotion words (e.g., love, nice, sweet), negative emotion words (e.g., hurt, ugly, nasty), perception words (e.g., see, feel, hear) and emotional tone. Emotional tone is a LIWC summary variable calculated as the difference between positive emotion words and negative emotions words (Cohn et al., 2004; Monzani et al., 2021). Emotional tone is a standardized score ranging from 0-100, with higher scores representing more positive tone, 50 representing neutral or ambiguous tone, and lower scores representing negative tone.

Coding for detail. Detail was initially manually coded using the Autobiographical Interview Scoring Manual (Levine et al., 2002), but this data had relatively low inter-rater reliability and was therefore not used in the analyses (see Supplement). Instead, we used a natural language processing automated scoring program (van Genugten & Schacter, 2022; https://github.com/rubenvangenugten/autobiographical_interview_scoring) based on the Autobiographical Interview to calculate internal detail (also referred to as episodic detail, including event, place, time, perception, and emotion/thought details) and external detail (also referred to as non-episodic detail, including semantic information, repetitions, editorializations, and other details). Proportion of episodic detail, a commonly used metric (Lempert et al., 2020; Levine et al., 2002), was calculated as internal / (internal + external detail).

Mood ratings. Before and after each imaginal recounting exercise, clients report their current mood on a scale from 0-10 (0 = worst mood, 10 = best mood). This data was extracted from the audio recordings (sessions 2 through 7).

Outcome Measures

Positive and Negative Affect Schedule (PANAS, Watson et al., 1988). The 20-item questionnaire measures trait negative affect (PANAS-N) and positive affect (PANAS-P) and has adequate psychometric properties (Crawford & Henry, 2004). Participants rate how they felt during the past week on a scale from 1 (very slightly/not at all) to 5 (extremely).

Depression Anxiety Stress Scales (DASS-21, Brown, Chorpita, Korotitscw, & Barlow, 1997). The 21-item questionnaire measures depression (DASS-D; e.g., dysphoria, hopelessness, self-deprecation, lack of interest/involvement, anhedonia inertia), anxiety (DASS-A; e.g., situational anxiety, anxious affect, autonomic arousal), and stress (DASS-S; e.g., difficulty relaxing, nervous arousal, being easily upset/agitated, irritable/overreactive, and impatient). Participants rate the degree to which statements apply to them over the past week using a scale from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time). The DASS has strong construct validity (Shea, Tennant, & Pallant, 2009) and good to excellent internal consistency (Antony, Beiling, Cox, Enns, & Swinson, 1998). The PANAS and DASS were administered at the beginning of each treatment session.

Analytic Plan

Mixed effects repeated measures models were conducted in SPSS version 27 to test whether characteristics of imaginal recounting change across sessions. Mixed effects models were conducted separately for each of the linguistic variables to assess change across session. We specified a fixed effect of session, random intercept by subject (to allow for individual differences at baseline), and a heterogenous autoregressive covariance structure (which allows the covariance at each timepoint to vary). This statistical approach is consistent with other studies that assessed change in linguistic variables in an expressive writing intervention (Pulverman et al., 2015).

To assess whether changes in characteristics were related to changes in clinical outcomes, a series of regression analyses was conducted to probe initial relationships. Random-intercept cross-lag panel models (RI-CLPM) were then conducted in MPlus version 8 to probe for causality to test whether linguistic variables in a given session predicted clinical symptoms at the next session, controlling for clinical symptoms at the previous session. The primary outcome was trait positive affect (PANAS-P). Secondary outcomes were negative affect (PANAS-N) and total depression, anxiety, and stress symptoms (DASS-total, which was the sum of DASS-D, DASS-A, and DASS-S subscales). Linguistic variables from sessions 2 through 7 and clinical variables from sessions 2 through 7 were entered into the models. The RI-CLPM was chosen over traditional CLPM because it parses out stable between-person variance from within-person variations, which is more appropriate to assess processes of change in psychotherapy (Etherson et al., 2022; Hamaker et al., 2015; Simkin et al., 2022). Model fit was evaluated using chi-square, with an insignificant test indicating good model fit. The following metrics were also inspected, with the following cutoffs indicating good fit: comparative fit index (CFI, values ≥ 0.95), Tucker-Lewis index (TLI, values ≥ 0.95), and the root mean square error of approximation (RMSEA, values ≤ 0.06) (Hu & Bentler, 1999). If model fit was good, individual paths for the within-person cross-lagged associations were inspected.

To determine whether change in mood ratings predicted treatment outcomes, identical analyses were conducted on in-session mood ratings. Specifically, a mood change variable was created for each session (simple difference score by subtracting mood rating before from mood rating after imaginal recounting; in the case that multiple recountings were conducted in a single session, the first and last ratings were used). Mixed effects modeling was conducted to assess the change in mood from sessions 2 through 7, and RI-CLPM was conducted to test whether change in mood predicts next-session clinical outcomes.

Results

Data inspection

Normality of LIWC and ABI variables. Inspection of data revealed violations in normality for perception words using cutoffs of ± 2 for skewness and ± 7 for kurtosis (Byrne, 2013) for perception words (skewness = 2.03, kurtosis = 10.40). Because this variable contained values including zero, it was corrected using a natural log transformation [transformed variable = ln(original variable + 1)], consistent with prior research using LIWC (Schultheiss, 2013). All other LIWC and ABI variables met normality assumptions.

Missing data. For TAD 1.0, of the 208 sessions that occurred, 10.1% of the audio recorded tapes were missing (i.e., were either not uploaded to the server or were unable to be located; n = 21). Of the 187 tapes that existed, 48.1% did not contain imaginal recounting (n = 90), and 3.7% had poor audio quality (n = 7), leaving a total of 90 tapes to be analyzed. For TAD 2.0, of 217 total sessions that occurred, 20.3% tapes were missing (n = 44) and 2.7% sessions did not include imaginal recounting (n = 6), leaving a total of 167 tapes to be analyzed. In sum, 257 tapes were included in the final analysis for TAD 1.0 and 2.0 combined.

Mixed effects modeling and RI-CLPM use maximum likelihood (ML) estimation, which does not require the most stringent assumption of the data being missing completely at random (MCAR) and will still produce valid estimates if the data is missing at random (MAR). While there is no way to test for MAR directly, a series of tests were conducted comparing groups with and without missing data for different reasons. If non-significant, the assumption that the data is missing at random is more likely.

With relevance for the mixed effects modeling that assessed change in linguistic variables over time, patterns of missing data were not correlated with session, suggesting that there was not a greater likelihood of data to be missing across time ($r(464) = -.04$, $p = .34$). With relevance for regression and RI-CLPM analyses, there was no difference in any of the outcome measures for sessions with versus without audio tapes (PANAS-P: $t(424) = -1.68$, $p = .09$; PANAS-N: $t(426) = .77$, $p = .438$; DASS-tot: $t(408) = 1.18$, $p = .23$), suggesting that the availability of audio data was likely missing at random. For sessions that contained imaginal recounting versus those that did not, there was no difference in positive affect ($t(354) = -.43$, $p = .66$) or negative affect ($t(35) = -1.60$, $p = .10$); however, there was a significant difference in total symptoms ($t(340) = -7.313$, $p < .001$), such that sessions without imaginal recounting occurred when clients reported higher symptom severity than sessions in which imaginal recounting was conducted (without IR: n = 90, M = 39.23, SD = 20.61; with IR: n = 252, M = 23.31, SD = 17.23). Although there was no formal documentation available for reasons why imaginal recounting was not conducted in a given session, this pattern is consistent with reports in clinical supervision that therapists did not conduct imaginal recounting when 1) clients did not complete homework to engage in pleasant activities for behavioral activation, which required spending session time problem-solving and planning activities rather than recounting, or 2) there was a need to deviate from protocol due to suicidality, safety planning, or other urgent clinical matters. In these scenarios, it is likely that clients presented with higher symptom severity. Taken together, the planned analyses were still conducted on the assumption of MAR for outcomes of positive affect and negative affect, and were still conducted on total symptoms with the caveat that the sample analyzed likely represents overall lower symptom severity compared to the full sample.

A substantial proportion of mood rating data (54% or 279/514 potential ratings from a total of 257 sessions that contained IR) was missing for several reasons including: the therapist did not ask, inaudible portions of audio-tape, and missing workbook data. A total of 235 mood ratings (pre- and post-IR) were used in the analyses. When comparing participants who did not have any mood ratings (n = 26) to participants with at least one mood rating (n = 39), there were no significant differences in positive affect ($t(61) = 1.44$, $p = .15$), negative affect ($t(62) = 0.60$, $p = .55$), or total symptoms ($t(58) = 1.21$, $p = .23$), indicating that this data was likely missing at random and there were no subject effects.

Change in linguistic variables across treatment

Change in linguistic variables across sessions is depicted in Figures 2a-d. For LIWC variables, there was no effect of session for positive emotion words ($F(5, 57.49) = .499$, $p = .77$), negative emotion words, ($F(5, 57.99) = 1.06$, $p = .39$), tone ($F(5, 56.01) = .57$, $p = .72$), first-person pronouns ($F(5, 53.16) = .71$, $p = .62$), or perception words ($F(5, 49.09) = .52$, $p = .76$). For AI variables, there was no effect of session for internal detail ($F(5, 47.06) = 1.62$, $p = .17$), external detail ($F(5, 70.54) = .53$, $p = .76$), or proportion of episodic detail ($F(5, 48.50) = 1.77$, $p = .14$).

Figure 2a

Mean Linguistic Variables Across Sessions

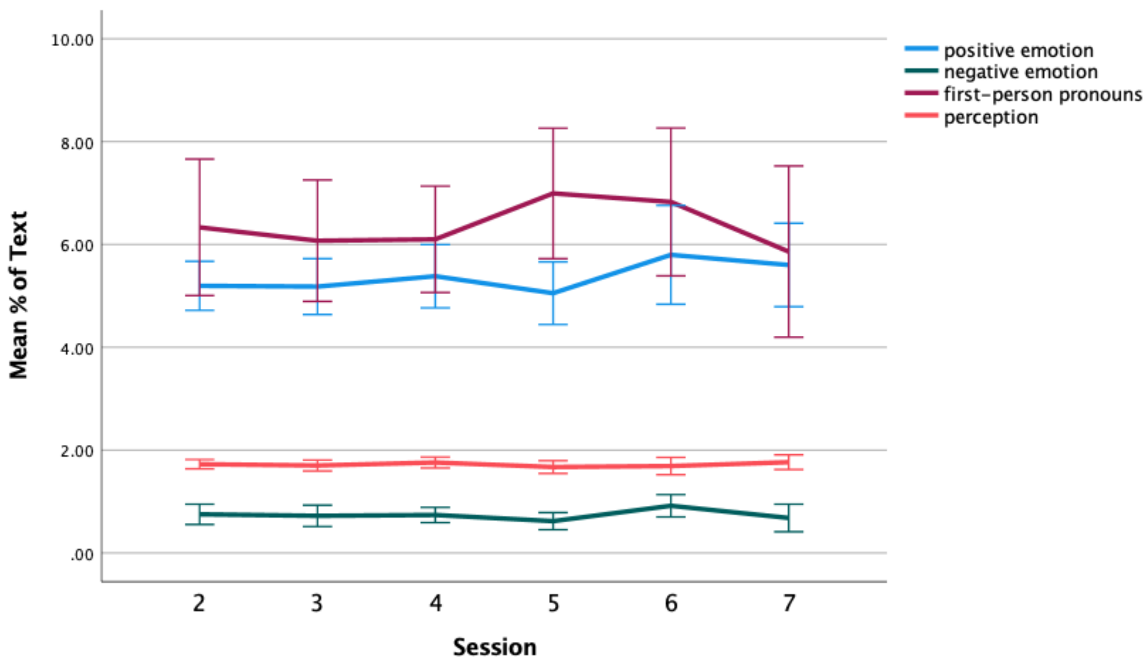


Figure 2b

Mean Emotional Tone Across Sessions

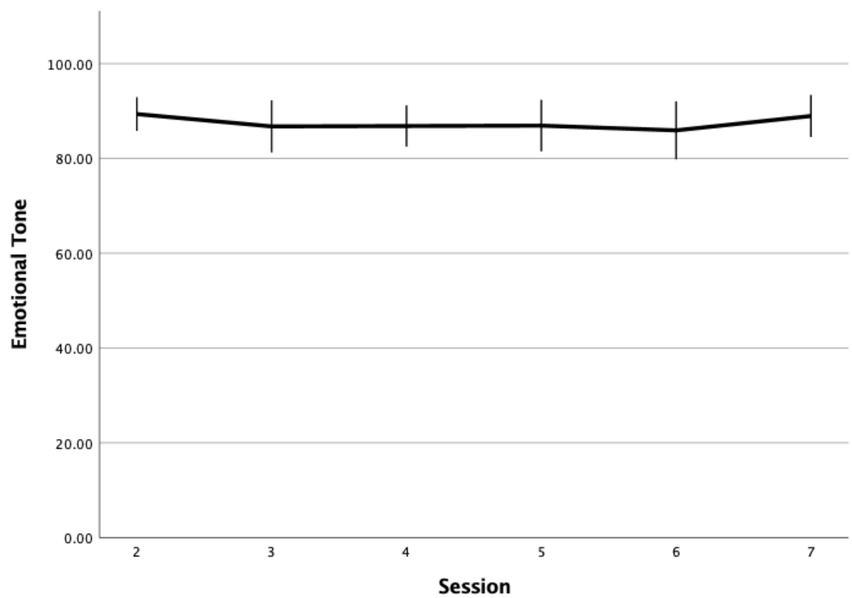


Figure 2c

Mean Detail Across Sessions

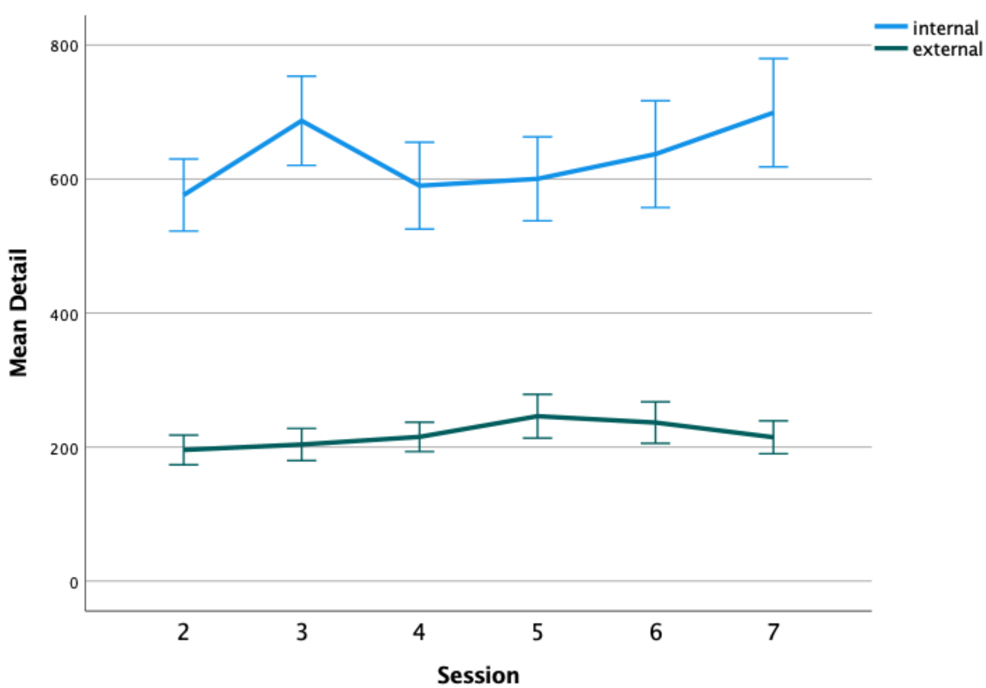
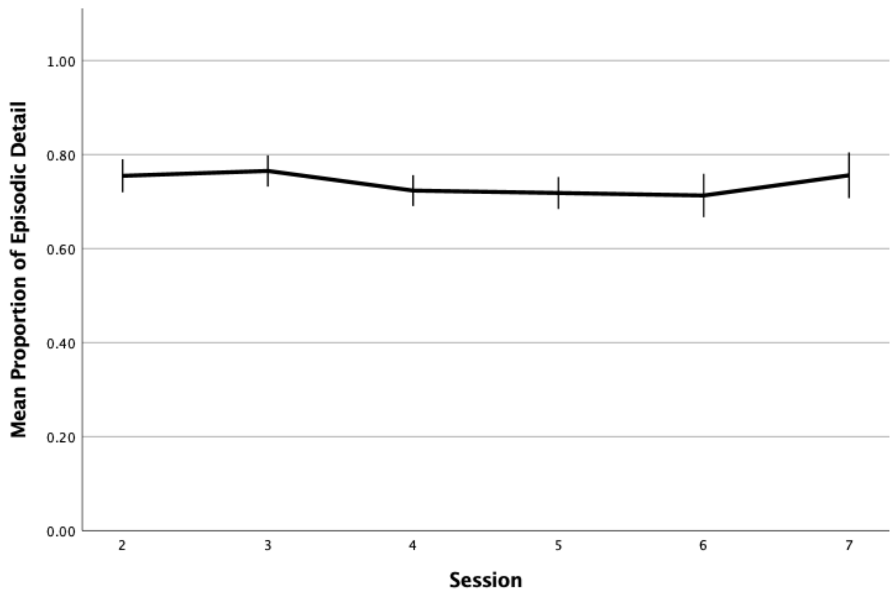


Figure 2d

Mean Proportion of Episodic Detail Across Sessions



Note. Error bars represent standard error.

Relationship between linguistic and clinical variables

Regression. Correlations among linguistic variables and symptoms collapsed across session are reported in Table 3. Among LIWC variables, positive emotion words correlated with perception words but not negative emotion words or first-person pronouns. Negative emotion words were positively correlated with first-person pronouns (opposite direction as expected) and inversely correlated with perception words. More positive emotional tone was correlated with perception words. Among AI variables, internal and external detail were significantly positively correlated. Proportion of episodic detail (calculated as internal / [internal + external]) was positively correlated with internal detail and inversely correlated with external detail. Between LIWC and AI variables, internal detail was associated with negative emotion and inversely associated with positive emotion. External detail was inversely correlated with positive emotion, negative emotion, and first-person pronouns. Proportion of episodic detail was positively correlated with first person pronouns.

I hypothesized that greater use of positive emotion words and emotional tone would correlate with greater positive affect and less depression, anxiety, and stress. Contrary to hypotheses, positive emotion words and emotion tone did not correlate with any symptom measures. Negative emotion words were inversely correlated with trait positive affect (PANAS-P), but were not associated with other symptom measures. I hypothesized that greater first-person pronouns would serve as an index of immersion and would therefore correlate with greater positive affect and lower symptoms. First person pronouns were inversely correlated with total symptoms ($p < .05$) but were also inversely correlated with positive affect ($p < .001$). This suggests that more first-person language during imaginal recounting corresponded with less symptom severity but also less positive affect during the week. Perception words did not correlate with any clinical outcome measures.

Internal detail positively correlated with positive affect and inversely correlated with negative affect and total symptoms ($p < .05$). External detail was also positively correlated with positive affect and inversely correlated with negative affect and total symptoms ($p < .05$). Proportion of episodic detail was not correlated with any outcomes.

Table 3

Correlations Among Linguistic and Clinical Variables Collapsed Across Session

	posemo	negemo	I	tone	percept	int	ext	pe	panasp	panasn	dasst
posemo	–										
negemo	.057	–									
I	-.061	.137*	–								
tone	.709**	-.304**	-.099	–							
percept	.177*	-.191**	-.215**	.175*	–						
int	-.225**	.138*	.095	.122	.081	–					
ext	-.138*	-.140*	-.185**	-.025	.018	.623**	–				
pe	-.006	-.065	.134*	-.030	.183**	.231**	-.456**	–			
panasp	-.020	-.138*	-.249**	-.045	.084	.132*	.188**	-.058	–		
panasn	-.039	.040	-.072	-.103	.036	-.176**	-.176**	.019	-.071	–	
dasst	-.021	.042	-.155*	-.052	.031	-.162*	-.190**	.053	-.258**	.746**	–

Note. * p <.05, ** p <.01. posemo = positive emotion words, negemo = negative emotion words, I = first person pronouns, tone = emotional tone, percept = perception words, int = internal detail, ext = external detail, pe = proportion of episodic detail, panasp = positive affect, panas-n = negative affect, dasst = total symptoms of depression, anxiety, and stress.

Random-intercept cross-lag panel analysis. Random-intercept cross-lag panel models (RI-CLPM) were conducted to probe for causality in order to test whether linguistic variables in a given session predicted clinical symptoms at the next session, controlling for clinical symptoms at the previous session. Goodness of fit measures for all models are reported in Table 4. Results from models with good fit are reported in Table 5 and results from all models regardless of fit are reported in the supplement (Table S1).

Table 4

Goodness of Fit Measures for the Random-Intercept Cross-Lag Panel Models

	X^2	TLI	CFI	RMSEA (95% CI)	AIC
Model 1 (I > PANAS-P)	52.85*	.91	.95	.08 (.01 - .12)	3717.62
Model 2 (I > PANAS-N)	51.29	.92	.95	.08 (.00 - .12)	3702.09
Model 3 (I > DASS-tot)	45.52	.96	.98	.06 (.00 - .11)	4305.38
Model 4 (posemo > PANAS-P)	61.76*	.81	.89	.10 (.05 - .15)	2547.39
Model 5 (posemo > PANAS-N)	62.33*	.79	.88	.10 (.05 - .15)	2526.41
Model 6 (posemo > DASS-tot)	61.61*	.83	.90	.04 (.05 - .15)	4058.13
Model 7 (negemo > PANAS-P)	47.40	.89	.94	.06 (.00 - .11)	2606.09
Model 8 (negemo > PANAS-N)	72.04*	.64	.79	.12 (.08 - .16)	2591.35
Model 9 (negemo > DASS-tot)	72.43*	.71	.83	.12 (.08 - .16)	3506.03
Model 10 (tone > PANAS-P)	57.67*	.83	.89	.09 (.04 - .14)	4517.22
Model 11 (tone > PANAS-N)	62.14*	.77	.87	.10 (.05 - .14)	4490.15
Model 12 (tone > DASS-tot)	65.70*	.78	.88	.11 (.06 - .15)	5093.94
Model 13 (percept > PANAS-P)	51.83	.89	.94	.08 (.00 - .13)	3513.63
Model 14 (percept > PANAS-N)	52.03	.88	.93	.09 (.00 - .13)	3489.86
Model 15 (percept > DASS-tot)	38.12	.99	.99	.02 (.00 - .09)	4087.71
Model 16 (int > PANAS-P)	74.65*	.76	.86	.12 (.08 - .17)	6109.07
Model 17 (int > PANAS-N)	93.22*	.62	.79	.15 (.11 - .19)	6106.09
Model 18 (int > DASS-tot)	71.64*	.79	.88	.12 (.08 - .16)	6691.93
Model 19 (ext > PANAS-P)	53.35*	.92	.87	.08 (.02 - .13)	5659.67
Model 20 (ext > PANAS-N)	54.56*	.90	.84	.08 (.03 - .13)	5658.06
Model 21 (ext > DASS-tot)	34.60	1.00	1.00	.00 (.00 - .08)	6247.79
Model 22 (pe > PANAS-P)	65.93*	.75	.86	.11 (.06 - .15)	2053.97
Model 23 (pe > PANAS-N)	60.71*	.77	.86	.09 (.05 - .14)	2052.48
Model 24 (pe > DASS-tot)	52.66*	.87	.92	.08 (.01 - .13)	2645.23

Note. The following values indicate good model fit: X^2 = Chi Square of Model Fit ($p > .05$), TLI = Tucker-Lewis Index (values ≥ 0.95), CFI = Comparative Fit Index (values ≥ 0.95), GFI = Goodness of Fit Index (values ≥ 0.90), RMSEA = Root Mean Squared Error of Approximation RMSEA (values ≤ 0.06), AIC = Akaike Information Criterion (lower values indicate better fit). *p <.05.

First-person pronouns as a predictor of next-session outcomes. Model test indicators suggested poor model fit for first-person pronouns as a predictor of next session positive affect and negative affect, and therefore the results of the individual paths should not be interpreted. The model for first-person pronouns as a predictor of next session total symptoms had indicators that suggested good model fit. One of five paths had a significant inverse relationship (session 1 first-person pronouns and session 2 symptoms, see Table 5); however, none of the other paths were significant and one path was in the opposite direction (positive relationship). Overall, this suggests that there was not a clear pattern of first-person pronouns predicting total symptoms.

Positive emotion as a predictor of next-session outcomes. Model test indicators suggested poor model fit for positive emotion words as a predictor of next session positive affect, negative affect, and total symptoms. Therefore, results of individual paths should not be interpreted.

Negative emotion as a predictor of next-session outcomes. For negative emotion words as a predictor of next session positive affect, the chi square test for model fit was insignificant indicating good fit, but the TLI and CFI indicated poor model fit, suggesting this model be interpreted with caution. One of the individual paths had a significant positive relationship between negative emotion words at session 4 predicting greater positive affect at session 5; however, none of the other paths were significant and 3/5 were in the opposite (negative) direction. Overall, this suggests there was not a clear relationship for negative emotion words predicting next-session positive affect. Model test indicators suggested poor model fit for negative emotion words as a predictor of next session negative affect and total symptoms, and results of individual paths should not be interpreted.

Emotional tone as a predictor of next-session outcomes. Model test indicators suggested poor model fit for emotional tone as a predictor of next session positive affect, negative affect, and total symptoms. Therefore, results of individual paths should not be interpreted.

Perception words as a predictor of next-session outcomes. While the chi square values for model fit was non-significant for perception words as a predictor of next-session positive affect and negative affect, all other indicators reflected poor model fit and therefore the results of the individual paths were not interpreted. Model test indicators suggested good model fit for perception words as a predictor of next session total symptoms; however, none of the individual paths were significant (ps > .05).

Internal detail as a predictor of next-session outcomes. Model test indicators suggested poor model fit for internal detail as a predictor of next session positive affect, negative affect, and total symptoms. Therefore, results of individual paths should not be interpreted.

External detail as a predictor of next-session outcomes. For external detail as a predictor of next session positive affect and negative affect, model test indicators suggested poor model fit and results of individual paths should not be interpreted. For external detail as a predictor of next session total symptoms, the model fit indicators were good. One of the individual paths had a significant positive relationship between external detail at session 3 predicting higher symptoms at session 4; however, none of the other paths were significant and 3/5 were in the opposite direction. Overall, this suggests there was not a clear relationship between external detail and next-session symptoms.

Proportion of episodic detail as a predictor of next-session outcomes. The model fit indicators for positive affect, negative affect, and total symptoms were poor, so none of the individual paths should be interpreted.

Table 5

Individual Path Results from RI-CLPM Models with Good Fit

	Predictor	Outcome	*B* (SE)
Model 3	I (S2)	DASS-tot (S3)	-.01 (.16)
	I (S3)	DASS-tot (S4)	-.49 (.16)**
	I (S4)	DASS-tot (S5)	.08 (.26)
	I (S5)	DASS-tot (S6)	.27 (.39)
	I (S6)	DASS-tot (S7)	-.35 (.40)
Model 7	Negemo (S2)	PANAS-P (S3)	-1.93 (3.11)
	Negemo (S3)	PANAS-P (S4)	-.57 (2.27)
	Negemo (S4)	PANAS-P (S5)	10.34 (4.56)*
	Negemo (S5)	PANAS-P (S6)	9.71 (6.41)
	Negemo (S6)	PANAS-P (S7)	-4.24 (3.85)
Model 15	percept (S2)	DASS-tot (S3)	.01 (.21)
	percept (S3)	DASS-tot (S4)	-.04 (.28)
	percept (S4)	DASS-tot (S5)	.35 (.18)
	percept (S5)	DASS-tot (S6)	-.18 (.22)
	percept (S6)	DASS-tot (S7)	-.15 (.28)
Model 21	Ext (S2)	DASS-tot (S3)	.03 (.16)
	Ext (S3)	DASS-tot (S4)	.44 (.16)*
	Ext (S4)	DASS-tot (S5)	-.28 (.14)
	Ext (S5)	DASS-tot (S6)	-.11 (.19)
	Ext (S6)	DASS-tot (S7)	-.17 (.34)

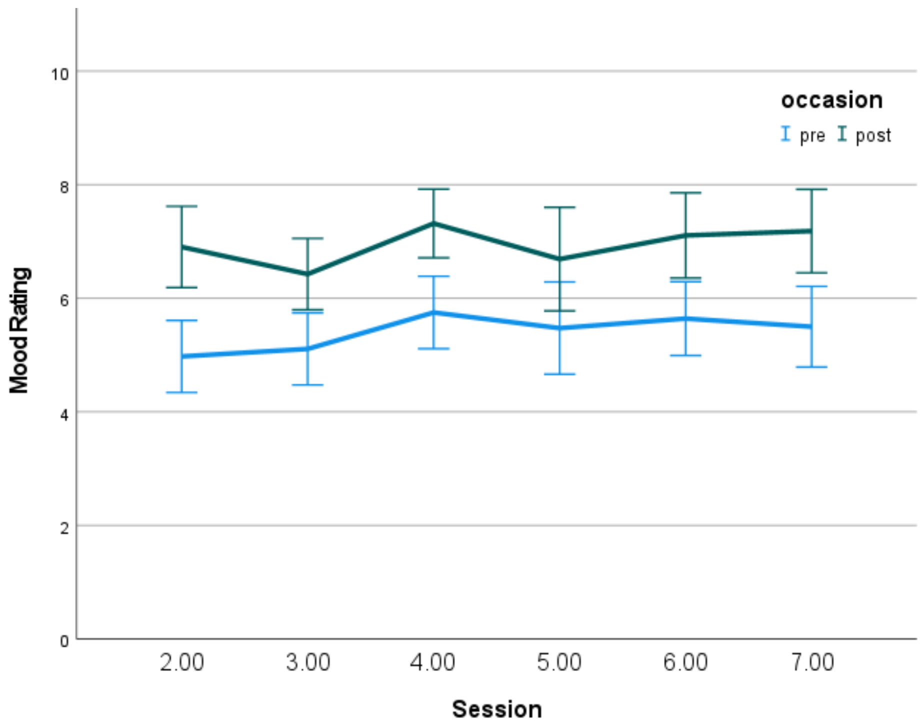
Note. S = session; I = first-person pronouns; Negemo = negative emotion words; percept = perception words; Ext = external detail. * $p < .05$. ** $p < .01$.

Change in mood ratings over time

A mixed model was conducted on mood ratings with session (2 through 7) and occasion (pre- and post- imaginal recounting) as fixed factors and random intercepts for each participant (Figure 3). There was a significant main effect of occasion ($F(1, 147.40) = 89.54$, $p < .001$), such that mood increased by an average of 1.55 points (pre-IR mean = 5.34, post-IR mean = 6.89). There was no significant main effect of session ($F(5, 49.67) = .88$, $p = .54$) nor session by occasion interaction (F(5, 42.75 = .41, $p = .84$).

Figure 3

Average Mood Ratings Pre- and Post- Imaginal Recounting Across Sessions



Note. Error bars represent standard error.

Relationship between mood ratings and symptoms

A mood change variable was conducted by taking the difference between pre- and post-mood ratings, and subsequently entered into the bivariate correlation and RI-CLPMs to assess the relationship between change in mood and clinical symptoms. Collapsing across session, change in mood was significantly positively associated with PANAS-N ($r(98) = .263$, p = .008) and inversely correlated with PANAS-P ($r(98) = -.178$, p = .076) at the level of a trend. There was no significant correlation between change in mood and total symptoms of depression, anxiety, and stress ($r(98) = .137$, $p = .184$). For the RI-CLPM, the models for change in mood as a predictor of next session clinical outcomes failed to converge due to unreliable parameter estimates, likely related to limited sample size and missing data.

Discussion

The current study analyzed language use during therapist-guided imaginal recounting of pleasant events in Positive Affect Treatment. We examined whether imaginal recounting characteristics changed across sessions, and whether changes corresponded to symptom improvement. Contrary to hypotheses, there was a lack of change in all linguistic variables across sessions. Collapsing across sessions, there were no associations between positive emotion words or emotional tone and clinical outcomes, but greater expressed negative emotion during imaginal recounting was associated with less positive affect experienced during the week prior. First-person pronouns were associated with less depression, anxiety, stress, as well as less positive affect. Both internal and external detail were associated with greater positive affect and less negative affect, but the proportion of episodic detail did not correspond with clinical symptoms. Of note, these findings were all correlational in nature. When assessing for causal relationships between linguistic variables predicting clinical outcomes using cross-lag panel modeling, no significant patterns emerged. Lastly, while mood reliably increased from before to after each imaginal recounting exercise, the degree of mood increase did not change across treatment and corresponded with greater negative affect and less positive affect during the week. The current study was limited by missing data and was underpowered to detect causal relationships; suggestions for future research are discussed below.

Change in linguistic variables

Emotional tone and episodic detail. Contrary to hypotheses, linguistic features during imaginal recounting did not change over time. This may be explained by scaffolding from the therapist, such that even in early sessions the therapists asked sufficient questions to consistently elicit a high degree of positive emotion and limited negative emotion. In this way, the lack of change may be driven by ceiling effects, as emotional tone was very high (M = 87.5/100 collapsed across sessions, with higher scores as more positive) as was the proportion of episodic detail (M = 73.9/100, with higher scores representing more episodic detail). Similarly, lack of change in negative emotion words could reflect floor effects, since clients expressed on average <2% of negative emotions words in a given imaginal recounting. One future direction of this work is to examine whether in-session therapist behaviors (e.g., positive affect labeling, redirection away from negatives, encouragement for elaboration) relate to client speech patterns and symptoms over time. Future designs may also include a self-guided imaginal recounting for each client as their baseline in each session before the therapist provides guidance for a subsequent imaginal recounting. Self-guided training programs (such as Mobile Virtual Reality-Reward Training; see Study 2) provide an opportunity to examine potential changes in an individual's abilities to savor and recount positive experiences on their own. Future psychotherapy trials could also administer an autobiographical memory task (e.g., AMT or similar procedures) at pre-, mid-, and post-treatment to assess independent changes in memory processes without therapist guidance.

First person pronouns. First person pronouns also did not increase across sessions, which we predicted as an index of field perspective or immersion based on prior experimental research (Mcisaac & Eich, 2002). It is possible that first-person pronouns are not a reliable index of field perspective and that more nuanced measures are necessary to more accurately capture this construct. First-person pronouns, especially in the context of negative valence such as writing about stressful or traumatic events, have been linked to greater negative emotion and has even been found to predict depression (Edwards & Holtzman, 2017; Zimmermann et al., 2017). Consistent with this notion, we found that first-person pronouns were associated with greater use of negative emotion words. Because first-person pronouns were also related to less use of perception words, it is possible that focusing on the self may detract from attending to experiential sensory details. Future studies should use qualitative coding and analysis to better understand the meaning of first-person language. To assess whether field perspective or immersion changes across treatment, future studies could use alternative methods such as self-report measures (see Study 3), which have been shown in other studies to change across practice for guided imagery (Hallford et al., 2020b).

Perception words. Perception words also did not increase over time, contrary to predictions, which was likely due to similar reasons as above related to therapist scaffolding. Perception words were associated with less negative emotion words, as well as more positive emotions, emotional tone, and proportion of episodic detail. This correlational pattern is consistent with the notion that experiential processing that focuses on sensory details is related to greater positive affect (Gadeikis et al., 2017), which future work should investigate experimentally to probe for causality in clinical samples (see Study 3).

Relationship between linguistic features and clinical outcomes

We attempted to probe for causal relationships between linguistic features of autobiographical memory and clinical outcomes by using RI-CLPM. However, contrary to hypotheses, there were no consistent evidence across models for any of the linguistic variables as a predictor or mechanism of symptom changes due to poor model fit for the majority of models. It is possible that linguistic features simply do not have predictive or causal relationships with symptoms. The lack of findings may also be in part due to substantial missing data and small sample size that limited our ability to detect effects using a more sophisticated statistical approach. Because the RI-CLPM approach has the advantage of modeling within-person changes, this type of approach is especially valuable for exploring mechanisms of change in psychotherapy (Etherson et al., 2022; Simkin et al., 2022), which future studies should do using well-powered designs. Although we were unable to assess causal relationships, below we discuss correlational associations between linguistic and clinical variables which could be useful for developing hypotheses for future research.

We hypothesized that greater use of positive emotion words and less use of negative emotion words would correlate with greater positive affect and less depression, anxiety, and stress. Contrary to hypotheses, positive emotion words did not correlate with any symptom measures. Overall, our results do not support either the down-regulation (Lieberman, 2011) or up-regulation (Lindquist, 2017) theories of how naming positive emotions relates to affective experience. Experimental studies are needed to better understand how positive emotional labeling impacts positive affective experience both in the short and long-term, and whether this process might differ in healthy versus clinical populations such as those with anhedonia. One clinical implication for PAT is that it may not necessarily matter how many positive emotion words are labeled during recounting. Aside from the sheer frequency of positive emotional word use as measured in this study, future work could also examine emotional granularity by assessing *variety* in emotional vocabulary (i.e., describing one's experience as "relaxed, grateful, and appreciative", rather than globally "good"). Emotional granularity, for both positive and negative emotions, has been found to relate to better coping and use of adaptive emotion regulation strategies (Smidt & Suvak, 2015; Tugade et al., 2004). In addition, newer natural language processing tools may provide more sensitive measures of emotional tone (see Future Directions below).

Negative emotion words were inversely correlated with trait positive affect (PANAS-P), but the causal direction of this relationship is unknown. It is possible that less attention to negatives during recounting is beneficial for enhancing positive affect; however, greater positive affect experienced during the week could also result in fewer negative emotion words expressed. It is likely that the relationship between positive and negative affective processes are bidirectional. Future longitudinal research is needed to tease apart these relationships.

We hypothesized that greater first-person pronouns would serve as an index of immersion and would therefore correlate with greater positive affect and lower symptoms. First-person pronouns were associated with less depression, anxiety, and stress but were also associated with less positive affect. This may suggest that first-person language during imaginal recounting relates to both blunted negative and positive affective outcomes. As discussed above, it is unclear what first-person pronouns represent and why it would correspond with diminished clinical outcomes of both negative and positive valence. Future research should investigate whether imagery perspective related to affect using other methods.

Mood change. We found that mood increased from before to after each recounting exercise, but did not find support for our hypothesis that change in mood would increase to a greater extent as sessions progressed. There was also no evidence that the degree of mood change related to better outcomes collapsed across session. Instead the degree of mood increase was correlated with greater negative affect and less positive affect experienced during the week prior. This may reflect that individuals with greater negative affect had more room for mood to improve during the session. It is possible that therapist scaffolding also precluded our ability to examine client's ability to upregulate positive emotion on their own. Future research may examine positive emotion regulation via behavioral tasks or ecological momentary assessment.

Limitations & Future Directions

The primary limitations of the current study include being underpowered to detect small effects due to substantial missing data. In addition, more sophisticated text analysis methods could be used in future research to better understand the interactions between multiple linguistic variables. LIWC only counts the number of words and does not take context into account, as exemplified in its failure to detect negations (e.g., “I don’t feel anxious”; “Excitement isn’t very strong”). Natural language processing tools could be used to detect more sensitive measures of affective tone, such as sentiment analysis using Bidirectional Encoder Representations from Transformers (BERT; Alaparthi & Mishra, 2020) which have been trained on actual human text such as narratives and tweets. Future work could also create algorithms that take into account multiple linguistic variables into one “linguistic signature”, such as linguistic distancing which includes both temporal and spatial language use (Nook et al., 2022). A similar measure could be created to capture immersion.

Another future direction involves attention to the interpersonal and cultural context. The current analyses were limited to being in the presence of the therapist, and future work should test how much this skill generalizes when individuals are alone. In addition, what does it mean to share a positive autobiographical memory with a therapist aloud? There may be additional processes that occur when telling a narrative aloud, especially related to interpersonal emotion regulation (Zaki & Williams, 2013). For example, capitalizing is strategy that involves communicating and celebrating positive events with others, which is associated with greater positive affect above that produced by the original event (Gable et al., 2004; Langston, 1994). PAT builds in a deliberate opportunity for capitalization of pleasant events from behavioral activation; however, it is unknown how the therapists’ responses may also impact how much positive emotion is up-regulated. Future work could use dyadic speech analysis approaches as well as examining interactions between client and therapist speech (e.g, Borelli et al., 2019). The current study also did not examine cultural considerations, which may be important because naming certain types of positive emotions may be more or less socially acceptable depending on cultural values (e.g., pride may be more culturally consonant in individualistic versus collectivistic societies (Eid & Diener, 2001) and emotion regulation goals (e.g., In the US, Latinx populations were more motivated to enhance positivity and decrease negativity, whereas Asian Americans valued moderating both positive and negative emotions, compared to those of European heritage who valued authenticity regardless of valence; Senft et al., 2021).

In sum, during therapist-guided imaginal recounting, linguistic variables did not change across sessions. While we observed several correlational relationships between linguistic variables and clinical outcomes, these relationships only emerged when collapsing across sessions and cross-lag panel modeling did not support causal relationships.

Supplement

Manually Coded Detail. To assess detail, text from imaginal recounting was originally manually coded by three trained research assistants who underwent a 5-week training process and achieved good or better reliability on practice training data using the Autobiographical Interview Scoring Manual (Levine, Svoboda, & Moscovitch, 2005). In addition to internal and external detail, coders also rated episodic richness on a scale from 0 (no episodic information) to 6 (rich in detail and evokes an impression of true re-experiencing), which assesses the overall sense of re-experiencing by taking a listener back to a specific moment in time and place in which they are able to re-create the perceptual, emotion, and cognitive contextual detail of an event. Inter-rater reliability was moderate to excellent for internal detail (ICCs = .672 - .949) and moderate for external detail (ICCs = .521.- .65). Episodic richness ratings had poor to excellent inter-rater reliability (ICCs = .167.- .909), and therefore could not be used in subsequent analyses. To improve overall measurement of detail, we instead used an automated scoring program.

Table S1

Individual Path Results from All RI-CLPM Models

	Predictor	Outcome	*B* (SE)
Model 1	I (S2)	PANAS-P (S3)	-.26 (.56)
	I (S3)	PANAS-P (S4)	1.88 (.26)
	I (S4)	PANAS-P (S5)	.78 (.48)
	I (S5)	PANAS-P (S6)	-1.01 (.01)*
	I (S6)	PANAS-P (S7)	.62 (.06)
Model 2	I (S2)	PANAS-N (S3)	-.87 (.38)
	I (S3)	PANAS-N (S4)	-.99 (.01)*
	I (S4)	PANAS-N (S5)	-.25 (.81)
	I (S5)	PANAS-N (S6)	.58 (.27)
	I (S6)	PANAS-N (S7)	-.28 (.49)
Model 3	I (S2)	DASS-tot (S3)	-.01 (.16)
	I (S3)	DASS-tot (S4)	-.49 (.16)**
	I (S4)	DASS-tot (S5)	.08 (.26)
	I (S5)	DASS-tot (S6)	.27 (.39)
	I (S6)	DASS-tot (S7)	-.35 (.40)
Model 4	Posemo (S2)	PANAS-P (S3)	.55 (9.38)
	Posemo (S3)	PANAS-P (S4)	-2.55 (3.73)
	Posemo (S4)	PANAS-P (S5)	1.22 (3.41)
	Posemo (S5)	PANAS-P (S6)	9.45 (7.65)
	Posemo (S6)	PANAS-P (S7)	.79 (2.83)
Model 5	Posemo (S2)	PANAS-N (S3)	.38 (.20)
	Posemo (S3)	PANAS-N (S4)	-.13 (.18)
	Posemo (S4)	PANAS-N (S5)	-.02 (.19)
	Posemo (S5)	PANAS-N (S6)	-.43 (.22)*
	Posemo (S6)	PANAS-N (S7)	-.33 (.36)
Model 6	Posemo (S2)	DASS-tot (S3)	-.26 (.13)*
	Posemo (S3)	DASS-tot (S4)	.07 (.18)
	Posemo (S4)	DASS-tot (S5)	-.04 (.18)
	Posemo (S5)	DASS-tot (S6)	.23 (.24)
	Posemo (S6)	DASS-tot (S7)	.73 (.77)
Model 7	Negemo (S2)	PANAS-P (S3)	-1.93 (3.11)
	Negemo (S3)	PANAS-P (S4)	-.57 (2.27)
	Negemo (S4)	PANAS-P (S5)	10.34 (4.56)*

	Negemo (S5)	PANAS-P (S6)	9.71 (6.41)
	Negemo (S6)	PANAS-P (S7)	-4.24 (3.85)
Model 8	Negemo (S2)	PANAS-N (S3)	.14 (2.93)
	Negemo (S3)	PANAS-N (S4)	-.76 (2.99)
	Negemo (S4)	PANAS-N (S5)	-6.21 (4.72)
	Negemo (S5)	PANAS-N (S6)	2.75 (3.02)
	Negemo (S6)	PANAS-N (S7)	14.06 (9.55)
Model 9	Negemo (S2)	DASS-tot (S3)	-3.74 (3.70)
	Negemo (S3)	DASS-tot (S4)	1.54 (3.78)
	Negemo (S4)	DASS-tot (S5)	-3.72 (6.62)
	Negemo (S5)	DASS-tot (S6)	4.23 (4.77)
	Negemo (S6)	DASS-tot (S7)	5.59 (9.08)
Model 10	Tone (S2)	PANAS-P (S3)	.12 (.22)
	Tone (S3)	PANAS-P (S4)	-.07 (.23)
	Tone (S4)	PANAS-P (S5)	-.01 (.25)
	Tone (S5)	PANAS-P (S6)	.10 (.28)
	Tone (S6)	PANAS-P (S7)	.18 (.17)
Model 11	Tone (S2)	PANAS-N (S3)	.09 (.18)
	Tone (S3)	PANAS-N (S4)	.37 (.15)*
	Tone (S4)	PANAS-N (S5)	.511 (.14)*
	Tone (S5)	PANAS-N (S6)	-.06 (.22)
	Tone (S6)	PANAS-N (S7)	-.778 (.46)
Model 12	Tone (S2)	DASS-tot (S3)	.38 (.21)
	Tone (S3)	DASS- tot (S4)	-.06 (.16)
	Tone (S4)	DASS- tot (S5)	-.09 (.24)
	Tone (S5)	DASS- tot (S6)	-.09 (.18)
	Tone (S6)	DASS- tot (S7)	-.22 (.27)
Model 13	percept (S2)	PANAS-P (S3)	.01 (.28)
	percept (S3)	PANAS-P (S4)	-.12 (.26)
	percept (S4)	PANAS-P (S5)	-.02 (.21)
	percept (S5)	PANAS-P (S6)	.31 (.25)
	percept (S6)	PANAS-P (S7)	-.28 (.17)
Model 14	percept (S2)	PANAS-N (S3)	.22 (.39)
	percept (S3)	PANAS-N (S4)	.20 (.26)
	percept (S4)	PANAS-N (S5)	.14 (.20)
	percept (S5)	PANAS-N (S6)	-.19 (.23)
	percept (S6)	PANAS-N (S7)	-.28 (.16)
Model 15	percept (S2)	DASS-tot (S3)	.01 (.21)
	percept (S3)	DASS-tot (S4)	-.04 (.28)
	percept (S4)	DASS-tot (S5)	.35 (.18)
	percept (S5)	DASS-tot (S6)	-.18 (.22)
	percept (S6)	DASS-tot (S7)	-.15 (.28)
Model 16	Int (S2)	PANAS-P (S3)	.40 (.19)
	Int (S3)	PANAS-P (S4)	-.09 (.24)
	Int (S4)	PANAS-P (S5)	.01 (.27)
	Int (S5)	PANAS-P (S6)	.29 (.27)

	Int (S6)	PANAS-P (S7)	.32 (.19)
Model 17	Int (S2)	PANAS-N (S3)	.05 (.21)
	Int (S3)	PANAS-N (S4)	-.10 (.19)
	Int (S4)	PANAS-N (S5)	-.11 (.22)
	Int (S5)	PANAS-N (S6)	-.44 (.35)
	Int (S6)	PANAS-N (S7)	-.04 (.20)
Model 18	Int (S2)	DASS-tot (S3)	.17 (.16)
	Int (S3)	DASS-tot (S4)	.11 (.26)
	Int (S4)	DASS-tot (S5)	-.26 (.23)
	Int (S5)	DASS-tot (S6)	-.67 (.23)
	Int (S6)	DASS-tot (S7)	.41 (.32)
Model 19	Ext (S2)	PANAS-P (S3)	-4.73 (4.47)
	Ext (S3)	PANAS-P (S4)	-6.09 (8.43)
	Ext (S4)	PANAS-P (S5)	-1.86 (6.02)
	Ext (S5)	PANAS-P (S6)	4.95 (6.04)
	Ext (S6)	PANAS-P (S7)	.07 (.216)
Model 20	Ext (S2)	PANAS-N (S3)	-.18 (.16)
	Ext (S3)	PANAS-N (S4)	.03 (.20)
	Ext (S4)	PANAS-N (S5)	-.05 (.15)
	Ext (S5)	PANAS-N (S6)	-.15 (.16)
	Ext (S6)	PANAS-N (S7)	-.05 (.19)
Model 21	Ext (S2)	DASS-tot (S3)	.03 (.16)
	Ext (S3)	DASS-tot (S4)	.44 (.16)*
	Ext (S4)	DASS-tot (S5)	-.28 (.14)
	Ext (S5)	DASS-tot (S6)	-.11 (.19)
	Ext (S6)	DASS-tot (S7)	-.17 (.34)
Model 22	PE (S2)	PANAS-P (S3)	-.01 (.01)
	PE (S3)	PANAS-P (S4)	-.01 (.01)
	PE (S4)	PANAS-P (S5)	-.01 (.01)
	PE (S5)	PANAS-P (S6)	.01 (.01)
	PE (S6)	PANAS-P (S7)	-.01 (.01)
Model 23	PE (S2)	PANAS-N (S3)	.26 (.15)
	PE (S3)	PANAS-N (S4)	-.08 (.18)
	PE (S4)	PANAS-N (S5)	.24 (.22)
	PE (S5)	PANAS-N (S6)	-.01 (.17)
	PE (S6)	PANAS-N (S7)	.22 (.19)
Model 224	PE (S2)	DASS-tot (S3)	.00 (.15)
	PE (S3)	DASS-tot (S4)	-.19 (.22)
	PE (S4)	DASS-tot (S5)	-.11 (.23)
	PE (S5)	DASS-tot (S6)	.07 (.25)
	PE (S6)	DASS-tot (S7)	.44 (.39)

STUDY 2

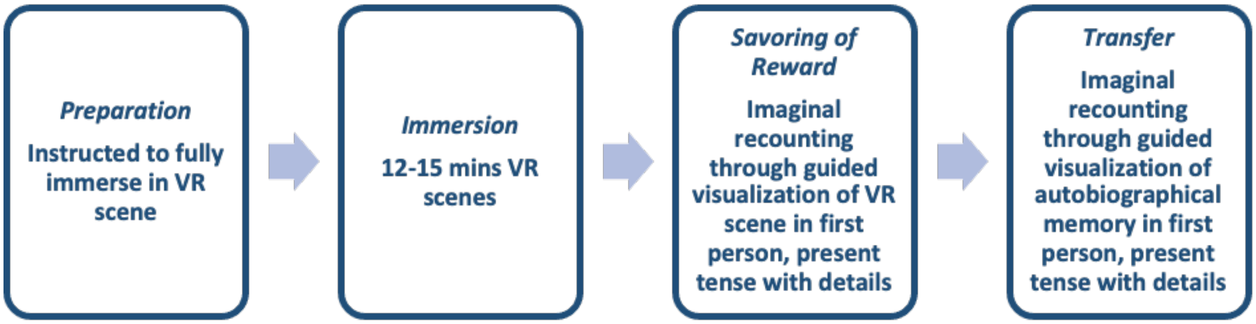
Imaginal Recounting in Mobile Virtual Reality-Reward Training

Introduction

The current study sought to address similar aims as in Study 1 by investigating whether linguistic features during imaginal recounting change across sessions and relate to symptom improvement in Mobile Virtual-Reality Reward Training (MVR-RT). Aimed at enhancing positive affect for individuals with anhedonia, MVR-RT is a completely self-guided treatment, which provides an opportunity to examine individual's ability to practice imaginal recounting on their own. MVR-RT is a 13-session treatment over 7 weeks in which participants first view pre-selected 360 degree virtual reality scenes on their cell phones with a headset, followed by memory specificity training (specifically, written imaginal recounting of the VR scene as well as a positive autobiographical memory to transfer savoring skills; See Figure 1). MVR-RT was tested in an open trial compared to a waitlist control condition (Sandman et al., in prep). Compared to the waitlist control, MVR-RT led to greater reduction in depression, stress, and negative affect by mid-treatment; however, these effects largely disappeared by post-treatment (Figure S1). Full clinical outcomes are presented in the Supplement.

Figure 1

MVR-RT session content



Drawing from the MVR-RT trial, the current study investigated whether linguistic features (positive and negative emotion words, emotional tone, first-person pronouns, perception words, episodic detail, episodic richness) during both VR and autobiographical memory recounting change across treatment. Positive emotion words, first-person pronouns, emotional tone, perception words, episodic detail, and episodic richness were hypothesized to increase across sessions (1-13). Negative emotion words and external (non-episodic) detail were expected to decrease across sessions (1-13), as an index of less attention to negative aspects of memory and less focus on information irrelevant to the memory. In addition, the current study tested whether changes in linguistic features related to symptom improvement. Increases in positive emotion words, first-person pronouns, emotional tone, perception words, episodic detail, and episodic richness were hypothesized to correlate with improvements in anhedonia and positive affect. Negative affect and total symptoms (depression, anxiety, stress) were tested as secondary outcomes. Decreases in negative emotion words and external detail were hypothesized to relate to symptom improvements.

Method

Participants. Enrolled participants were 44 adults who were recruited through the University of California, Los Angeles (UCLA) Anxiety and Depression Research Center via referrals, flyers and internet advertisements. The UCLA Office for the Protection of Human Research Subjects approved all procedures, and participants provided written informed consent. Participants were 18-40 years of age, fluent in English, and met cutoffs on self-report measures of reward sensitivity, depression, anxiety, stress, and functional disability: Behavioral Activation Scale (BAS; Drive subscale score of ≤ 11, Fun Seeking score of ≤ 11, or Reward Responsiveness subscale score of ≤ 16; Carver & White, 1994), Depression, Anxiety and Stress Scales (DASS-21; Depression subscale score of 10-27, Anxiety subscale score of ≥ 8, and Stress subscale score of ≥ 15; Brown et al., 1997), and Sheehan Disability Scale (SDS; score of ≥6). To increase recruitment, the depression cutoff on the DASS-D subscale was increased partway through the study (scores from 10-35) to include individuals with extremely severe levels of depression (n = 7 in the current sample).

Participants were excluded under several circumstances: (a) a lifetime history of bipolar disorder, psychosis, mental retardation, or organic brain damage, (b) substance use disorder in the past 6 months, (c) current use of psychotropic medications, and/or (d) currently pregnant or planning to become pregnant. Participants were also asked to refrain from participating in other psychotherapy during the course of MVR-RT. In addition, those who had experienced epilepsy or seizures within the last year or had self-reported motion sickness were excluded in order to avoid the risks of neural episodes or motion sickness, respectively, from the VR experience. Eligible participants were randomized to either the treatment group (MVR-RT) or the waitlist control group (WLC). Sociodemographic and baseline clinical variables for all participants are presented in Tables 1 and 2. For the purposes of the current study, only participants from the MVR-RT group were included (n = 22) due to the lack any written recall procedure in the WLC condition.

Table 1

Sociodemographic Characteristics of Participants

	MVR		WLC		Full sample	
	n	%	n	%	n	%
Sex						
Female	14	63.6	14	63.6	28	63.6
Male	8	36.3	8	36.3	16	36.3
Gender						
Female	25	78.1	28	87.5	80	83.3
Male	6	18.8	4	12.5	15	15.6
Nonbinary	0	0	0	0.0	0	0
Transgender identity	0	0	0	0.0	0	1.0
Cisgender identity	22	100	22	100	44	100
Race						
Native American	0	0	1	4.5	1	2.3
Black	1	4.5	0	0	1	2.3
Indian	2	9.1	1	4.5	3	6.8
Chinese	3	13.6	2	9.1	5	11.4
Filipino	1	4.5	0	0	1	2.3
Japanese	0	0	3	13.6	3	6.8
Korean	1	4.5	0	0	1	2.3
White	7	31.8	9	40.9	16	36.4
Other/None of the above	4	18.1	2	9.1	6	13.6
Prefer not to answer	3	13.6	2	9.1	5	11.4
Ethnicity						
Hispanic/Latinx	6	27.3	7	31.8	13	29.5
Non-Hispanic/Latinx	16	72.7	15	68.2	31	70.5

Note. MVR-RT = Mobile Virtual Reality-Reward Training; WLC = Wait List Control

Table 2

Participant Demographics and Baseline Clinical Variables

	MVR-RT		WLC	
	M	*SD*	*M*	*SD*
Age	25.36	5.69	24.82	6.04
DASS-D	12.78	5.78	16.09	9.78
DASS-A	6.67	6.36	7.81	5.51
DASS-S	17.00	6.86	19.90	7.03
DASS-tot	37.80	15.44	43.81	17.05
MASQ-AD	51.78	10.86	51.52	11.02
PANAS-P	25.94	7.77	25.38	7.71
PANAS-N	23.50	7.02	24.95	7.46
SDS	14.44	8.67	14.81	6.71

Note. MVR-RT = Mobile Virtual Reality-Reward Training; WLC = Wait List Control; DASS-D = Depression Anxiety and Stress Scales - Depression Subscale; DASS-A = Depression Anxiety and Stress Scales - Anxiety Subscale; DASS-S = Depression Anxiety and Stress Scales - Stress Subscale; MASQ-AD 14-item = Mood and Anxiety Symptom Questionnaire Anhedonia Subscale; PANAS-P = Positive and Negative Affect Scale – Positive Affect Subscale; PANAS-N = Positive and Negative Affect Scale – Negative Affect Subscale; BAS-Drive = Behavioral Activation Scale – Drive Subscale; BAS-Reward = Behavioral Activation Scale – Reward Responsiveness Subscale; BAS-Fun = Behavioral Activation Scale – Fun Seeking Subscale; RRS = Ruminative Response Scale; SDS = Sheehan Disability Scale.

Procedure. Mobile Virtual-Reality Reward Training consisted of 13 twice-weekly self-guided sessions that participants completed over the span of eight weeks. The first session took place in-person, during which participants completed baseline measures (PANAS, DASS-21, MASQ-AD) and were given an orientation on how to use the VR technology (i.e., instructions about how to troubleshoot potential issues and how to insert their phones into the VR headset).

They then completed their first VR session at the laboratory. All subsequent sessions (2-13) were completed at home.

Each session was 45 minutes long. First, participants were given a description of the VR experience. Then, the participants watched one to four VR videos. For the VR experience, participants inserted their smartphones into a DESTEK V4 VR, 103°FOV, Eye Protected HD Virtual Reality Headset. All videos were 360 VR, and participants were given the option to stream at 1080P. Videos were initially screened by a researcher for violence or inappropriate content. Subsequently, five different raters watched the videos to provide ratings for valence (0 = negative to 9 =positive), arousal, (0 = calm to 9 = activated), dominance (0 = dominant to 9 = dominated), liking (0 = not at all to 5 = very much), and nausea (0 = not at all to 5 = very much). Videos were excluded if they were too lengthy (>15 minutes), unlikeable (<2/5), or nausea-inducing (>3). Videos were chosen based on valence ratings (≥ 5/9) and were organized into YouTube playlists for participants' convenience.

The VR videos included either physical reward experiences (e.g., meeting wild elephants, traveling down a Venice canal), social reward experiences (e.g., attending an electronic music festival), or both. During the first half of the intervention (Sessions 1-7), the videos were highly positive (e.g., flying over a tropical island) (valence: $M = 6.62$, $SD = .23$; arousal: $M = 3.11$, $SD = .96$. The second half of treatment (Sessions 8-13) consisted of neutral to low-positive videos (e.g., observing cityscape, sitting under waterfalls) (valence: $M = 5.76$, $SD = .25$; arousal $M = 2.91$, $SD = .89$). Neutral-positive videos were intended to train participants' ability to identify the positive aspects of even neutral situations.

VR Recall. After viewing the VR scenes, participants were prompted to recall a scene from the VR experience and write about it by 1) using the present tense, as if they were experiencing it through their own eyes, 2) going through the entire scene from beginning to end, and 3) describing in detail any positive sights, sounds, sensations and emotions they experienced. Participants completed the written recounting by typing into Qualtrics, and there was no time limit for the duration of the written recounting. After recounting the scene, participants then listened to a six-minute pre-recorded mindfulness-based guided recall to savor positive emotions and mentally highlight details from the VR scene.

Autobiographical Memory (AB) Recall. To further personalize the treatment and translate skills to situations outside the VR environment, participants subsequently recounted a positive autobiographical memory following similar instructions. For this task, participants were prompted to recall a positive experience from their own lives based on three positively-valenced cue words (e.g., *smile, happy, hug*). Instructions for the recall were identical to those of the VR recall. Upon completion, participants listened to a similar mindfulness-based guided recall for the autobiographical memory.

Text analysis

Written recounting of VR scenes and positive autobiographical memories were analyzed using Linguistic Inquiry Word Count 2015 (LIWC; Pennebaker et al., 2001) for emotional tone, positive emotion words, negative emotions words, first-person pronouns, and perception words. Positive emotion (e.g., happy, excited), negative emotion (e.g., sad, anxious), first-person pronouns (e.g., I, me, mine), and perception words (e.g., see, feel, hear) were calculated by dividing the number of words in the respective category by the total word count of the passage, creating a percentage (e.g., 6 would represent 6% of the text consists of positive emotion words). Emotional tone is a LIWC summary variable calculated as the difference between positive emotion words and negative emotions words (Cohn et al., 2004; Monzani et al., 2021).

Emotional tone is a standardized score ranging from 0-100, with higher scores representing more positive tone, 50 representing neutral or ambiguous tone, and lower scores representing negative tone.

To assess detail, all written recounting were manually coded by three research assistants who were trained on the Autobiographical Interview (AI) coding scheme and achieved excellent inter-rater reliability on the training dataset of practice memories (ICCs = .92-.98) and who met weekly as a group along with the first author to discuss consistency in coding. Coded variables included internal detail (number of episodic details relevant to the event), external detail (semantic information, repetitions, or editorializations not relevant to the event), and episodic richness (an overall rating given from 0 = no episodic information to 6 = rich in detail, containing at least 2 elaborations, and evokes an impression of true re-experiencing).

Inter-rater reliability was good to excellent for internal detail (ICCs = .863 - .956) and for episodic richness (ICCs = .794.- .923); however, reliability was poor to moderate for external detail (ICCs = .264.- .623). Proportion of episodic detail, one of the most commonly used metrics, is calculated as internal / (internal + external detail); therefore, we could not calculate this metric using the manually coded data. Instead, we used a natural language processing automated scoring program (van Genugten & Schacter, 2022; https://github.com/rubenvangenugten/autobiographical_interview_scoring) based on the Autobiographical Interview (Levine et al., 2002) to calculate internal detail, external detail, proportion of episodic detail, which were used in the final analyses. Because no there was no episodic richness rating produced by the automated program, the manually scored episodic richness rating was retained.

Outcome measures

The Mood and Anxiety Symptoms Questionnaire – Anhedonic Depression Subscale (MASQ-AD 14 Item, Watson, Clark, et al., 1995; Watson, Weber, et al., 1995). As the primary outcome measure, this questionnaire includes a 14-item anhedonic depression subscale, which was designed to measure the low levels of positive affect unique to depression. Individuals indicate how frequently they have experienced a variety of different symptoms during the past week. The MASQ demonstrates excellent convergent and discriminant validity (Reidy & Keogh, 1997; Watson, Weber, et al., 1995) and excellent reliability (Geisser et al., 2006).

Positive and Negative Affect Schedule (PANAS, Watson et al., 1988). The 20-item questionnaire measures trait negative affect (PANAS-N) and positive affect (PANAS-P) and has adequate psychometric properties (Crawford & Henry, 2004). Participants rate how they felt during the past week on a scale from 1 (very slightly/not at all) to 5 (extremely).

Depression Anxiety Stress Scales (DASS-21; Brown et al., 1997). The 21-item questionnaire measures depression (DASS-D; e.g., dysphoria, hopelessness, self-deprecation, lack of interest/involvement, anhedonia inertia), anxiety (DASS-A; e.g., situational anxiety, anxious affect, autonomic arousal), and stress (DASS-A; e.g., difficulty relaxing, nervous arousal, being easily upset/agitated, irritable/overreactive, and impatient). Participants rate the degree to which statements apply to them over the past week using a scale from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time). The DASS has strong construct validity (Shea et al., 2009) and good to excellent internal consistency (Antony et al., 1998). The PANAS and DASS were administered during in-person lab visits at pre-treatment (before session 1), mid-treatment (after session 7), and post-treatment (after session 13).

Statistical Analyses

Change in linguistic variables across treatment. To assess whether features of VR and AB recounting change across sessions, data were analyzed using multilevel modeling (MLM) using Stata version 17.0. In the mixed model the dependent variable was the linguistic variable and the fixed factor was Session (1 through 13).

Relationship between change in linguistic variables and clinical outcomes. To assess whether changes in linguistic characteristics during VR and AB recounting corresponded with symptom improvement, individual slopes were extracted for all linguistic variables for each participant using SPSS version 27 for subsequent use in a regression coefficient analysis (RCA) (Pfister et al., 2013; Pulverman et al., 2015). Slopes were then entered as an interaction term in multilevel models using Stata's mixed command. In the mixed model the dependent variable was the clinical outcome, the fixed factor was Time (pre, mid, post), and linguistic slopes (across all thirteen sessions) were entered as a covariate. Primary outcomes were trait positive affect (PANAS-P) and anhedonia (MASQ-AD). Secondary outcomes were negative affect (PANAS-N) and total depression, anxiety, and stress symptoms (DASS-tot).

Results

Missing data

Within the MVR-RT group, participants completed an average of 10.5 out of 13 possible sessions (*SD* = 2.59). Of 286 possible sessions that could have occurred (if 22 participants completed 100% of sessions), 19.6% of the written recounting data was missing due to the participant not having completed the self-guided session (n = 56 total missing sessions, with 11.7% missing from the first half of treatment and 38.9% missing from the second half of treatment). For the VR recalls, a total of 230 sessions from 22 participants were included in analyses. After quality inspection of data, one participant (10 sessions) was excluded due to not writing about an autobiographical memory (instead wrote about a different virtual reality scene), leaving a total of 21 participants in the autobiographical recall analyses with 220 sessions. There was no significant difference between high session completers (defined as completing at least 5/7 sessions during the first half and 4/6 sessions during the second half, n = 18) versus low session completers (n = 4) on clinical outcomes at pre-, mid- or post-treatment (*p*s >.05). Whereas all participants completed pre- and mid- clinical assessments, 4 participants did not complete the post-treatment assessment (n = 1 of the high session completers and n = 3 of the low session completer), making it more likely for participants with low session completion to also have missing post-treatment clinical outcome data.

Change in Linguistic Variables Across Treatment

Virtual Reality Recalls. Multilevel modeling revealed significant effects of Session for tone ($X^2(1) = 105.28$, $z = 10.26$, $p < .001$) and perception words ($X^2(1) = 8.23$, $z = 2.87$, $p = .004$), such that these variables increased across the thirteen sessions. Internal detail decreased across sessions ($X^2(1) = 9.73$, $z = -3.12$, $p = .002$) as did episodic richness ($X^2(1) = 21.15$, $z = -4.60$, $p < .001$). There were no significant changes in positive emotion words ($X^2(1) = 1.11$, $z = 1.05$, $p = .29$), negative emotion words ($\mathrm{X}^2(1) = 0.02$, $z = 0.15$, $p = .88$), first-person pronouns ($X^2(1) = 2.63$, $z = -1.62$, $p = .10$), external detail ($\mathrm{X}^2(1) = 0.03$, $z = -0.17$, $p = .86$), or proportion of episodic detail ($X^2(1) = 1.59$, $z = -1.26$, $p = .21$).

Figure 3a

Mean Tone During VR Recall Across Sessions

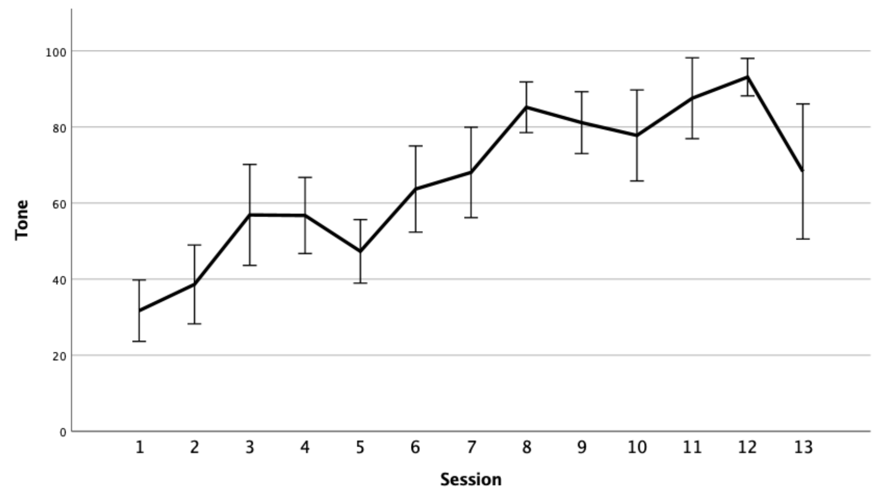


Figure 3b

Mean Perception Words During VR Recall Across Sessions

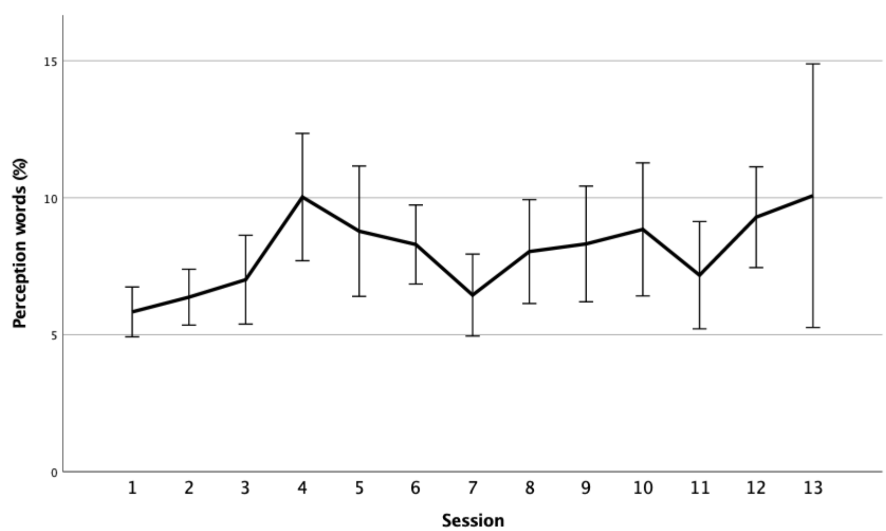


Figure 3c

Mean Episodic Richness During VR Recall Across Sessions

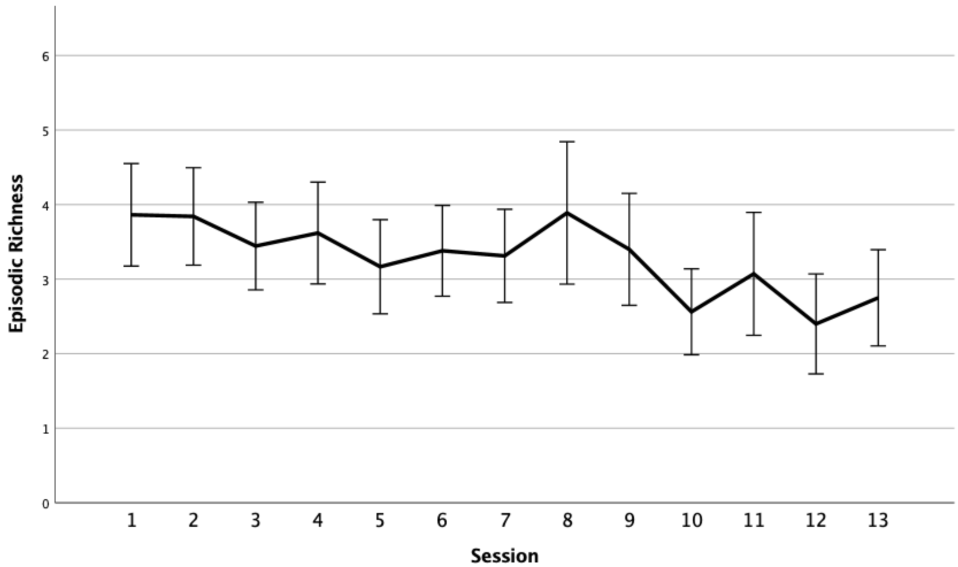
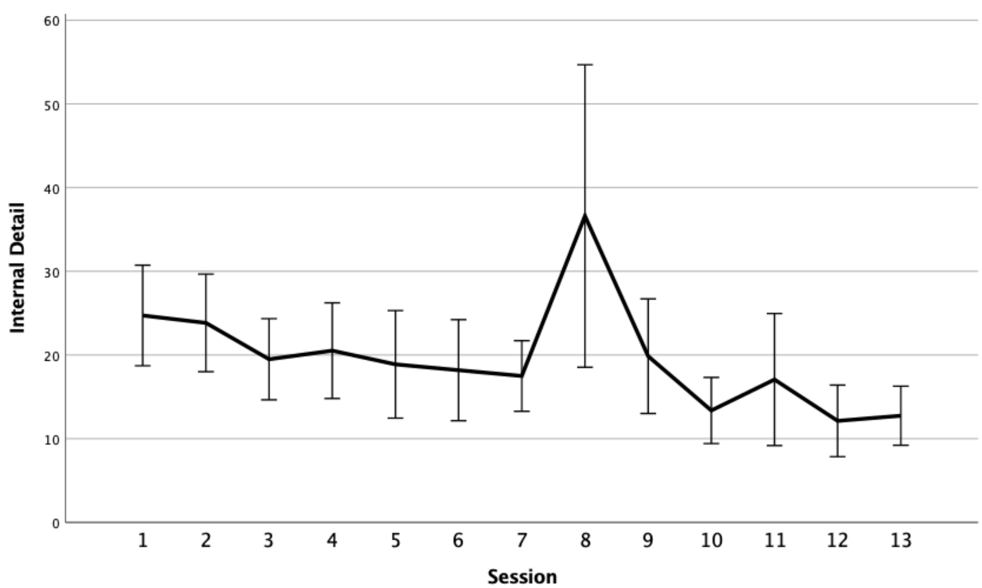


Figure 3d

Mean Internal Detail During VR Recall Across Sessions



Note. Error bars represent standard error.

Autobiographical Memory Recalls. For autobiographical recalls, tone increased across sessions ($X^2(1) = 4.38$, $z = 2.09$, $p = .036$) and negative emotion words decreased across sessions ($X^2(1) = 5.74$, $z = -2.40$, $p = .017$). Internal detail ($X^2(1) = 6.80$, $z = -2.61$, $p = .009$) and episodic richness ($X^2(1) = 13.66$, $z = -3.70$, $p < .001$) decreased across sessions. There were no significant changes in positive emotion words ($X^2(1) = 0.65$, $z = 0.80$, $p = .42$), perception words ($X^2(1) = 2.10$, $z = -1.45$, $p = .15$), first-person pronouns ($X^2(1) = 0.01$, $z = -0.03$, $p = .97$), external detail ($X^2(1) = 0.67$, $z = 0.82$, $p = .41$), or proportion of episodic detail ($X^2(1) = 1.27$, $z = -1.13$, $p = .26$).

Figure 4a

Mean Tone During Autobiographical Recall Across Sessions

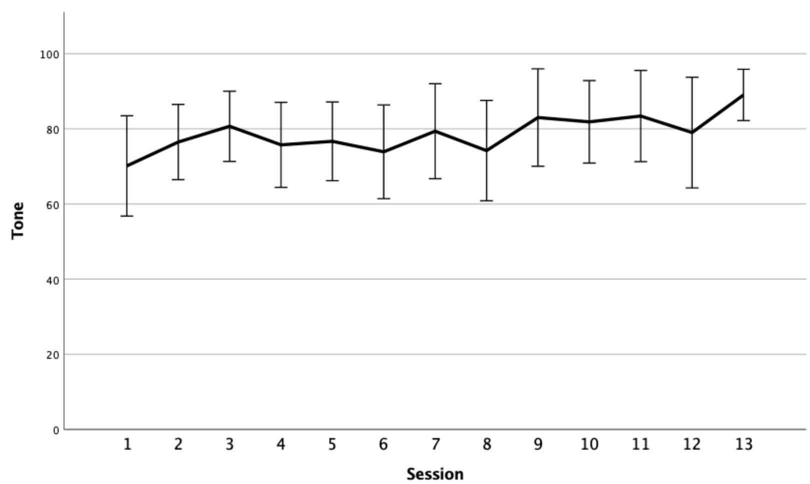


Figure 4b

Mean Negative Emotion During Autobiographical Recall Across Sessions

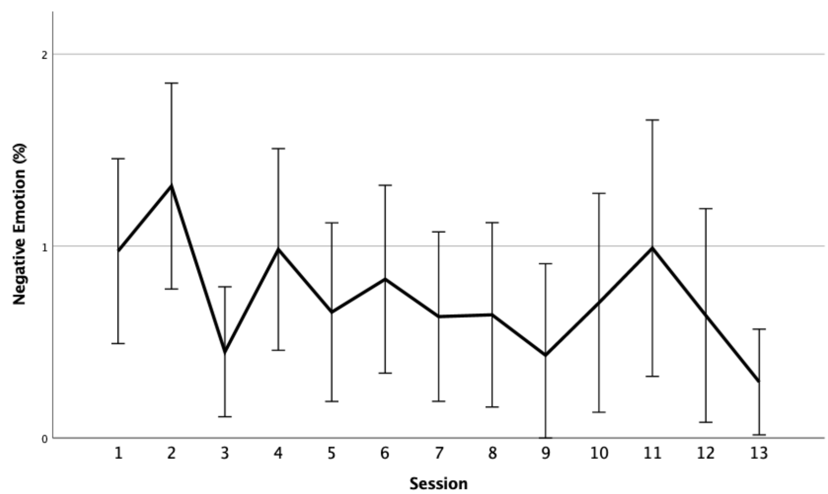


Figure 4c

Mean Internal Detail During Autobiographical Recall Across Sessions

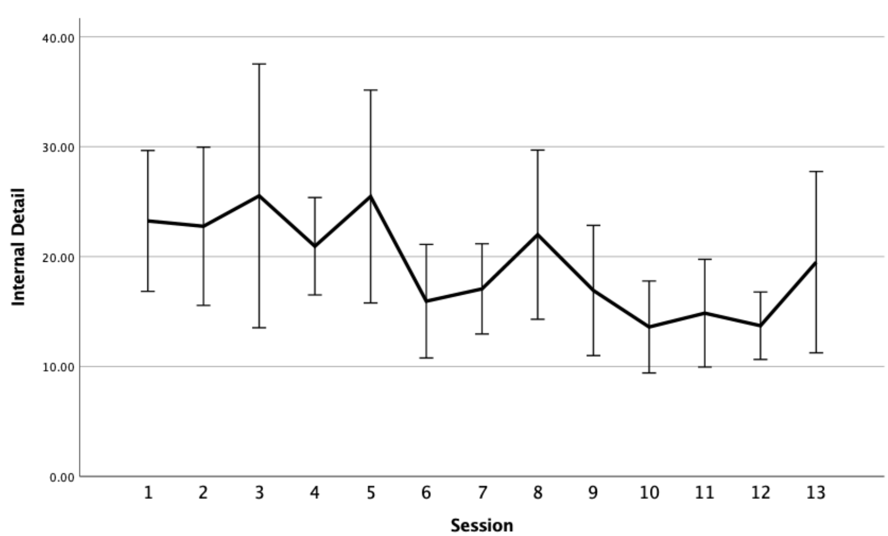
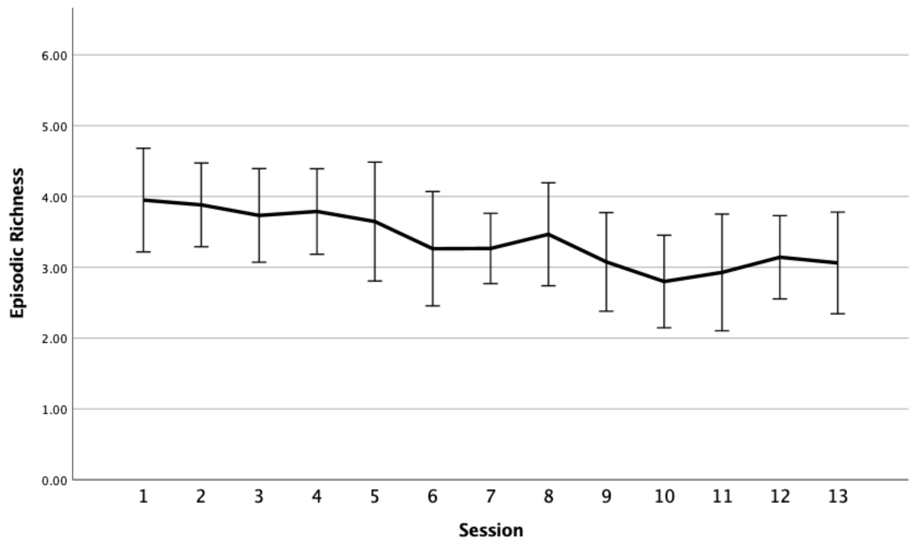


Figure 4d

Mean Episodic Richness During Autobiographical Recall Across Sessions



Note. Error bars represent standard error.

Relationship between Change in Linguistic Variables and Clinical Outcomes

VR Recalls. There was a marginally significant Time by perception word slope interaction, such that increases in perception words related to decreases in total symptoms ($X^2(3) = 24.18$, $z = -1.95$, $p = .051$). Increases in proportion of episodic detail related to decreases in anhedonia ($X^2(3) = 6.69$, $z = -2.25$, p = .025). The slopes for tone, positive emotion words, negative emotion words, internal detail, external detail, and episodic richness were not associated with change in any clinical outcomes (*p*'s > .05). Exploratory analyses were conducted on the DASS subscales individually, and revealed a significant interaction between Time and positive emotion slopes, such that greater increases in positive emotion words throughout sessions related to decreases in stress ($X^2(3) = 29.48$, $z = -2.10$, $p = .036$).

AB Recalls. Increases in first-person pronouns were associated with decreases in total symptoms ($X^2(3) = 27.56$, $z = -2.12$, $p = .034$). Increases in episodic richness were associated with increases negative affect ($X^2(3) = 33.61$, $z = 3.17$, $p = .002$). Similarly, increases in internal detail were associated with increases in negative affect ($X^2(3) = 35.74$ $z = 3.41$, $p = .001$). The slopes for tone, positive emotion words, negative emotion words, perception words, external detail, and proportion of episodic detail were not associated with change in any clinical outcomes (p's > .05). Exploratory analyses on individual DASS subscales revealed similar patterns in which increases in episodic richness ($X^2(3) = 36.89$, $z = 2.06$, $p = .030$) and increases in internal detail ($X^2(3) = 36.60$, $z = 2.05$, $p = .041$) were associated with increases in stress.

Discussion

The current study investigated the hypothesis that written recounting of positive virtual reality scenes and autobiographical memories would become more positive, immersive (first-person pronouns and perception words), detailed and episodically rich across treatment with MVR-RT, and that these changes would relate to better symptom outcomes. These hypotheses were only partially supported. For both VR and autobiographical recounting, emotional tone became increasingly positive, in part driven by decreased negative emotion words; however, the degree of change did not correspond to clinical improvement. Contrary to hypotheses, neither positive emotion words nor first-person pronouns (a measure of immersion) increased significantly across sessions. However, the extent to which positive emotion words and first-person pronouns increased related to decreases in stress and total symptoms, respectively. Surprisingly, internal detail and episodic richness decreased across treatment, which may be explained by challenges with limited engagement during written recountings due to the self-guided nature of MVR-RT. Participants who displayed greater increases in internal detail and episodic richness also had increases in negative affect. In contrast, increases in the *proportion* of episodic detail (internal/total detail) were associated with decreases in anhedonia. Taken together, this pattern of findings suggests that MVR-RT enhanced positive emotional tone as intended, and there may be a benefit to keeping recountings “short and sweet.” Conclusions are curbed by several limitations, discussed below.

Change in linguistic variables

Emotional tone became increasingly positive and contained more perception words, especially for VR recalls. At minimum, these findings serve as a manipulation check to verify that participants were following instructions to focus the recounting on rewarding, sensory details of the VR experience. For autobiographical recalls, tone also increased across sessions while negative emotion words decreased across sessions, suggesting that participants were better able to shift the valence away from negatives when writing about their own memories. Surprisingly, positive emotion words did not increase across sessions for VR or AB recalls, and there did not appear to be a ceiling effect as in Study 1 (see General Discussion). The emotional tone LIWC variable is calculated by subtracting the negative emotion from positive emotion words (Cohn et al., 2004). Therefore, increases in emotional tone appear to be driven more so by negative emotions decreasing rather than positive emotions increasing. This finding complements emerging evidence that treatments designed to target the Positive Valence System (Positive Affect Treatment, VR-RT, AMP, PASS) impact negative affect as well as or instead of positive affective outcomes (Chen et al., 2021; Craske et al., 2019; Kryza-Lacombe et al., 2021; Taylor et al., 2017) (for a review see Sandman and Craske, 2022). Future research should elucidate the mechanisms of change in these treatments and investigate whether change in positive affective outcomes precede negative affective outcomes or vice versa.

First-person pronouns also did not increase across sessions, which we predicted as an index of field perspective or immersion based on prior experimental research (Mcisaac & Eich, 2002). However, the degree of increase in first-person pronouns during autobiographical recounting related to decreases in total symptoms. On the one hand, this finding supports our hypothesis and could mean that greater field perspective relates to better outcomes. On the other hand, this result should not be overinterpreted since, as in Study 1, first-person pronouns may not accurately capture the construct of field perspective and are likely highly dependent on valence. For instance, within the autobiographical recounting, first-person pronouns were significantly positively correlated with both positive and negative emotion words (Table S2 in Supplement). In this way, it is possible that using more self-focused language is associated with greater emotion word use regardless of valence, which is in turn may relate to more clinical improvement. Notably, these relationships are correlational in nature and future research should elucidate the meaning of first-person pronoun use across positive and negative contexts and clarify the direction of potential causal relationships.

Drawing from memory specificity training interventions (MEST) which target overgeneral memory in depression (Raes et al., 2009), MVR-RT sought to enhance memory specificity for rewarding experiences by instructing participants to elaborate on as many details as possible in the recounting. We hypothesized that MVR-RT would result in increases in internal detail, episodic richness, and proportion of episodic detail, and would lead to decreases in external non-episodic detail. Contrary to predictions, internal detail and episodic richness decreased across sessions for both VR and AB recalls. This finding could be understood due to limited control over fidelity of recounting due to the self-guided nature of the treatment. Participants may have become less likely to include detail over time related to decreased interest.

As is common with self-guided digital interventions for depression (Himle et al., 2022), there was a low completion rate especially during the second half of treatment, resulting in substantial missing linguistic data during sessions 8-13 as well as some missing clinical data at post-treatment. This may be in part due to the relatively poor quality of the VR available on mobile devices as well as the passive 360 degree scenes that were used in the current study; higher quality VR with interactive scenes may improve engagement.

Relationship between change in linguistic and clinical variables

Although emotional tone became more positive for both VR and AB recalls, the degree of change did not correspond to clinical improvements. It is unknown why changes in positive emotions did not relate to primary outcomes of positive affect or anhedonia or secondary outcomes of negative affect or total symptoms. Exploratory analyses conducted on individual symptom subscales revealed that increases in positive emotion related to decreases in stress for VR recalls. Stress has been implicated as a potential causal pathway for the development of anhedonia (Pizzagalli, 2014). Positive affect has been proposed as a buffer for stress by activating reward-related neural networks which in turn dampen threat-related regions (e.g., anterior cingulate, insula, amygdala) (van Steenbergen et al., 2021). Treatments for anhedonia that target positive affect may exert effects through several pathways including 1) directly increasing reward-related processes, which in turn reduces negative affect, 2) reducing stress and negative affect which indirectly improve anhedonia, or 3) changing both positive and negative processes simultaneously with complex interactions between the two (for a discussion see Sandman and Craske, 2022). While the current study cannot speak directly to which of these possibilities is more likely, it is possible that reductions in stress may emerge before changes in anhedonia, which should be tested in future longitudinal research or clinical trials with longer periods of follow-up.

In line with hypotheses, perception words significantly increased across treatment for VR recountings, and the extent to which corresponded with improvements in total symptoms, although this finding was marginal ($p = .051$). This finding may suggest that improvements in one's ability to retrieve sensory details is related to decreases in clinical outcomes, at least for depression, anxiety, and stress. This relationship is complementary with the literature on the benefits of experiential processing of pleasant stimuli for mood (Gadeikis et al., 2017; Nelis, Holmes, Palmieri, et al., 2015), although these studies have found this effect for pleasant autobiographical memories. It is unknown why our finding was limited to VR and not autobiographical recounting. Especially since perception words did not increase for autobiographical recounting across the course of MVR-RT, it is possible that more practice is needed to transfer the skill of recalling sensory details to one's own memories for that ability to confer a clinical benefit.

A complex relationship emerged between detail and clinical outcomes. Overall, internal detail and episodic richness decreased across treatment; however, for autobiographical recounting, the degree of increase in internal detail and episodic richness related to increases in negative affect and stress. It should be noted that these measures of detail do not reflect valence, so it may also be possible that those who experienced greater negative affect and stress were writing about negative experiences in detail. This pattern only emerged for autobiographical and not VR recounting, which could reflect self-referential processing specific to writing about one's own personal experience. It is also possible that participants who continued to experience a higher degree of stress and negative affect were the ones who continued to persist in providing many the self-guided treatment as opposed to those who discontinued, who may have improved.

Increases in the *proportion* of episodic detail for VR recounting related to decreases in anhedonia. It could be that it is not the *number* of total internal details but the overall balance of relatively greater episodic vs non-episodic detail that could relate to clinical benefit, at least for anhedonia. However, this finding should not be overinterpreted because the same pattern did not extend to other clinical outcomes or appear in the autobiographical recountings. Taken together, there may be a benefit of keeping recountings "short and sweet," given that 1) decreases in detail (internal detail and episodic richness) related to better outcomes, and 2) the proportion of episodic detail related to improvements in anhedonia, and 3) increases in positive emotions related to decreases in stress. Future experimental research could disentangle the relative importance of valence versus detail by manipulating these variables directly. It would also be important for future work to consider non-linear relationships, especially to determine whether level of episodic detail might follow a quadratic relationship, with moderate levels of detail conferring the greatest benefit.

Limitations & Future Directions

The current study has several limitations which mitigate the generalizability and reliability of the results. First, there was a small sample size (n=22), which was further reduced due to substantial missing data especially during the second half of treatment. Challenges with engagement and dropout were likely due to the self-guided nature of treatment as well as the relatively poor quality of the VR available on mobile devices compared to Oculus Rift, as used in a previous trial of VR-RT (Chen et al., 2021). Reduced sample size decreased statistical power and our ability to detect small effects, which are common with linguistic variables (Nook et al., 2022).

Due to the self-guided nature there was limited control over the fidelity of the imaginal recounting exercises. Participants did not receive feedback on their skills at recalling the virtual reality scene in detail, nor their ability to translate these skills to their autobiographical memories. On the one hand, the lack of coaching may contribute not only to decreased levels of engagement but also limited longer-term effects given that improvements in clinical outcomes faded by post-treatment. On the other hand, this prevented ceiling effects as observed in Study 1, since the initial levels of tone, positive emotion, and detail were much lower in MVR-RT than in PAT (see Table 1 in General Discussion for a comparison). After an initial self-guided recounting, an additional recounting could be further scaffolded by having coaches or therapists guide participants' recounting aloud in real time, as is done in PAT (Craske et al., 2019) and an ongoing trial of VR-RT.

The current study compared MVR-RT to a wait list control; therefore we could not compare changes in linguistic features of imaginal recounting due to the lack of written exercises completed in the control group. Future research should involve comparison with an active treatment group, particularly one matched on cognitive load and memory training. The current study's analyses were also correlational in nature and causal conclusions cannot be drawn about language use causing clinical outcomes or vice versa. Experimental studies should directly test whether labeling positive emotions serves to increase (label-feedback hypothesis; Lindquist, 2017) or dampen (disruption theory; Lieberman, 2011) the positive affective experience.

Linguistic variables were analyzed individually using commonly used metrics from LIWC. More advanced natural language processing approaches such as BERT (Alaparthi & Mishra,

2020) sentiment analysis could be used to better assess emotional tone. In addition, future work could be used to include multiple variables into an algorithm to predict clinically meaningful change (e.g., a "positive immersion" measure could combine positive valence, first-person pronouns, and sensory details). For measures of detail, we were unable to use several manually-coded Autobiographical Interview variables due to poor inter-rater reliability. Instead, we used a recently developed automated version to score detail. While the automated variables had a high degree of correlation with the reliable manually coded variables, it should be noted that the automated scoring program has not been widely validated. Future research should continue to explore which methods of assessing episodic detail and memory specificity are appropriate and sensitive to tracking clinical change over time.

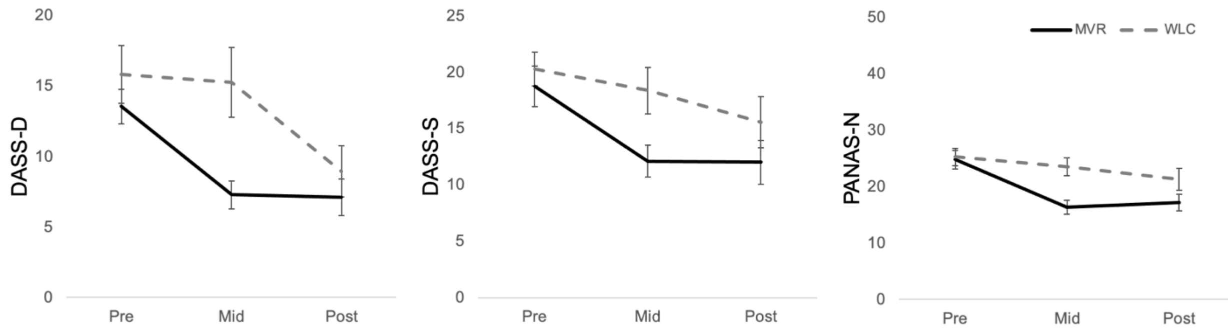
Supplement

Clinical Outcomes in MVR-RT vs WLC

Compared to wait-list control, MVR-RT led to greater reduction in depression, stress, and negative affect by mid-treatment; however, these effects largely disappeared by post-treatment (Figure S1). There were no between group differences in change in anhedonia, positive affect, or anxiety. Within the MVR-RT group, state negative affect (PANAS-N Short Form) decreased across the 13 sessions as well as from before to after each session (Figure S2). There was no change in state positive affect (PANAS-N Short Form) across or within sessions.

Figure S1

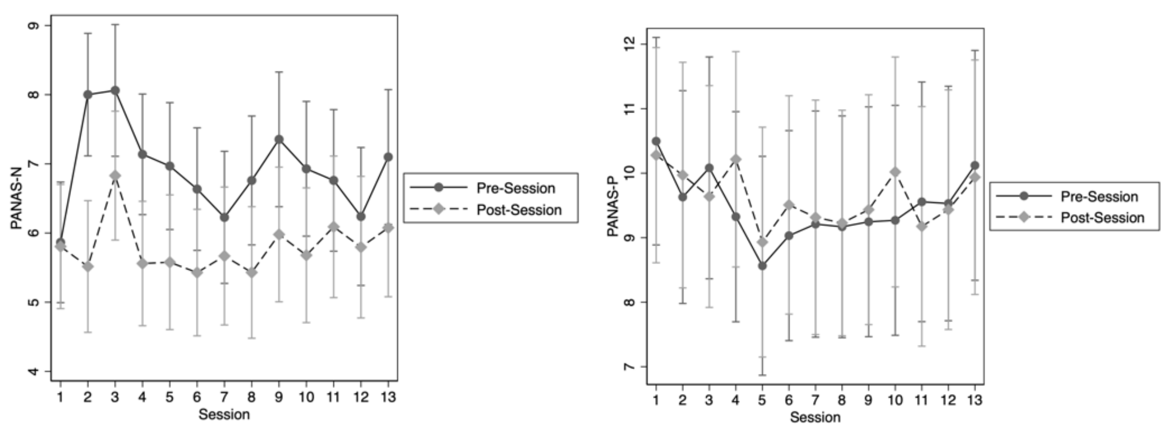
Changes in Depression, Stress, and Negative Affect in MVR vs. WLC



Note. Error bars represent standard error.

Figure S2

Mean Positive and Negative Affect Before and After Sessions



Note. Error bars represent standard error.

Table S1

Correlations Among Linguistic Variables During VR Recounting Collapsed Across Session

	tone	posemo	negemo	i	percept	int	ext	pe	erich
tone	–								
posemo	.063	–							
negemo	-.047	-.030	–						
i	-.012	.262**	.163*	–					
percept	.097	.168*	-.196*	.139*	–				
int	-.074	-.294**	.130*	-.178**	-.166*	–			
ext	-.060	-.113	.095	-.030	-.102	.171*	–		
pe	.045	-.020	-.234**	-.144*	.102	.139*	-.693**	–	
erich	-.130	-.365**	.083	-.198**	-.207**	.798**	.183**	.152*	–

Note. * *p* <.05, ** *p* <.01. tone = emotional tone, posemo = positive emotion words, negemo = negative emotion words, i = first person pronouns, percept = perception words, int = internal detail, ext = external detail, pe = proportion of episodic detail, erich = episodic richness.

Table S2

Correlations Among Linguistic Variables During Autobiographical Recounting Collapsed Across Session

	tone	posemo	negemo	i	percept	int	ext	pe	erich
tone	–								
posemo	.535**	–							
negemo	-.263**	-.083	–						
i	-.030	.148*	.137*	–					
percept	.069	.216**	-.016	.175*	–				
int	-.228**	-.309**	.046	.122	-.087	–			
ext	-.029	-.053	-.016	-.025	-.199**	.187**	–		
pe	-.104	-.105	-.030	-.030	.249**	.243**	-.689**	–	
erich	-.219**	-.378**	.195**	-.224**	-.087	.780**	.107	.309**	–

Note. * *p* <.05, ** *p* <.01. tone = emotional tone, posemo = positive emotion words, negemo = negative emotion words, i = first person pronouns, percept = perception words, int = internal detail, ext = external detail, pe = proportion of episodic detail, erich = episodic richness.

STUDY 3

Experiential vs. Analytical Processing of Positive Autobiographical Memories and Future Events on Affect, Dampening, and Meaning

Introduction

"I get this feeling whenever I feel good, it'll be the last time."

– Phoebe Bridgers (example of a dampening appraisal)

The first two studies were correlational in nature, and therefore causal conclusions cannot be drawn about how features of imaginal recounting impact affect and clinical outcomes. Therefore, the current study experimentally manipulated different methods of recounting positive autobiographical memories. Characteristics of imaginal recounting assessed in Studies 1 and 2 fall conceptually within two modes of processing: experiential and analytical (see Table 1).

Table 1

Hypothesized Relationships Between Linguistic Features and Processing Mode

Experiential (Concrete/Imagery)	Analytical (Abstract/Verbal)
Positive emotion words (LIWC) More positive emotional tone (LIWC) Field perspective (greater first-person pronouns; LIWC) Greater perception words (LIWC)	Fewer positive emotion words (LIWC) Less positive emotional tone (LIWC) Reduced field perspective (fewer first-person pronouns; LIWC) Fewer perception words (LIWC)
More internal detail (event, time, perception, emotion/thought; AI) Less external detail (semantic, editorializations; AI)	Less internal detail (event, time, perception, emotion/thought; AI) More external detail (semantic, editorializations; AI)

Note. LIWC = Linguistic Inquiry Word Count; AI = Autobiographical Interview

Experiential vs. Analytical Processing Mode

Processing mode, or the way in which one recalls or imagines an experience, can influence positive emotion, and potentially impact the success of therapeutic exercises in a clinical setting. Experiential processing mode, also referred to as concrete/imagery-based processing, is defined as non-judgmental attention to sensory and bodily experience as it unfolds in a specific situation (e.g., sights, smells, sounds) (Nelis, Holmes, Palmieri, et al., 2015; Watkins et al., 2008). In contrast, analytical processing mode, also referred to as abstract/verbal processing, involves a conceptual and evaluative way of thinking about the meaning, causes, and consequences of an event (Watkins et al., 2008).

Several studies have examined the impact of processing mode during positive autobiographical recall on affective experience, with mixed findings. For example, after a negative mood induction, recalling a positive memory using experiential compared to analytical processing resulted in sad mood repair in depressed participants (these studies did not measure positive affect; Werner-Seidler & Moulds, 2012, 2014). However, in another study that measured positive affect, both experiential and analytical processing increased happiness after a sad mood induction compared to a distraction control condition (Hetherington & Moulds, 2015). All of these studies took place in the context of a negative mood induction, which may impact results of subsequent processing mode inductions.

Two studies have since examined processing mode on positive memory recall without induced negative mood (Gadeikis et al., 2017; Nelis, Holmes, Palmieri, et al., 2015). In healthy sample, both spontaneous and instructed use of experiential processing increased happiness compared to analytical and distraction conditions (Gadeikis et al., 2017). Similarly, concrete/imagery (akin to experiential) versus abstract/verbal processing (akin to analytical) led to a greater increase in positive affect in a non-clinical sample; however, a follow-up experiment in the same article (Study 2) failed to replicate this effect (Nelis, Holmes, Palmieri, et al., 2015). Instead, both concrete/imagery and abstract/verbal instructions led to an increase in positive affect compared to a third comparative/verbal condition, that involved making comparisons between one's current and past self at the time of the happy memory. Perhaps unsurprisingly, higher depressive symptoms correlated with less positive mood change in the comparative/verbal condition due to making unfavorable comparisons with a previously more positive state, consistent with the notion that only self-concordant positive memories have beneficial effects in clinically depressed individuals (Werner-Seidler et al., 2017).

The lack of neutral control group in Nelis et al., 2015 makes it difficult to determine whether effects were driven by negative components of comparative/verbal thinking or by potentially positive aspects of abstract/verbal condition, as instructions may have unintentionally encouraged positive abstraction (i.e., medical students were instructed to reflect upon the causes of successful performance after passing a medical school entrance exam, which was rated as a highly meaningful event). The authors speculated that abstract/verbal processing in and of itself may not necessarily be problematic, but rather it may increase the likelihood of drawing negative comparisons in some individuals. Experiential processing, on the other hand, may be less likely to trigger negative thoughts. Indeed, abstract but not experiential processing led to greater generation of negative evaluations/generalizations during positive memory recall among high but not low dysphoric participants (Hetherington & Moulds, 2015). Further, among individuals with high trait dampening (tendency to use mental strategies to reduce positive mood), positive affect was better maintained after using concrete/imagery compared to abstract processing during positive memory recall (Nelis, Holmes, Palmieri, et al., 2015).

Mixed findings highlight the need to elucidate under what circumstances positive memory recall is beneficial, especially for anhedonic individuals, which have implications for the emerging field of "memory therapeutics" (Dalgleish & Werner-Seidler, 2014) as well as improving outcomes for behavioral activation/pleasant event scheduling through in-session consolidation of reward learning. Two candidates that might determine the impact of processing mode during episodic thinking include 1) dampening appraisals, and 2) deriving positive meaning.

Future episodic thinking

Given that anhedonia is also characterized by deficits in reward anticipation (Borsini et al., 2020; Treadway & Zald, 2011), often presenting as difficulty with motivation to engage in activities, recently developed interventions also target prospection for future events. For example, Future Specificity Training led to greater increases in anticipatory pleasure and likelihood of engagement in future activities (Hallford et al., 2020). Whether experiential processing of past events transfers to the way in which future events are imagined has not been tested in an anhedonic sample. In healthy samples, recalling past experiences using an episodic style (similar to experiential) increases vividness when imagining future events (Madore & Schacter, 2014; 2016; Madore, Jing, & Schacter, 2018). Guided episodic thinking of either memories or future events increased anticipatory pleasure and intention to engage in future activities to a similar extent in a non-clinical sample (Hallford et al., 2020). However, it is unknown whether experiential processing of positive memories translates to the way in which future events are imagined among individuals with anhedonia.

Positive emotion regulation: dampening & amplifying

While the field of emotion regulation has typically focused on managing negative affect, there is burgeoning interest in positive emotion regulation, or the ways in which individuals attempt to change the intensity or duration of positive emotional experience. Two main strategies include dampening appraisals (e.g., “this is too good to last”; “I don’t deserve this”) which serve to decrease positive affect, and amplifying appraisals (emotion-focus [EF], e.g., “I am feeling full of energy”; self-focus [SF], e.g., “I am living up to my potential”), which serve to intensify and prolong positive affect. Trait tendency to use dampening or amplifying appraisals is commonly measured through the Responses to Positive Affect (RPA) scale (Feldman et al., 2008). More recently, a scale that measures state appraisals of positive affect was developed (Dunn et al., 2018), which is an exciting avenue given calls for future research to use this approach (Nelis, Holmes, Palmieri, et al., 2015) to better understand positive emotion regulation in the moment.

In non-clinical samples, greater trait dampening and reduced amplifying (EF and SF) appraisals are associated with reduced positive affect (Kiken & Shook, 2014; Raes et al., 2009). In community samples, higher levels of dampening are associated with more severe depressive symptoms both concurrently (Nelis, Holmes, & Raes, 2015) and prospectively (Raes et al., 2012). Further, in depressed individuals, elevated dampening and reduced amplifying (EF) are linked to anhedonic symptoms cross-sectionally (Nelis, Holmes, & Raes, 2015; Werner-Seidler et al., 2013), even when controlling for other depressive symptoms (Werner-Seidler et al., 2013). Experimentally manipulating dampening and amplifying appraisals also impacts affective experience in the moment. Instructed use of dampening decreases positive affect and increases negative affect during pleasant activity scheduling (i.e., taking a walk in a nice location, Burr et al., 2017) and positive memory recall (Dunn et al., 2018). Instructed use of amplifying appraisals do not, on the other hand, change positive or negative affect relative to uninstructed control conditions (Burr et al., 2017; Dunn et al., 2018; Yilmaz et al., 2019).

Experiential Processing to Decrease Dampening

Dampening appraisals may be a key mechanism that drives anhedonia and could account for why clinical interventions that attempt to raise positive affect, such as behavioral activation, can sometimes have a limited effect (Dichter et al., 2009; Moore et al., 2013) or even backfire (Burr et al., 2017). To date, no studies have investigated 1) use of dampening appraisals in an anhedonic sample, and 2) ways to reduce dampening appraisals during pleasant memory recall in order to maximize positive affect. It has yet to be tested whether experiential processing may be a strategy to mitigate dampening appraisals and enhance positive affect. The current study tests whether processing mode (experiential vs analytical) during positive autobiographical recall impacts positive emotion and dampening appraisals in an anhedonic sample.

Meaning, Values, & Eudaimonia

A second factor that may impact whether processing mode impacts affective experience is deriving positive meaning or value. Thinking about why an event is meaningful, significant, or connected to one's values is a form of analytical/abstract processing that may have a beneficial effect on mood. Several studies found that abstract processing of positive memories increased positive affect as much as experiential processing (Hetherington & Moulds, 2015; Nelis, Holmes, & Raes, 2015). For instance, when medical students recalled a highly meaningful event of passing a medical school entrance exam in an abstract manner, positive affect increased. Authors speculated that instructions for the abstract condition may have been phrased to unintentionally encourage positive meaning (e.g. "what was the meaning of the event in your life; what does your performance said about your capabilities"). However, the hypothesis that abstract processing can have beneficial impacts on affect insofar as it encourages positive meaning has yet to be tested.

Identifying and behaving in line with one's values is a central component in Acceptance and Commitment Therapy (Hayes, 2004), which has been found to improve depression (Bai et al., 2020) and anhedonia among cancer patients (Baghmalek et al., 2020). Finding meaning from situations is also related to the phenomenon of post-traumatic growth, which has been linked to better mental and physical health outcomes (less depression and anxiety, more active coping) among people with serious medical conditions (Barskova & Oesterreich, 2009; Hefferon et al., 2009). Finding positive meaning specifically related to better adjustment in cancer survivors, and moderated the impact of intrusive thoughts on positive and negative affect (Park et al., 2010). In addition to benefits of finding meaning after distressing events, deriving meaning from positive events aligns with the concept of eudaimonic well-being. Eudaimonic well-being is defined as a sense of purpose, meaning, and satisfaction in life, and is associated with greater physical and psychological health benefits above and beyond hedonic well-being (pleasure and positive affect) (Cole et al., 2015; Fredrickson et al., 2013, 2015; Kitayama et al., 2016).

According to the Broaden & Build Theory, positive emotions serve the evolutionary function of broadening "thought-action repertoires" (Fredrickson & Branigan, 2005). As opposed to negative emotions, which narrow attention and behavior to address the threat at hand, positive emotions widen attention and promote behaviors that build resources and relationships. Broadened attention is even evident at the perceptual level, as measured by the global-local scope tasks, in which positive affect is linked to faster responses to global ("big picture") versus local (smaller detail) stimuli (Fredrickson, 2001; Fredrickson & Branigan, 2005).

Extending from this concept, the mindfulness-to-meaning theory posits that mindfulness enhances positive emotion regulation through facilitating decentering (non-judgmental observation), which broadens attention, which in turn enhances interoceptive awareness and savoring of hedonic experience, which leads to positive reappraisal, culminating a sense of meaningfulness and purpose in life (Garland et al., 2015, 2017). Considering that mindful awareness is conceptually overlaps with experiential processing, it is plausible that inducing experiential processing during positive memory recall would increase a sense of meaningfulness. On the other hand, in studies that found abstract processing to increase positive affect, instructions involved thinking about the "meaning" of an event (Hetherington & Moulds, 2015; Nelis, Holmes, Palmieri, et al., 2015). As such, the current study tests whether processing mode impacts participants' ability to derive positive meaning from memories, and whether a sense of meaning mediates the effect of processing mode on affect.

Study Aims

The current study builds upon prior work in several ways. First, given the relevance of dampening appraisals for positive emotion regulation, the current study examined state dampening using previously validated scales during positive memory recall (Dunn et al., 2018). Second, previous studies have not analyzed whether negative thoughts during memory recall relate to changes in affect, which would be important to verify insofar as reducing dampening appraisals should be a target for clinical intervention. Third, many studies include a sad mood induction followed by positive memory recall. Although this approach is useful to test emotion regulation from a negative mood state, the sad mood induction may confound effects on processing mode and appraisals. Therefore, the present study did not include a sad mood induction to better align with more recent studies and allow for replication (Gadeikis et al., 2017; Nelis, Holmes, Palmieri, et al., 2015). Fourth, purely between groups designs in which participants undergo a single instructed positive memory recall obscure the effect of mood induced from recalling a positive memory in and of itself versus using processing mode. A mixed within-between participants design (modeled off Gadeikis et al., 2017) was used to increase sensitivity to between-groups manipulation effects by first including an uninstructed memory recall followed by a second memory recall with processing mode induction. This way, individual differences in mood reactivity to the first memory recall can be controlled for statistically. Another advantage is the capacity to examine spontaneous processing mode and dampening appraisals before manipulating processing mode. Fifth, previous research on processing mode and dampening appraisals have been conducted in healthy or dysphoric/depressed samples more generally, rather than examining anhedonia specifically. The current study fills this gap by examining the impact of processing mode on affective and cognitive experience in an anhedonic sample. Lastly, we examined whether the way in which positive memories are recalled transfers to imagining future positive events, relevant to reward anticipation difficulties in anhedonia.

Aim 1: Effect of processing mode on affect. How does processing mode (experiential, analytical, control) impact affect during positive autobiographical memory recall in an anhedonic sample? *Hypothesis*: Experiential processing will increase happiness and decrease sadness compared to the analytical and control conditions.

Aim 2: **Effect of processing mode on dampening appraisals and positive meaning.** How does processing mode during positive memory recall impact the use of dampening appraisals and positive meaning? *Hypothesis*: Experiential processing will lead to fewer dampening appraisals during positive memory recall compared to the analytical condition. Based on the mindfulness-to-meaning theory (Garland et al., 2015), the experiential condition is hypothesized to construe greater positive meaning than the analytical condition.

Aim 3: **Mediation.** Do dampening appraisals and positive meaning mediate the relationship between processing mode and positive affect regulation success (increases in positive affect after positive memory recall)? *Hypothesis*: Dampening appraisals will mediate the relationship between processing mode and changes in positive affect before to after the 2nd memory recall, such that greater dampening appraisals will relate to smaller increases in positive affect. Positive meaning will mediate the relationship between processing mode and changes in positive affect, such that greater derived positive meaning after the 2nd memory recall will relate to greater increases in positive affect.

Aim 4: Effect of processing mode on attention. How does processing mode impact attention? *Hypothesis:* Based on the Broaden & Build theory, because the experiential condition is expected to increase positive affect to the greatest extent, it is also hypothesized to result in broadened attention after positive memory recall compared to the analytical and control conditions.

Aim 5: Effect of processing mode on prospection of a future positive event. Does the way in which one recalls a positive memory transfer to the way in which one imagines a future positive event? *Hypothesis*: Experiential processing of a future positive event will lead to greater anticipatory pleasure and behavioral intention compared to the analytical and control conditions.

Method

Participants

Participants were recruited from the UCLA undergraduate psychology department subject pool and compensated for participation with course credit. Prospective participants completed online pre-screening questionnaires and were invited to participate if they met initial eligibility criteria for elevated anhedonia (>21 on MASQ-AD 8-item subscale; this cutoff score can be used to screen for anhedonia consistent with clinically significant depression in an undergraduate population) (Bredemeier et al., 2010). Exclusion criteria were: younger than 18 years of age, not fluent in English, substance use disorder in the past 6 months, a lifetime history of bipolar disorder, psychosis, intellectual disability or organic brain damage. The UCLA Office for the Protection of Human Research Subjects approved all procedures (IRB#21-000441). An a priori power analysis using G*power (Faul et al., 2007) indicated that a sample size of 96 (32 per group) would be sufficient to detect a significant effect of processing mode condition on positive affect (primary dependent variable) with a medium to large effect size (d = .325 based on previous studies, e.g., Gadeikis et al., 2017) with a power of .80 and an alpha of .05. Of the 122 participants who completed Day 1, 15 participants did not complete Day 2 (no show or cancellation). 11 participants were excluded for unusable data (i.e., the future event nominated during Day 1 had already occurred before Day 2), leaving a total of 96 participants included in the analyses (Table 2).

Table 2

Sociodemographic Characteristics of Participants

	Experiential		Analytical		Control		Full sample	
	n	%	n	%	n	%	n	%
Sex								
Female	26	81.3	28	87.5	27	84.4	81	84.4
Male	6	18.8	4	12.5	5	15.6	15	15.6
Gender								
Female	25	78.1	28	87.5	27	84.4	80	83.3
Male	6	18.8	4	12.5	5	15.6	15	15.6
Nonbinary	1	3.1	0	0.0	0	0.0	1	1.0
Transgender identity	1	3.1	0	0.0	0	0.0	1	1.0
Cisgender identity	31	96.9	32	100	32	100	95	98.9
Race[a]								
Native American	2	6.3	2	6.3	2	6.3	6	6.3
Asian	9	28.1	16	50.0	15	46.9	40	41.7
Black	3	9.4	3	9.4	4	12.5	10	10.4
Pacific Islander	0	0.0	0	0.0	0	0.0	0	0.0
White	18	56.3	7	21.9	14	48.8	39	40.6
Other/None of the above	6	18.8	8	25.0	3	9.4	17	17.7
Multiple	4	12.5	3	9.4	2	6.3	9	9.4
Ethnicity								
Hispanic/Latinx	9	28.1	9	28.1	7	21.9	25	26.0
Non-Hispanic/Latinx	23	71.9	23	71.9	25	78.1	71	74.0

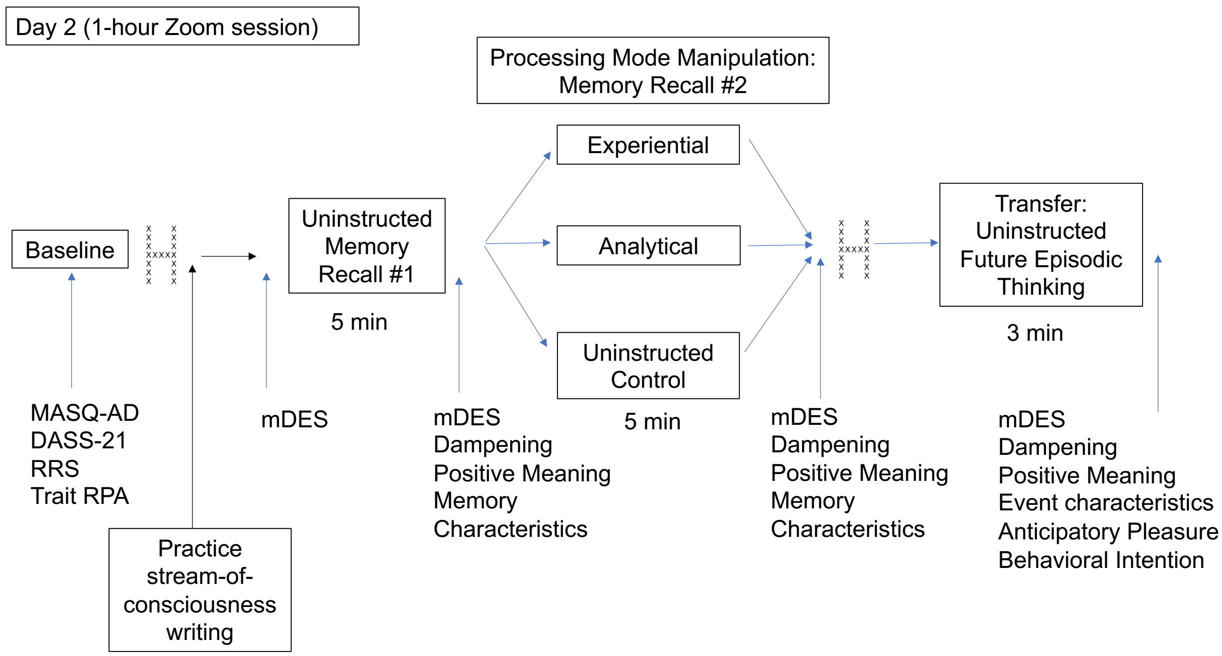
Note: N = 96 (n = 32 per condition). Participants were on average 20.4 years old (SD = 3.56), and age did not differ by condition ($p > .05$).

[a] The total percentage exceeds 100% because more than one race could be selected.

Study Design

Figure 1

Schematic of Experimental Procedure



Note. This figure depicts the experimental procedure during Day 2. MASQ-AD = Mood and Anxiety Symptom Questionnaire - Anhedonia Subscale; DASS-21 = Depression Anxiety and Stress Scales; RRS = Ruminative Response Scale; Trait RPA = Responses to Positive Affect; mDES = Modified Differential Emotions Scale (positive and negative affect). The "H" made of small "x's" represents the Navon Task.

Overview

On Day 1, which took place online at least 48 hours prior to the experimental session on Day 2, participants completed written informed consent, provided demographic information, and identified two positive autobiographical memories and one future positive event with corresponding cue words to be used during Day 2 (consistent with the procedure of Gadeikis et al., 2017 to ensure participants can identify relevant memories and to minimize pre-rehearsal of memories immediately before recall).

Day 2 consisted of an hour-long experimental testing session conducted remotely over Zoom due to the COVID-19 pandemic (Figure 1). Participants completed baseline questionnaires followed by the first set of affect ratings. Subsequently, participants completed the Navon task presented online using the PsyToolkit platform (Stoet, 2010, 2017) as a measure of global vs local attention bias (see details below). Next, participants practiced writing for one minute using a ‘stream of consciousness’ procedure to use in subsequent memory recalls, in which they were instructed to write whatever came to mind (see Supplement). Next, one of the participant’s cue words for a positive autobiographical memory provided during Day 1 was selected (order was counterbalanced) and presented on the screen. Participants completed the first uninstructed memory recall, using the written stream of consciousness approach for 5 minutes (Dalgleish et al., 2009; Gadeikis et al., 2017), and then completed a series of ratings (positive affect, negative affect, state dampening, positive meaning, experiential processing, analytical processing, field perspective, observer perspective, self-focus, self-concordance).

Participants were then randomized to one of three processing mode conditions: experiential processing, analytical processing, or a control condition (see description below). The condition corresponded to the instructions for the way in which the second positive autobiographical memory should be recalled. The second cue word was presented on the screen and participants again wrote for 5 minutes while recalling their second memory, followed by the same series of ratings as after the first memory recall. Next, the Navon task was completed for the second time. Finally, participants completed a future episodic thinking task, in which their cue word for an upcoming positive event was displayed and they were instructed to write for three minutes and imagine the event as they "naturally" would. Finally, participants completed a series of ratings identical to after the memory recalls with the addition of items assessing anticipatory pleasure and behavioral intention (see below). Lastly, participants were debriefed about the purpose of the study and offered a brief cool-down period to mitigate any potentially unpleasant emotions that might have arisen during the study (videos previously shown to induce positive mood in the short-term, Chen et al., 2021) as well as a list of mental health resources on campus to improve mood in the long-term.

Processing mode instructions

Processing mode instructions were adapted from prior studies on experiential and analytical processing (Hetherington & Moulds, 2015). In the experiential condition, participants were instructed to: "Try to build up a detailed image of the event, as if you were reliving the event and seeing it again through your own eyes. Imagine the event as vividly as possible, as if you were really there in that situation. What could you see around you? What could you hear? What could you feel, touch, and experience in that situation? What was happening around you? What happened immediately after the event? As before, I would like you to write down whatever comes into your mind when you imagine the memory in this way."

In the analytical condition, participants were instructed to: "Try to understand the event you described and think about the possible causes of the event, the meanings and implications of the event for you, and its consequences for you. Think in words about why the event happened as it did. Reflect and analyze the meanings, implications, and consequences. As before, I would like you to write down whatever comes into your mind when you think about the memory in this way."

In the control condition, participants were instructed to: "Take five minutes to recall this memory as you naturally would. As before, I would like you to write down whatever comes into your mind when you think about the memory."

For the future episodic thinking task, all participants were instructed to: "Take three minutes to think about this upcoming positive event as you naturally would. As before, I would like you to write down whatever comes into your mind when you think about the future event."

Measures

Screening Measure

The Mood and Anxiety Symptoms Questionnaire (MASQ-AD 8 Item, Watson, Clark, et al., 1995; Watson, Weber, et al., 1995). The anhedonia subscale includes 8-items designed to capture anhedonic symptoms such as low levels of motivation, energy, and positive emotion. Individuals rate the extent to which they have experienced symptoms during the past week from 1 (Not at all) to 5 (Extremely). The MASQ-AD 8-item subscale can be used to screen for anhedonia consistent with clinically significant depression in an undergraduate population using a cutoff score of 21 (Bredemeier et al., 2010). For the purposes of the current study, the suicidality item was removed due to ethical/risk issues, leaving 7 items. We retained the cutoff score of >21 due to evidence that removal of the suicidality item from a depression self-report measure the Patient Health Questionnaire (PHQ-9) only) minimally reduces sensitivity and does not affect specificity (Wu et al., 2020).

Baseline Questionnaires

The Mood and Anxiety Symptoms Questionnaire (MASQ-AD 14 Item, Watson, Clark, et al., 1995; Watson, Weber, et al., 1995). This questionnaire includes a 14-item anhedonic depression subscale, which was designed to measure the low levels of positive affect unique to depression. Individuals indicate how frequently they have experienced a variety of different symptoms during the past week. The MASQ demonstrates excellent convergent and discriminant validity (Reidy & Keogh, 1997; Watson, Weber, et al., 1995) and excellent reliability (Geisser et al., 2006).

Depression Anxiety Stress Scales (DASS-21; Brown et al., 1997). The 21-item questionnaire measures depression (DASS-D; e.g., dysphoria, hopelessness, self-deprecation, lack of interest/involvement, anhedonia inertia), anxiety (DASS-A; e.g., situational anxiety, anxious affect, autonomic arousal), and stress (DASS-A; e.g., difficulty relaxing, nervous arousal, being easily upset/agitated, irritable/overreactive, and impatient). Participants rated the degree to which statements apply to them over the past week using a scale from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time). The DASS has strong construct validity (Shea et al., 2009) and good to excellent internal consistency (Antony et al., 1998).

Ruminative Response Scales (RRS; Nolen-Hoeksema & Morrow, 1991). The RRS is a 22-item measure that assesses one's tendency to engage in rumination. Individuals rate how often they think or behave when feeling down, sad, or depressed from 1 (almost never) to 4 (almost always). It has good internal consistency and construct validity (Roelofs et al., 2006).

The Responses to Positive Affect (RPA; Feldman, Joormann, & Johnson, 2008). This 17-item measure was used to assess trait tendency to dampen or amplify positive emotional experience. Participants indicate how often they respond in a certain way when feeling happy, excited, or enthused from 1 (almost never) to 4 (almost always). The RPA has 3 subscales: dampening, self-focused positive amplification, and emotion-focused amplification.

State measures given after each writing task

Memory / future event characteristics. Single items were used to assess characteristics of the memory recalls or future episodic task including self-reported use of 1) experiential processing, 2) analytical processing, 3) field perspective, 4) observer perspective, 5) self-focus, 6) self-concordance. For experiential processing, participants rated to what extent they focused on sensory experience of the memory during recall from 1 (not at all) to 9 (extremely). For analytical processing, participants rated to what extent they thought about the causes, meanings, and consequences of the memory during recall from 1 (not at all) to 9 (extremely). Based off similar scales used in previous studies (Holmes, Lang, et al., 2008; Nelis, Holmes, Palmieri, et al., 2015), participants rated the degree of field perspective from 1 (totally not in first person) to 9 (completely first person) and observer perspective from 1 (totally not third person) to 9 (completely third person). Consistent with prior research (Gadeikis et al., 2017), self-focus was assessed to rule out the possibility that this variable accounts for condition differences. Participants rated how self- or externally- focused they were during the memory recall from 1 (entirely self-focused) to 9 (entirely externally focused). In addition, for self-concordance participants rated "whether you feel your current self is the same person as your past self in your memories" from 0 (absolutely a different person) to 100 (identical person) (consistent with Matsumoto and Mochizuki, 2018).

Positive and negative emotion. The Modified Differential Emotions Scale (mDES) (Fredrickson et al., 2003) was used to assess positive and negative emotions experienced during each writing task, with 10 items for positive emotions and 10 items for negative emotions. Based off the Broaden and Build Theory, this scale was chosen because it includes a range of both low and high arousal positive emotions. Participants rate the greatest amount they experienced each emotion during the memory recall/future episodic thinking task on a scale from 0 (not at all) to 4 (extremely).

State dampening appraisals. After each memory recall/future episodic thinking task, participants completed a state version of the Responses to Positive Affect questionnaire (RPA; Feldman et al., 2008) recently developed and validated by Dunn et al., 2018 for use during autobiographical memory recall, which was shown to have acceptable or better reliability. Only the 7-item dampening subscale (e.g., "remind yourself that these feelings won't last"; "think 'my streak of luck is going to end soon'") was used. Participants rated to what extent they engaged in dampening appraisals during each writing task from 1 (Almost never) to 4 (Almost always).

Positive meaning. A 5-item measure was created for this study (see Supplement) to assess a state sense of positive meaning during the writing tasks, due to a lack of previously existing measures. Two items assessing meaning and purpose in life were adapted from the Daily Meaning Scale (Steger et al., 2008), which has been used in daily diary studies to measure changes in meaning over time (Newman et al., 2018; Steger et al., 2008; Steger & Kashdan, 2013). Two items were adapted from the Mental Health Continuum Short Form (MHC; Keyes, 2006, 2002) to assess other dimensions of eudemonic well-being from Ryff's model such as positive relations to others and self-esteem (Ryff, 1995; Ryff & Keyes, 1995). One question ("How much do you feel connected to your values?") was created by the authors due to a lack of established measures that assess present moment awareness of connection to values (Barney, 2019). Participants rated the extent to which they felt the following way in the moment from 0 (Not at all) to 4 (Extremely).

Anticipatory pleasure and behavioral intention. Two items were drawn from prior research on future episodic thinking (Hallford et al., 2022). After the future event task, participants rated anticipatory pleasure ("How pleasant do you think it will be?") from 1 (little to no positive emotion) to 10 (the most), and behavioral intention to engage in the future event ("How likely is it that you will do this activity?") from 1 (not at all) to 10 (very likely).

Navon task.

The Navon task was administered online via Psytoolkit (https://www.psytoolkit.org/experiment-library/navon.html) (Stoet, 2010, 2017) and completed on participants' personal computers due to remote administration of the study via Zoom. The Navon task is a widely used measure of local versus global attention bias (Navon, 1977, 2003). Fifty trials were displayed that included global and local trial types. Participants were given up to four seconds on each trial to decide whether a target letter (H or O) was present at the global or local level by responding with a key press as quickly as possible while maintaining accuracy.

An attention bias score was calculated for each participant by subtracting the mean reaction time (RT) for global trials minus the mean RT for local trials (trials in which the participant made no response were excluded, consistent with Fockert et al., 2014). Therefore, a negative value indicates a global bias and a positive value indicates local bias. To assess change in attention bias from before to after the recalls, a difference score was calculated (post [mean global RT - mean local RT] - pre [mean global RT - mean local RT]). Negative values indicate increasingly global, or broadened attention bias, whereas positive values indicate increasingly local, or narrowed attention bias.

Statistical Analysis. Analyses were conducted using SPSS Version 27.

Manipulation checks. To assess whether instructions for the second memory recall successfully induced the intended processing mode, ANCOVAs were conducted on self-reported analytical and experiential processing ratings during the second memory recall as the dependent variables, condition (experiential, analytical, control) as the between-subjects factor, and rating during the first memory recall as a covariate. ANOVAs were conducted to rule out potential condition differences in self-focus and self-concordance ratings provided during memory recall #2. Independent samples t-tests were used to test the effect of counterbalancing for the order of the cue word presentation.

Linguistic variables. To assess whether hypothesized linguistic features correspond with processing mode, ANCOVAs were conducted on linguistic variables during the second memory recall as the dependent variable, controlling for the corresponding variable during the first memory recall as the covariate, and group as the between-subjects factor. Mirroring procedures in Studies 1 and 2, variables extracted from Linguistic Inquiry and Word Count software 2015 (LIWC; Pennebaker et al., 2015) count included positive emotion words, negative emotion words, emotional tone, first-person pronouns, and perception words, and variables extracted from the Autobiographical Interview automated scoring program (Genugten & Schacter, 2022) were internal detail and external detail.

Uninstructed memory recall #1. The uninstructed nature of the first memory recall provided an opportunity to investigate whether spontaneous use of processing mode corresponded with positive and negative affect, dampening, meaning, and imagery perspective. We conducted a series of regressions to test the hypothesis that experiential processing during the first memory recall would correspond with greater increases in positive affect, greater decreases in negative affect, less dampening, greater meaning, and greater use of field but not observer perspective. We also hypothesized that analytical processing would correspond with observer perspective and dampening appraisals, but made no predictions about relationships with positive and negative affect (since positive affect was still expected to increase after the positive memory recall) or meaning. Dampening was expected to correlate with less positive affect and greater negative affect. We made no a priori hypotheses regarding the relationship between meaning and dampening or imagery perspective.

Instructed memory recall #2. To test the impact of processing mode on affect, we conducted a series of ANCOVAs with positive and negative affect after the second memory recall as the dependent variable, condition (experiential, analytical, control) as the between subjects-factor, and affect from after the first memory recall as the covariate. Similarly, ANCOVAs were conducted to test whether processing mode impacted dampening and meaning, with dampening or meaning during second memory recall as the dependent variable, condition as the between-subjects factor, and dampening or meaning during the first memory recall as the covariate.

Mediation. To test whether dampening appraisals and positive meaning mediated the relationship between processing mode and change in positive affect, we conducted two separate mediation models using the PROCESS macro for SPSS Version 4.0 (Hayes 2012) using 5000 bootstrap samples. The mediator was either dampening or meaning ratings from the 2nd memory recall (M), and the dependent variable was positive affect rating after the 2nd memory recall (Y). Positive affect rating from after the first memory recall was entered as a covariate. We used the multicategorical option with indicator coding for the independent variable of condition (X_1 for analytical relative to control and X_2 for experiential relative to control), which is recommended for independent variables with more than two levels (A. F. Hayes & Preacher, 2014). A bias-corrected bootstrap confidence interval (CI) for the product of the a and b paths that does not include zero indicates a significant indirect effect.

Moderation. We tested whether baseline questionnaires assessing trait rumination (RRS), trait dampening (RPA), depression (DASS-D), and anhedonia (MASQ-AD 14-item) moderated the relationship between processing mode on positive and negative affect. To do so, we conducted separate moderation models using the PROCESS macro for SPSS Version 4.0 (Hayes 2012). The moderator was the baseline score (W) and the dependent variable was either the positive or negative affect rating after the 2nd memory recall (Y). The positive or negative affect rating from after the first memory recall was entered as a covariate. We used the multicategorical option with indicator coding for the independent variable of condition (X_1 for analytical relative to control and X_2 for experiential relative to control), which is recommended for independent variables with more than two levels (Hayes & Montoya, 2017).

Future Episodic Thinking Task. As a manipulation check, two ANOVAs were conducted with either self-reported experiential or analytical ratings after the future episodic thinking task as the dependent variable and condition as the between-subjects factor. Planned analyses were ANCOVAs with processing mode as the between-subjects factor, positive or negative affect after the future episodic thinking task as the dependent variable, and positive or negative affect before the task as the covariate. ANOVAs were the planned analyses for behavioral intention and anticipatory pleasure ratings after the future episodic thinking task as the dependent variable and condition as the between-subjects factor.

Navon task. To test the impact of processing mode on change in attention bias, an ANCOVA was conducted with post-attention bias score (mean RT for global trials minus mean RT for local trials) as the dependent variable, condition as the between-subjects factor, and pre-attention bias score as the covariate.

Results

Sample characteristics. Descriptive statistics for anhedonia, depression, anxiety, stress, trait rumination, and trait dampening are reported in Table 3. On average, the sample was characterized by depression in the extremely severe range (<14), anxiety in the extremely severe range (<10), and stress in the severe range (13-16.5). Scores did not differ between conditions for any measures (p >.05).

Table 3.

Sample characteristics

	Experiential		Analytical		Control		Full sample	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
MASQ-AD 14-item	48.78	8.89	50.06	11.62	45.25	11.39	48.01	10.78
DASS-D	14.50	8.44	15.6	11.07	13.00	7.08	14.39	8.89
DASS-A	11.62	7.57	11.00	8.21	9.18	6.48	10.60	7.45
DASS-S	17.06	7.64	15.94	9.99	14.94	8.44	15.97	8.69
RRS	54.75	13.22	53.55	14.68	51.96	14.51	53.42	14.04
RPA-Damp	18.25	5.03	19.03	5.25	18.34	5.05	18.54	5.07

Note: MASQ-AD 14-item = Mood and Anxiety Symptom Questionnaire Anhedonia Subscale; DASS-D = Depression Anxiety and Stress Scales - Depression Subscale; DASS-A = Depression Anxiety and Stress Scales - Anxiety Subscale; DASS-S = Depression Anxiety and Stress Scales - Stress Subscale; RRS = Ruminative Response Scale; RPA-Damp = Responses to Positive Affect – Dampening Subscale.

Manipulation checks. To assess whether instructions for the second memory recall successfully induced the intended processing mode, ANCOVAs were conducted on self-reported analytical and experiential processing ratings during the second memory recall as the dependent variables, condition (experiential, analytical, control) as the between-subjects factor, and rating during the first memory recall as a covariate. As intended, there was a significant effect of condition on experiential ratings ($F(2, 95) = 10.27$, p <.001), such that experiential ratings were greater in the experiential condition compared to the analytical condition ($t(62) = 3.64$, $p < .001$) and compared to the control condition ($t(62) = 4.19$, $p < .001$). Experiential ratings did not differ between the analytical and control conditions ($t(62) = .20$, $p = .84$). Similarly, there was a significant effect of condition on analytical ratings ($F(2, 95) = 13.41$, $p < .001$), such that analytical ratings were greater in the analytical condition compared to the experiential condition ($t(62) = 6.39$, $p < .001$) and compared to the control condition ($t(62) = 2.48$, $p = .016$). Analytical ratings were greater in the control condition compared to the experiential condition ($t(62) = 2.97$, $p = .004$). Taken together, the processing mode instructions were successful.

In line with prior studies (Gadeikis et al., 2017; Matsumoto & Mochizuki, 2018), we used ANCOVAs to test whether self-focus and self-congruence differed as a result of processing mode condition. There were no group differences for self-focus ratings ($F(2,95) = .002$, $p = .998$) or self-congruence ratings ($F(2,95) = .915$, $p = .400$), which allows us to rule out these variables for explanations of effects.

Independent samples t-tests were conducted to test whether counterbalancing order of the two positive memories cues provided on Day 1 impacted affect. There was no significant effect of counterbalancing order on positive affect after the first memory recall ($t(94) = .290$, $p = .733$) or second memory recall ($t(94) = -1.245$, $p = .216$).

Linguistic variables. Tests for skewness revealed that perception words were skewed, so this variable was adjusted using a 1 + log transformation, consistent with previous approaches with linguistic data (Schultheiss, 2013). Results for the relationship between linguistic variables and processing mode condition are displayed in Table 4. Contrary to hypotheses, there were no differences in any of the LIWC variables from the second memory recall as an effect of condition (ps > .05). For internal detail, an ANCOVA revealed a significant effect of condition

($F(2, 96) = 14.95$, p <.001). Pairwise comparisons using independent samples t-tests revealed that internal detail was greater in the experiential compared to the analytical condition ($t(62)$ = 3.63, p < .001) and control condition ($t(62) = 2.53$, p = .01). Internal detail not differ between the analytical and control condition ($t(62) = 1.46$, p =.15). There was also a significant effect of condition on external detail ($F(2, 96) = 23.12$, p <.001), such that external detail was greater in the analytical condition compared to the experiential condition ($t(62) = 6.41$, p < .001) and compared to the control condition ($t(62) = 4.45$, p < .001). External detail not differ between the analytical and control condition ($t(62) = 1.66$, p =.10).

Table 4

Relationships between linguistic features and processing mode

Experiential (Concrete/Imagery)	Analytical (Abstract/Verbal)
X Positive emotion words (LIWC) X More positive emotional tone (LIWC) X Field perspective (greater first-person pronouns; LIWC) X Greater perception words (LIWC) √ More internal detail (event, time, perception, emotion/thought; AI) √ Less external detail (semantic, editorializations; AI)	X Fewer positive emotion words (LIWC) X Less positive emotional tone (LIWC) X Reduced field perspective (fewer first-person pronouns; LIWC) X Fewer perception words (LIWC) √ Less internal detail (event, time, perception, emotion/thought; AI) √ More external detail (semantic, editorializations; AI)

Note. X indicates non-significance (p > .05). √ indicates significance (p < .05). LIWC = Linguistic Inquiry Word Count; AI = Autobiographical Interview

Uninstructed memory recall #1: Relationships among spontaneous processing mode, affect, dampening, meaning, and imagery perspective

Hypotheses were partially supported (Table 5). Greater spontaneous experiential processing was associated with greater increases in positive affect ($r(94)$ = .309, p = .002) and greater use of field perspective ($r(94) = .217, p = .034$). There was no correlation between spontaneous experiential processing and change in negative emotion, dampening, meaning, or observer perspective (ps > .05). Spontaneous analytical processing was correlated with greater dampening ($r(94) = .290, p = .004$) but was not significantly associated with change in positive or negative affect, meaning, or with field or observer perspective (ps > .05). Spontaneous use of dampening was associated with smaller increases in positive emotion following the memory recall ($r(94) = -.212, p = .039$) and less meaning ($r(94) = -.217, p = .034$), and was not associated with field or observer perspective (ps <.05). Meaning was positively associated with change in positive affect ($r(94) = .285, p = .005$) and was not associated with field or observer perspective (ps > .05). As expected, field and observer perspective were significantly inversely correlated ($r(94) = -.676, p < .001$), as were change in positive and negative affect ($r(94) = -.415, p < .001$).

Table 5

Correlations among variables from uninstructed memory recall 1

	Experiential	Analytical	PA	NA	Dampening	Meaning	Field	Observer
Experiential	–							
Analytical	-.101	–						
Δ PA	.309**	.023	–					
Δ NA	-.169	-.019	-.415**	–				
Dampening	-.027	.290**	-.212*	.040	–			
Meaning	.102	.167	.285**	-.191	-.217*	–		
Field	.217*	-.085	.026	-.047	-.015	.145	–	
Observer	-.138	.132	-.035	.023	.177	.005	-.676**	–

Note: * p <.05, ** p <.01. PA = positive affect; NA = negative affect; Field = field perspective; Observer = observer perspective

Instructed memory recall #2: Effect of processing mode on positive and negative affect

Positive affect. The ANCOVA revealed a significant effect of condition on positive affect ($F(2, 95) = 3.32, p = .04$), Figure 2. Pairwise comparisons using independent samples t-tests revealed that positive affect was greater in the experiential condition compared to the analytical condition ($t(62) = 2.76$, $p = .01$). Positive affect did not differ between the experiential and control condition ($t(62) = 1.66$, $p = .10$), nor between the analytical and control condition ($t(62) = .99$, $p = .33$).

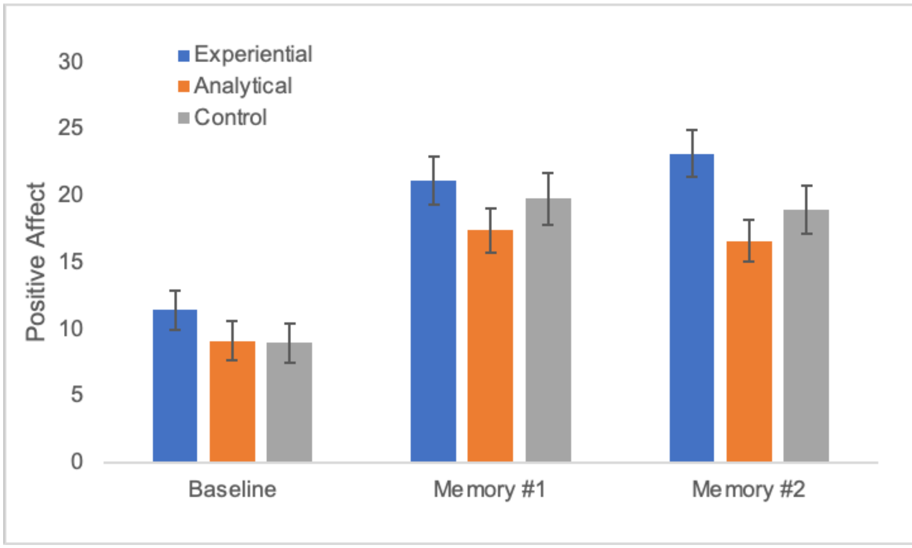
Paired-samples t-tests were used to investigate whether there was a significant change in positive affect within each condition from first to second memory. There was not a significant increase in positive affect from the first to second memory recall in the experiential ($t(31) = 1.66$, $p = .10$), analytical ($t(31) = .69$, $p = .49$), or control condition ($t(31) = .71$, $p = .48$).

Negative affect. There was no effect of condition on negative affect ($F(2,95) = 2.24$, $p = .11$), Figure 3. Planned pairwise comparisons using independent samples t-tests revealed that negative affect was lower in the experiential condition than the analytical condition ($t(62) = 2.02$, $p = .047$). Negative affect did not differ between the experiential and control condition ($t(62) = 1.38$, $p = .17$), nor between the analytical and control condition ($t(62) = .44$, $p = .66$).

Paired-samples t-tests were used to investigate whether there was a significant change in negative affect within each condition from first to second memory. There was no significant change in negative affect from the first to second memory recall in the experiential ($t(31) = 1.44$, $p = .16$), analytical ($t(31) = 1.04$, $p = .31$), or control condition ($t(31) = 1.62$, $p = .12$).

Figure 2

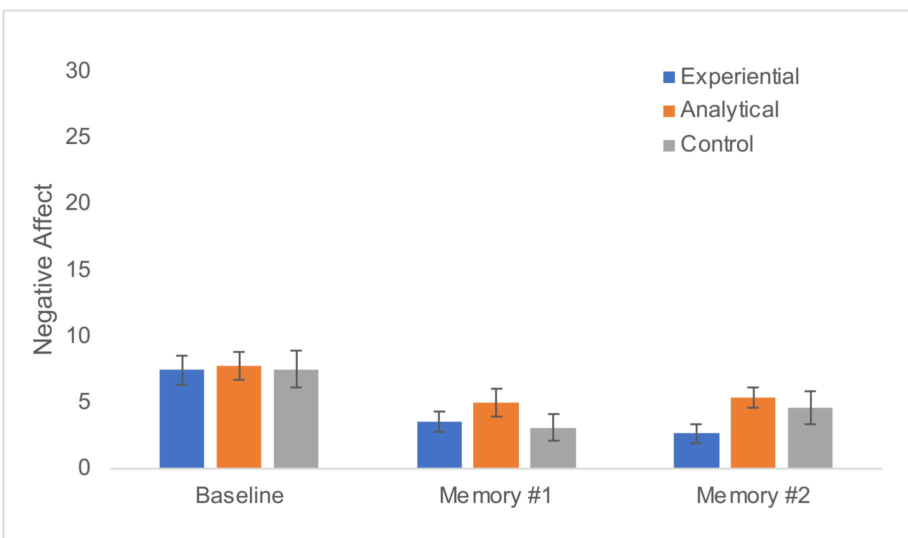
Positive Affect for Processing Mode Conditions



Note: Positive affect scores are shown for experiential, analytical, and control conditions at baseline and after the first and second memory recalls (error bars represent standard errors).

Figure 3

Negative Affect for Processing Mode Conditions



Note: Negative affect scores are shown for experiential, analytical, and control conditions at baseline and after the first and second memory recalls (error bars represent standard errors).

Effect of processing mode on dampening appraisals

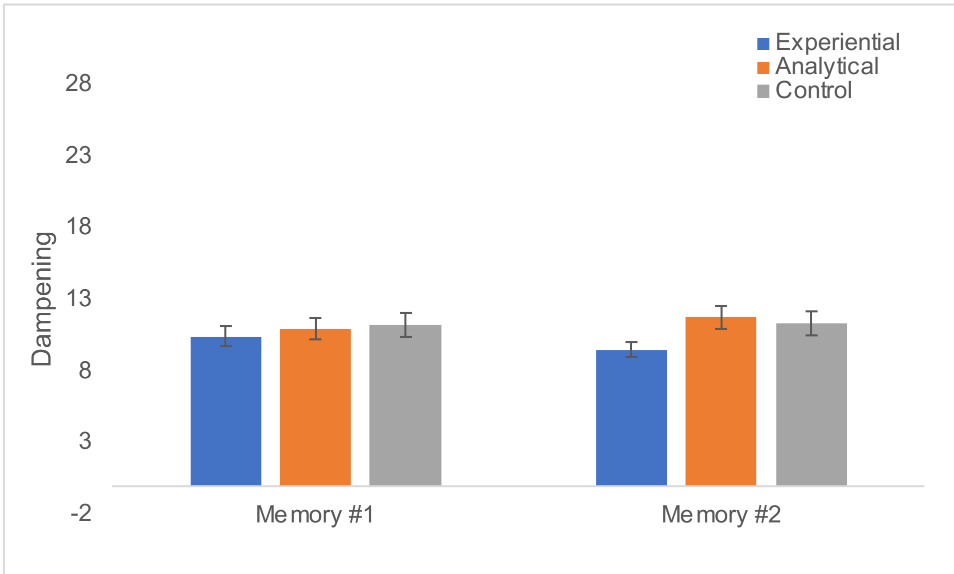
To test whether processing mode impacted dampening, an ANCOVA was conducted with dampening during second memory recall as the dependent variable, condition as the between-subjects factor, and dampening during the first memory recall as the covariate.

The ANCOVA revealed a significant effect of condition on dampening ($F(2, 95) = 3.34$, $p = .04$). Pairwise comparisons using independent samples t-tests revealed that dampening was significantly lower in the experiential condition compared to the analytical condition ($t(62) = 2.37$, $p = .02$). Dampening was marginally lower in the experiential condition compared to the control condition ($t(62) = 1.83$, $p = .07$). Dampening did not differ between the analytical and control condition ($t(62) = 0.36$, $p = .71$).

Paired-samples t-tests were used to investigate whether there was a significant change in dampening within each condition from first to second memory. There was no significant change in dampening from the first to second memory recall in the experiential ($t(31) = 1.50$, $p = .14$), analytical ($t(31) = -.81$, $p = .43$), or control condition ($t(31) = 0.15$, $p = .88$).

Figure 4

Dampening for Processing Mode Conditions



Note: State dampening scores are shown for experiential, analytical, and control conditions at after the first and second memory recalls (error bars represent standard errors).

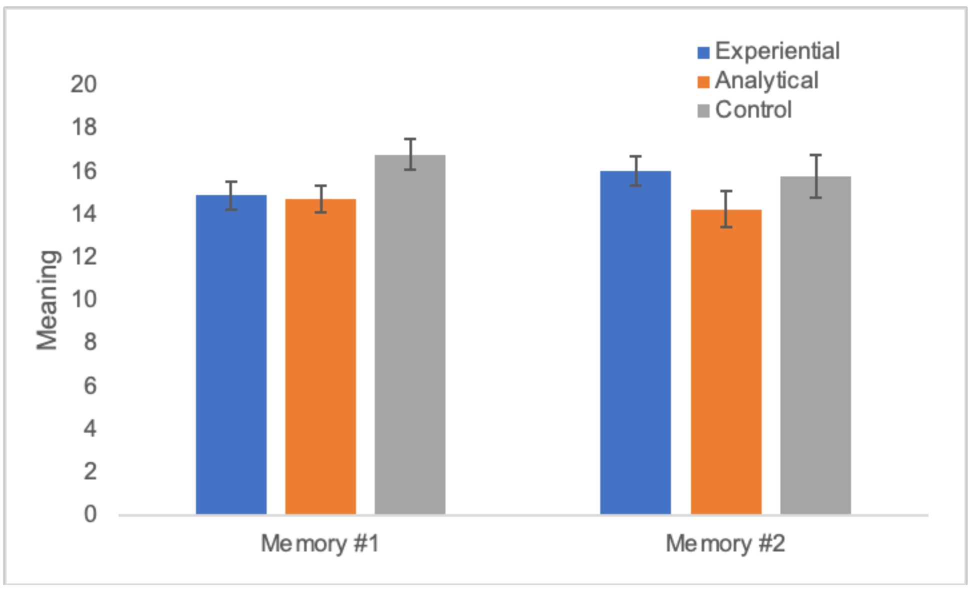
Effect of processing mode on positive meaning

To test whether processing mode impacted meaning, an ANCOVA was conducted with meaning after the second memory recall as the dependent variable, condition as the between-subjects factor, and meaning from after the first memory recall as the covariate. The ANCOVA revealed a marginal effect of condition on meaning ($F(2, 95) = 2.51$, $p = .08$). Planned pairwise comparisons using independent samples t-tests revealed that meaning was marginally greater in the experiential condition compared to the analytical condition ($t(62) = 1.67$, $p = .09$). Meaning did not differ between the experiential and control conditions ($t(62) = 0.21$, $p = .83$), nor between the analytical and control condition ($t(62) = 1.19$, $p = .24$).

Paired-samples t-tests were used to investigate whether there was a change in meaning within each condition from first to second memory. In the experiential group, there was a marginal increase meaning from the first to second memory recall ($t(31)= 1.79$, $p = .08$). There was no change in meaning in the analytical ($t(31)= 0.59$, $p = .56$) or control condition ($t(31)= 1.35$, $p = .19$).

Figure 5

Meaning for Processing Mode Conditions



Note: Meaning scores are shown for experiential, analytical, and control conditions at after the first and second memory recalls (error bars represent standard errors).

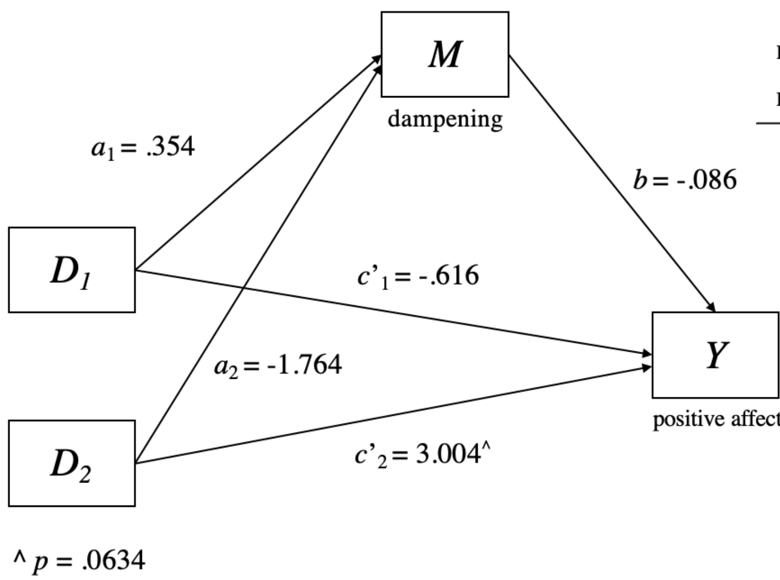
Mediation

Dampening. Coefficients for all paths of the mediation model are displayed in Figure 6. The estimated indirect effects had confidence intervals that contained zero (D_1: B = -.030, SE = .267, 95% CI [-.715, .442]; D_2: B = .151, SE = .386, 95% CI [-.517, 1.08]), suggesting that dampening did not significantly mediate the relationship between processing mode and positive affect. Mediation was not conducted for negative affect as the dependent variable due to the lack of the relationship between processing mode and negative affect found in previous analyses.

Meaning. Coefficients for all paths of the mediation model are displayed in Figure 7. The estimated indirect effects had confidence intervals that contained zero (D_1: B = -.607, SE = .732, 95% CI [-2.224, .730]; D_2: B = -.034, SE = .629, 95% CI [-1.284, 1.297]), suggesting that meaning did not significantly mediate the relationship between processing mode and positive affect.

Figure 6

Mediation Model of Processing Mode on Positive Affect Through Dampening

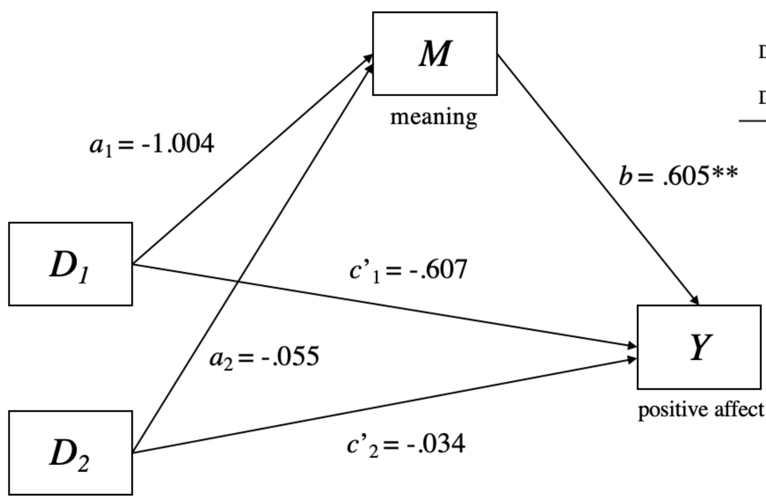


	Indicator Coding		
	Control	Analytical	Experiential
D_1	0	1	0
D_2	0	0	1

Note. Multicategorical mediation model of processing mode condition on positive affect after memory recall 2 through dampening, controlling for positive affect after memory recall 1.

Figure 7

Mediation Model of Processing Mode on Positive Affect Through Meaning



	Indicator Coding		
	Control	Analytical	Experiential
D_1	0	1	0
D_2	0	0	1

** $p < .001$

Note. Multicategorical mediation model of processing mode condition on positive affect after memory recall 2 through meaning, controlling for positive affect after memory recall 1.

Moderator analyses of trait measures

Results of the moderation analyses are reported in Table 6. For positive affect as the dependent variable, there were no significant interactions between X_1 or X_2 with rumination, trait dampening, depression, or anhedonia. Similarly, for negative affect as the dependent variable, there were no significant interactions between X_1 or X_2 and any of the baseline questionnaires.

Table 6

Moderated Regression Results

DV	Moderator	X	*B*	*SE*	*t*	*p*
Positive affect	MASQ-AD	X_1	-.042	.142	-.298	.766
		X_2	-.038	.153	-.231	.817
	RPA-damp	X_1	-.365	.313	-1.163	.248
		X_2	-.024	.317	-.074	.941
	RRS	X_1	-.048	.110	-.439	.661
		X_2	.110	.116	.948	.345
	DASS-D	X_1	-.174	.192	-.905	.367
		X_2	-.069	.209	-.332	.741
Negative affect	MASQ-AD	X_1	.183	.128	1.431	.156
		X_2	.093	. 147	.630	.530
	RPA-damp	X_1	.539	.273	1.975	.051
		X_2	.049	.222	.222	.825
	RRS	X_1	.057	.076	.756	.452
		X_2	-.107	.081	-1.323	.181
	DASS-D	X_1	.094	.163	.574	.567
		X_2	-.196	.177	-1.104	.273

Note. Indicator coding was used for the multicategorical independent variable of condition, such that X_1 represents analytical versus control conditions and X_2 represents experiential versus control conditions. DV = dependent variable; MASQ-AD = Mood and Anxiety Symptom Questionnaire – Anhedonia Subscale; RPA-damp = Response to Positive Affect – Dampening Subscale; RRS = Ruminative Response Scale; DASS-D = Depression, Anxiety, Stress Scale – Depression Subscale.

Future Episodic Thinking Task

Manipulation check. The future episodic thinking task was intended to test whether the processing mode for an autobiographical memory transferred to the way in which future events were prospected. As a manipulation check, two ANOVAs were conducted with either self-reported experiential or analytical ratings after the future episodic thinking task as the dependent variable and condition as the between-subjects factor. There was no effect of condition on experiential ($F(2, 95) = 1.307$, $p = .275$) or analytical ($F(2, 95) = .414$, $p = .662$) ratings during the future task. Therefore, the way in which participants were instructed to recall the second memory did not affect the way they imaged in the future positive event. Because the processing mode manipulation failed to transfer to the future episodic thinking task, we were unable to conduct originally planned analyses to test the impact of processing mode on affect, dampening, meaning, anticipatory pleasure, and behavioral intention.

Exploratory analyses. Because processing mode condition did not impact experiential/analytical ratings for the future episodic thinking task, we conducted exploratory analyses collapsing across condition to examine relationships among variables from the future episodic thinking task (self-reported processing mode, positive and negative affect, dampening, meaning, anticipatory pleasure, and behavioral intention) using linear regression (Table 7).

Table 7

Correlations for Variables from the Future Episodic Thinking Task

	Experiential	Analytical	PA	NA	Dampening	Meaning	AP	BI
Experiential	–							
Analytical	.229*	–						
PA	.449**	.022	–					
NA	-.197^	-.043	-.503**	–				
Dampening	.063	.271**	.074	.356**	–			
Meaning	.340**	.192^	-.084	-.158	-.167	–		
AP	.238*	.223*	.199	-.366**	-.053	.353**	–	
BI	.252*	.029	.148	-.207*	-.040	.161	.324**	–

Note. $^{**}p < .001$, $^{*}p < .05$, $^{\wedge}p < .10$. PA = positive affect; NA = negative affect, AP = anticipatory pleasure; BI = behavioral intention.

Experiential processing during the future episodic thinking task was significantly correlated with greater positive affect, greater meaning, greater anticipatory pleasure, greater behavioral intention, and lower negative affect at the level of a trend. Experiential processing was not associated with dampening. Analytical processing during future episodic thinking was significantly correlated with greater dampening, anticipatory pleasure, and meaning at the level of a trend. Analytical processing was not associated with change in positive or negative affect, or behavioral intention.

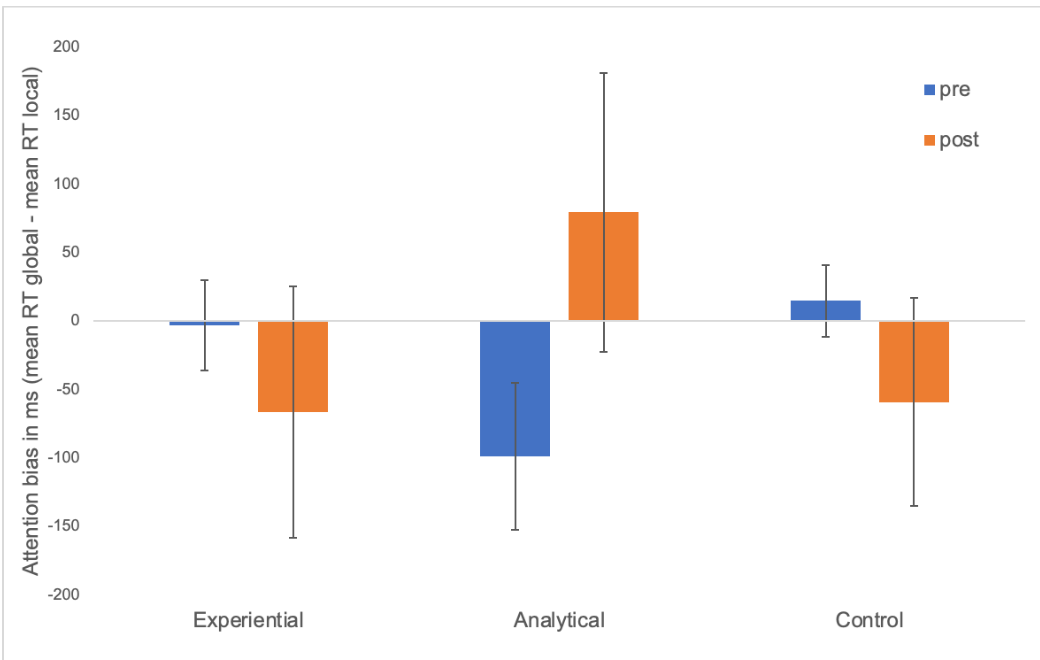
Dampening during the future event was correlated with greater negative affect, but did not correlate with positive affect, anticipatory pleasure, or behavioral intention. Meaning derived from the future event correlated with greater anticipatory pleasure but was not associated with change in positive or negative affect, or behavioral intention. Anticipatory pleasure and behavioral intention were positively correlated.

Navon Task: Impact of processing mode on attention

We hypothesized that processing mode would impact change in attention bias, such that the experiential group (expected to yield the greatest increase in positive affect) would demonstrate greater increases in global bias, consistent with Broaden and Build theory. Data from two participants in the analytical condition was unusable (one due to interruption during task and one due to corrupted data file), leaving 94 participants in the current analysis. To test the impact of processing mode on change in attention bias, an ANCOVA was conducted with post-attention bias score (mean RT for global trials minus mean RT for local trials) as the dependent variable, condition as the between-subjects factor, and pre-attention bias score as the covariate. Results are displayed in Figure 8. There was no main effect of condition ($F(2, 93) = 1.12, p = .33$). Planned comparisons using independent samples t-tests revealed no difference in change in attention bias between the experiential and analytical conditions ($t(60) = -1.06$, p = .29), experiential and control conditions ($t(62) = -.06$, $p = .95$), nor analytical and control conditions ($t(60) = 1.10$, $p = .27$). Paired samples t-tests revealed that attention bias changed in the analytical condition at the level of a trend ($t(29) = -1.74$, $p = .09$) in the direction of increasingly local attention bias. There was no change in attention bias within the experiential condition ($t(31) = .65$, $p = .51$) or control condition ($t(31) = .89$, $p = .37$).

Figure 8

Navon Task Reaction Times by Processing Mode Condition

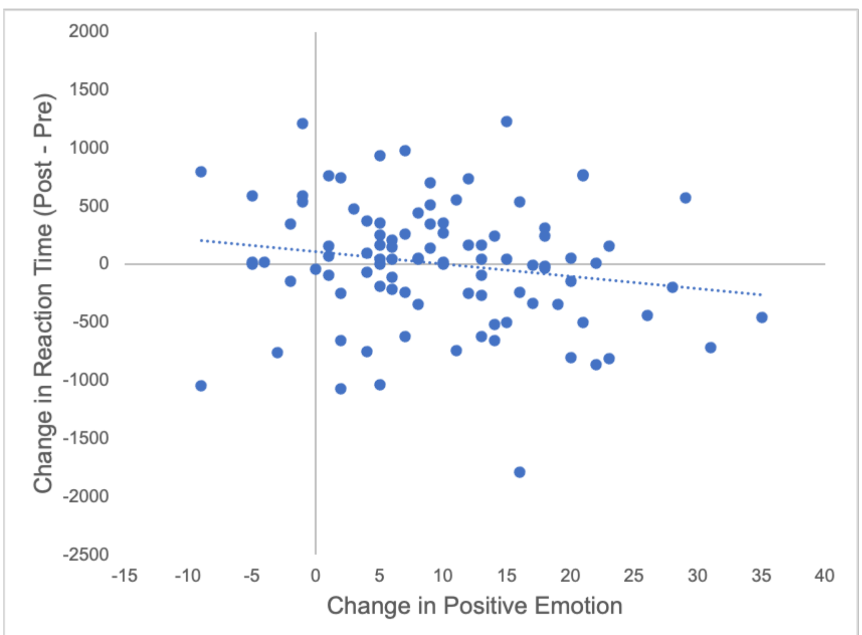


Note. Attention bias scores from the Navon Task (mean reaction time (RT) in milliseconds (ms) from global trials minus mean RT from local trials) are shown for experiential, analytical, and control conditions before memory recall 1 (pre) and after memory recall 2 (post). Error bars represent standard errors.

Exploratory analyses. To test the Broaden and Build Theory and to replicate prior work demonstrating a relationship between positive affect and broadened attention, we explored whether change in positive affect from before to after both memory recalls (uninstructed and instructed) correlated with change in attention bias, hypothesizing that greater increases in positive affect would correlate with increasingly global attention bias. Change scores were calculated for positive affect ratings (positive affect after memory recall 2 minus ratings before memory recall 1) and attention bias scores (post – pre). A bivariate correlation revelated that change in positive emotion was significantly correlated with change in attention bias ($r(94) = -.211$, $p = .041$), such that increases in positive affect were related to increases in global bias (Figure 9). Change in negative emotion from before to after both memory recalls was not correlated with change in attention bias ($r(94) = .147$, $p = .153$).

Figure 9

Correlation between Change in Positive Affect and Navon Task Reaction Times



Note: Relationship between change in positive emotion (before to after memory recalls) and change in reaction time on the Navon task (pre to post memory recalls). Negative values for change in reaction time represent increasingly global attention bias.

Discussion

The present study investigated the impact of experiential versus analytical processing of positive autobiographical memories and future episodic thinking on affective and cognitive experience in individuals with elevated anhedonia. Specifically, we tested whether experiential processing would enhance positive affect and meaning, and decrease negative affect and dampening compared to analytical processing and a control condition. Overall, we found evidence to support that both spontaneous and instructed experiential processing of positive memories may be beneficial for increasing positive affect and mitigating dampening appraisals, which has clinical relevance for improving treatments for anhedonia, such as augmenting behavioral activation via savoring. Neither dampening nor meaning mediated the relationship between processing mode and positive affect. There was no effect of processing mode on attention; however, greater increases in positive affect regardless of condition were associated with broadened attention. Lastly, when imagining a future positive event, both experiential and analytical processing were associated with anticipatory pleasure, but only experiential processing was associated with greater behavioral intention to engage in the future activity.

Spontaneous memory recall

The uninstructed nature of the first memory recall allowed us to examine how spontaneous use of experiential and analytical processing mode corresponded with change in affect, as well as spontaneous use of dampening appraisals and derived sense of positive meaning. Spontaneous experiential processing was associated with greater positive affect, consistent with previous findings in a healthy sample (Gadeikis et al., 2017). Neither experiential nor analytical processing was associated with change in negative affect, which may be because levels of negative affect were low to begin with. Spontaneous analytical, but not experiential, processing was associated with greater dampening, which was in turn associated with smaller increases in positive affect. Although this finding is correlational, this pattern is consistent with previous studies suggesting that analytical processing may be more likely to trigger negative thoughts (Hetherington & Moulds, 2015). Meaning was not associated with spontaneous use of either processing mode, but was associated with greater increases in positive affect, suggesting that regardless of how one recalled the memory, the degree of meaning was highly related to positive affect experienced. This pattern is consistent with daily diary studies that found greater daily meaning in life predicted positive affect (Miao et al., 2017).

Instructed memory #2: Experiential processing led to higher positive affect compared to analytical and control conditions.

Positive affect. Consistent with our primary hypothesis, instructed experiential processing of a positive autobiographical memory led to greater positive affect compared to analytical processing. This finding replicates previous research in healthy samples (Nelis et al., 2015; Gadeikis 2017), and extends them to individuals with elevated anhedonia specifically, which is important to verify for application in clinical contexts. This result supports the use of experiential processing via savoring into treatments for anhedonia as a way of promoting positive affect, which has been included as a component of several newly developed treatments (for a review see Sandman and Craske, 2022). For example, experiential processing can take the form of verbal or written reflection on pleasant activities from behavioral activation, as in Positive Affect Treatment (Craske et al., 2019) and Augmented Depression Treatment (Dunn, Widnall, Reed, Taylor, et al., 2019). Within each condition, there was a lack of significant change in positive affect after the second positive memory recall. This may be explained by ceiling effects, in that positive affect had already substantially increased from baseline to after the first memory recall.

Negative affect. Contrary to our prediction, there was no impact of processing mode on negative affect. It is possible that experiential and analytical processing do not differentially affect negative affective experience for individuals with anhedonia. Alternatively, floor effects may be another explanation, since negative affect was relatively low for all participants at baseline (mean mDES = 8/40) and was further reduced after the first positive memory recall. Floor effects also likely explain why negative affect did not change from before to after the second memory recall within each condition. Previous studies which first use a negative mood induction followed by positive autobiographical memory recall found that experiential and/vs analytical processing reduced negative affect to a greater extent (Werner-Seidler & Moulds, 2012, 2014). Because our design did not include a negative mood induction, it may have been more difficult to detect changes in negative affect.

Moderation by baseline traits and symptoms. Overall there was no evidence that trait rumination, trait dampening, anhedonia, or depression moderated the impact of processing mode on positive or negative affect. The lack of moderation is somewhat surprising given prior research that found analytical processing led to negative thought content for individuals with high but not low levels of dysphoria (Hetherington & Moulds, 2015). However, it should be noted that we recruited the current sample based on elevated levels of anhedonia. Therefore the null findings may be due to our sample being constrained to a relatively high symptom severity (e.g., mean depression scores fell in the extremely severe range, see Table 2). Future studies should recruit a more heterogenous sample (i.e., high and low rumination and anhedonia) to test whether different methods of processing positive emotional experiences are more advantageous for clients with certain symptom profiles compared to others.

Dampening. Instructed experiential processing resulted in less dampening compared to the analytical condition, and compared to the control condition at the level of a trend, whereas dampening did not differ between the analytical and control conditions. This finding suggests that experiential processing could serve as a beneficial strategy to mitigate dampening appraisals, which has clinical relevance for interventions for anhedonia. Because dampening can rob an individual from absorbing the benefit of pleasant activities, traditional behavioral activation can have a limited effect or event backfire by inducing negative feelings (Burr et al., 2017; Dichter et al., 2009; Moore et al., 2013). When clients become caught in negative thinking, such as dampening appraisals, therapist can guide clients to redirect their attention to focus on physical sensations and sensory details in order to reconnect with the positives. Recent treatments that take this approach have shown promise, such as in Positive Affect Treatment (Craske et al., 2019), which involves therapist-guided imaginal recounting to not only deepen positive emotions but also train attention. Contrary to our hypothesis, dampening appraisals did not mediate the relationship between processing mode on positive affect, which may be explained by being underpowered to detect mediational effects. It is also possible that there may be other potential mechanisms that explain why experiential processing leads to greater positive affect.

Meaning. Based on the Mindfulness to Meaning theory (Garland et al., 2017), we hypothesized that experiential processing, akin to mindful awareness of sensations, would result in a greater sense of meaning derived from the positive memory. Meaning was marginally greater in the experiential versus analytical condition, but did not differ compared to the control condition. This finding was in the expected direction, but should not be over-interpreted due to the lack of significance. The analytical condition was instructed to “Reflect and analyze the *meanings*, implications, and consequences” (emphasis added), which naturally may have caused participants to indeed connect with what was meaningful about their memories. Rather than mentioning meaning in the instructions, future studies could instead clarify the impact of imagery versus verbal processing of positive memories on a sense of meaning.

Meaning was strongly associated with positive affect, but did not mediate the relationship between processing mode and positive affect. This pattern of results is partially consistent with previous work that demonstrated that both analytical and experiential processing of highly meaningful events increased positive affect (Nelis, Holmes, Palmieri, et al., 2015). It may be that the content of the memory itself (e.g., wedding day versus an exercise class) is more important in determining meaning than the way in which the memory is recalled. One limitation of the current study is that we did not control for the content of memories, which future research may do by manipulating processing mode for memories that are matched in meaningfulness. In addition, future work could directly study why certain memories are more meaningful than others (e.g., by coding content for categories such as social, leisure, mastery), which is important to understand so that clinicians can guide clients to focus on the most meaningful memories. Cultural considerations are also important, given that interpersonal versus personal events are linked to happiness in collective versus individualistic cultures respectively (Uchida & Ogihara, 2012). Additionally, we created a measure of meaning, which has not been previously validated. It would be useful for future research to develop a scale to capture state connection to a sense of meaning, values, and eudaimonia.

Future episodic thinking

The processing mode instructions did not generalize to the way in which the future event was imagined, which suggest that further practice is needed to transfer these skills from a memory to a future event. In a clinical setting, specific instructions and guidance should be used to encourage imagining future events in from an experiential perspective, as is done in recently developed Future Specificity Training (Hallford et al., 2020, 2020), which resulted in increased anticipatory pleasure and likelihood of engagement in future activities. Interestingly, when we collapsed across condition, the degree of experiential and analytical processing were positively correlated with each other when imagining the future positive event, suggesting that these modes are not necessarily in opposition during prospection (as they were during the first uninstructed memory recall). Insofar as one is planning a future activity, it may be necessary to assume somewhat of an analytical stance by thinking about the “causes” (i.e., effort and logistics required to do the activity). Perhaps when imagining a future event, prospection relies in part on conceptual knowledge (e.g., scripts for events) that are first brought to mind, and then through a top-down approach, the experiential details are filled in (Schacter et al., 2017).

During the future event task, self-reported degree of experiential processing corresponded with greater positive affect and meaning whereas analytical processing was not, suggesting a potential benefit to imagining future positive events with attention to sensory details. The degree of analytical processing of the future event corresponded to greater dampening appraisals, consistent with the notion that thinking in the abstract may correspond with a greater likelihood of negative thoughts (Hetherington & Moulds, 2015); however this did not appear to correspond with poorer affective experience after imagining the future event. Surprisingly, the degree of both experiential and analytical processing of a future positive event were both positively associated with anticipatory pleasure. However, only experiential, and not analytical processing, was associated with greater behavioral intention. While the current study cannot speak to whether experiential processing mode resulted in a greater likelihood of actually completing the future activity, our findings are consistent with literature linking mental imagery and engagement in health behaviors (Blackwell, 2018). In depressed participants, repeatedly imagining engaging in positive everyday activities led to faster increases in self-reported behavioral activation than a non-imagery control condition (Renner et al., 2017). Indeed, several treatments which incorporated exercises focused on training future specific positive imagery (e.g. "imagining the positives" from PAT (Craske et al., 2019); Future Event Specificity Training (D. J. Hallford et al., 2020)) show initial promise. Future research should directly compare behavioral activation with and without mental imagery exercises while measuring activity levels, and move beyond self-report to measuring behavior via passive mobile sensing (Rohani et al., 2019).

Attention

We hypothesized that the experiential processing, expected to increase positive affect to the greatest extent, would also lead to broadened attention. Instead, results from the Navon task revealed that increases in positive affect corresponded to broadened attention regardless of processing mode condition. This finding is generally in line with the broaden and build theory and earlier research that found inducing a positive mood related to global processing in perceptual categorization tasks (Fredrickson & Branigan, 2005). However, more recent work has suggested a more complicated picture beyond valence as the determinant of attentional scope. Instead, motivational intensity also plays a significant role, in which low motivational intensity affects (e.g., sadness, gratitude, amusement) broaden attention whereas high motivational intensity affects (e.g., anger, excitement, desire) narrow attention (Domachowska et al., 2016;

Harmon-Jones et al., 2013). Future work could examine specific positive emotions that vary on motivational intensity, as well as translate this work clinically by investigating whether a changes in attentional scope across positive affect treatments relate to symptom change for anhedonia.

Limitations

In addition to those mentioned above, the current study has several limitations. First, the sample consisted mainly of a non-treatment seeking college student sample, which limits generalization of our findings to community clinical samples engaged in treatment. Second, the study took place remotely during the COVD-19 pandemic, which provides context for our findings in which participants likely had less access to rewarding experiences as usual (especially in person social activities). On the one hand, these circumstances mimic the decreased engagement in enjoyable activities characteristic of anhedonic depression. On the other hand, the collective nature of more limited activities may have impacted the effect of positive memory recall (e.g., either by boosting positive affect more or by blunting the impact perhaps due to mixed emotions related to comparing memories with more restricted opportunities participants could access during the pandemic). The remote administration also meant that the Navon task was completed on participant's personal devices, which may have impacted results by introducing variability in this perceptual task. Methodologically, we relied almost exclusively on self-report measures for the processing mode as well as retrospective report of dampening appraisals. Future research could develop potentially more objective measures of these constructs, possibly using experience sampling to measure engagement in dampening appraisals in real time or behavioral tasks to assess experiential vs analytical processing mode. Another limitation is that findings were limited to one trial of instructed processing; therefore, future research should test whether effects might strengthen with repeated practice, which is important for clinical application.

Future directions

One of the main future directions of this work involves clinical translation. Specifically, which components of experiential processing are key for producing positive affect? Dismantling the "ingredients" (e.g., first person perspective, sensory focus, specific details) could help guide how imaginal recounting exercises are conducted. Future work should also examine how experiential processing ability changes through treatment and whether it predicts symptom improvement, which may suggest experiential processing as a mechanism of change in anhedonia treatments. If so, does experiential processing relate to reward consumption and anticipation, and in turn predict increased engagement in positive activities? Similarly, clinical research should investigate how dampening changes throughout treatment and how clinicians can best manage this in the moment (e.g., redirect attention in the moment to experiences vs psychoeducation). We did not find evidence for dampening or positive meaning as mediators between processing mode and positive affect; future work should investigate this question in a more highly powered design and explore other potential mechanisms that might account for this effect.

Conclusions

Given that dampening is a risk factor for depression and may block the impact of treatments, there is great clinical need to understand strategies for preventing dampening of positive emotions. Focusing on sensory experience may be a strategy to lessen dampening of positive emotions in anhedonia.

Supplement

Stream of Consciousness Procedure for Writing Tasks:

To familiarize with the write out loud procedure, participants practiced a for one minute prior to completing the first memory recall task. They were be given the following instructions: "During this study we will ask you to use a write-out-loud procedure in which you will write down your thoughts as they come to you. To practice this, for the next few minutes you will simply be asked to write down your stream of consciousness, writing down whatever is going through your mind. This might include, but is not limited to, images, ideas, memories, feelings, fantasies, plans, sensations, observations, daydreams, objects that catch your attention, and efforts to solve a problem. There are no restrictions, qualifications, conventions, or expectations. Measures have been taken to ensure your privacy and to guarantee confidentiality concerning your participation in the study, so please write down whatever goes through your mind. Do not worry if what goes through your mind seems silly, embarrassing, or disturbing, just keep writing. Only the experimenters will have access to this information. Remember to try to keep writing for the entire time until the timer goes off to indicate what is going through your mind. If nothing comes to mind, just stop writing and wait. When something else comes to mind start writing about this. Do you have any questions? Please start now."

The following scale was created for the purposes of this study to assess a state sense of connection to positive meaning. Items 1 and 2 were derived from the Daily Meaning Scale (Steger et al., 2008), items 4 and 5 were derived from the Mental Health Continuum-Short Form (MHC; Keyes, 2006, 2002), and item 3 was created by the author due to a lack of existing measure of state connection to values (Barney, 2019).

Meaning

Instructions: Using the 0-4 scale below, indicate the extent to which you feel the following ways **in this moment**.

Not at all	A little bit	Moderately	Quite a bit	Extremely
0	1	2	3	4

1. How much do you feel your life has a sense of meaning?
2. How much do you feel a sense of purpose in life?
3. How much do you feel connected to your values?
4. How much do you feel connected to other people?
5. How much do you feel confident and positive about yourself?

General Discussion

Overall summary

In three studies, this dissertation explored how features of imaginal recounting of positive experiences related to affect and clinical symptoms in individuals with anhedonia. The first two studies drew from clinical trials of novel treatments for anhedonia, Positive Affect Treatment (PAT) and Mobile Virtual Reality-Reward Training (MVR-RT), which include imaginal recounting exercises to train memory to encourage savoring of specific positive details. Using text analysis of spoken (PAT) and written (MVR-RT) imaginal recounting exercises, I tested whether linguistic features of imaginal recounting changed across treatment and corresponded with clinical outcomes. I predicted that positive emotion words, first-person pronouns (an indicator of field perspective), perception words, internal (episodic) detail, and episodic richness would increase across treatment and relate to improved clinical outcomes, whereas negative emotion words and external (non-episodic) detail would decrease across treatment relate to worse clinical outcomes. Because the first two studies could not detect causal relationships, a third experimental study compared the impact of recalling positive autobiographical memories using an experiential versus analytical processing mode on affective and cognitive experience, specifically focusing on dampening appraisals and positive meaning.

Comparison of Studies 1 & 2

Change in linguistic variables across treatment

Regarding change in linguistic variables across sessions, in PAT there was a lack of change in all variables, likely explained by ceiling effects due to therapist guidance such that even early sessions had a high degree of positivity and detail. In contrast, in MVR-RT, linguistic variables did change across treatment and were not affected by ceiling effects, likely due the self-guided nature of the treatment which allowed participants to practice imaginal recounting on their own (as shown in Table 1, participants in MVR indeed started with lower mean scores in the first two sessions for tone and detail compared to PAT). During virtual reality recalls, emotional tone became increasingly positive and contained more perception words, and during autobiographical recalls tone also became increasingly positive and contained fewer negative emotion words. Contrary to hypotheses, internal detail and episodic richness decreased across sessions for both VR and autobiographical recalls, likely due to dropout and challenges with engagement especially during the second half of treatment.

Table 1

Mean Linguistic Variables in Early Sessions of PAT vs MVR-RT

	PAT	MVR (VR)	MVR (AB)
Tone	88.07 (15.67)	34.92 (20.72)	72.99 (26.47)
Posemo	5.19 (1.72)	3.17 (2.87)	4.77 (3.11)
Negemo	0.74 (0.68)	0.75 (0.78)	1.13 (1.10)
I	6.20 (4.23)	6.82 (3.08)	8.43 (3.57)
Percept	4.86 (1.92)	6.08 (2.16)	5.96 (3.21)
Int	631.68 (411.94)	24.32 (13.31)	23.03 (14.36)
Ext	199.91 (155.81)	1.07 (1.87)	2.29 (2.99)
PE	0.76 (.12)	0.98 (.11)	0.91 (.12)
Epi rich	-	3.85 (1.51)	3.92 (1.44)

Note. The mean of linguistic variables were calculated from the first two sessions that contained imaginal recounting (sessions 2 and 3 in PAT and sessions 1 and 2 in MVR-RT). Episodic richness ratings are missing for PAT due to poor inter-rater reliability in manually coded data. Tone = emotional tone, Posemo = positive emotion words, Negemo = negative emotion words, I = first person pronouns, Percept = perception words, Int = internal detail, Ext = external detail, PE = proportion of episodic detail, Epi rich = episodic richness.

Relationship between linguistic and clinical variables

Methodological approach. The relationship between linguistic variables and clinical outcomes was analyzed in slightly different ways for PAT and MVR-RT depending on the timing of data collection. For both studies linguistic variables were collected at each session (2-7 for PAT and 1-13 for MVR-RT). For PAT, clinical outcomes were also collected at each session, whereas in MVR-RT clinical outcomes were only collected at pre, mid, and post-treatment. Therefore, in PAT I tested for predictive relationships using random-intercept cross-lag panel modeling (RI-CLPM). No significant relationships emerged using this approach, therefore no causal claims could be made. Instead, I collapsed across sessions to examine bivariate correlations between all linguistic and clinical variables. For MVR-RT, I extracted individual slopes to represent change in clinical variables from sessions 1-13 as predictor of change in clinical outcomes from pre-, mid-, and post-treatment in the mixed model. Because these timepoints are overlapping (i.e., lack temporal precedence), only concurrent changes can be detected and no causal claims can be made.

Emotional tone. In PAT, there were no associations between emotional tone or positive emotion words and clinical outcomes; however, greater negative emotion words corresponded with less trait positive affect. Similarly in MVR-RT, there was no association between change in emotional tone and clinical outcomes; however, exploratory analyses revealed that increases in positive emotion words were related to decreases in stress. As previously discussed, more sensitive measures of emotional tone such as sentiment analysis using natural language processing will be advantageous in future research.

First-person pronouns. For both PAT and MVR-RT, there were no changes in first-person pronoun use over time, but there were significant correlations between greater first-person use and lower total symptoms of depression, anxiety, and stress. This could be interpreted in support of the hypothesis that greater field perspective relates to better outcomes; however, it is unclear whether first-person pronouns are a valid metric of field perspective, which is called into question due to unexpected relationships with other linguistic and clinical variables. For example, in PAT, first-person pronoun use was associated with greater negative emotion word use and was also associated with less trait positive affect along with less total symptoms, suggesting an overall blunting effect. In MVR-RT, first-person pronouns were associated with both positive and negative emotion word use during autobiographical recounting, suggesting an overall link to greater emotion expression regardless of valence, which could be in turn associated with lower symptoms. In study 3, during the first uninstructed memory recall, first-person pronoun use was neither correlated with self-reported field perspective nor observer perspective. It is possible that first-person pronoun use may reflect self-referential language; however, there was also no correlation with self-reported degree of self-focus. Taken together, it appears that first-person pronouns may not be a valid index of field perspective and its meaning is likely highly dependent upon context and valence. If first-person pronouns do not necessarily represent field perspective, what construct do they capture and why did they correspond with fewer clinical symptoms in both PAT and MVR-RT? Future research should investigate whether these findings replicate in clinical trials, especially treatments that target positive affect, and if so elucidate which psychological processes are involved and related to clinical change.

Detail. Regarding the relationship between detail and clinical outcomes, contrasting results were found in PAT and MVR-RT. In PAT, both internal and external detail were associated with greater positive affect and less negative affect, suggesting that elaboration regardless of whether it was episodic was beneficial, possibly reflective of overall higher motivation to engage during therapy. In MVR-RT, internal detail and episodic richness decreased across treatment, likely due to challenges with engagement in the self-guided treatment. In the opposite direction as hypothesized, the degree to which internal detail and episodic richness increased corresponded with greater negative affect, which may reflect that those who were experiencing more negative affect were more inclined to continue with treatment and provide more detailed recountings. However, increases in the *proportion* of episodic detail was associated with improvements in anhedonia, possibly suggesting that relatively more episodically-focused recounting could be beneficial rather than simply providing a greater number of episodic details.

Taken together, our results fit within the larger literature of mixed findings on the precise relationship between autobiographical memory specificity and depressive symptoms, which may be in part explained by differences in measurement. The Autobiographical Memory Task (AMT) (Williams et al., 2007) assesses a relatively more global sense of specificity by classifying memories as either general or specific, whereas the Autobiographical Interview coding scheme (Levine et al., 2002) is a relatively more granular measure that is used to count the number of episodic and non-episodic details within a given memory. Memory specificity and detailedness have been theorized to be two distinct yet related constructs, in which specific memories tend to also contain a greater number of episodic detail (Hallford et al., 2021). A recent meta-analysis found that retrieval of more specific memories and greater episodic detail was associated with less severe depressive symptoms, although the effect size was small (Hallford et al., 2021). The effects are clearer when comparing depressed versus non-depressed samples on specificity as measured by the AMT (Farina et al., 2019), but are more murky when examining the link between detailedness and individual differences in depression dimensionally (Kyung et al., 2016; Lam et al., 2022; Salmon et al., 2021). Overall, the clinical relevance of detail remains unclear and is likely highly dependent upon the valence, meaning, and context of the memory. Future work should continue to elucidate relationships between level of detail, including exploration of non-linear relationships and change across treatment.

Perception words. In PAT, although perception words were associated with fewer negative emotion words more positive emotion words, and greater proportion of episodic detail, there was no relationship with any clinical outcomes. In MVR-RT, perception words increased across sessions, the degree to which corresponded with improvements in total symptoms of depression, anxiety, and stress (although this effect was marginally significant). These patterns generally align with the notion that experiential processing, with attention to sensory details, is related to enhanced emotional experience (as tested in Study 3), and may relate to clinical benefit.

Challenges of Text Analysis for Process Research

Analyzing language use during therapy offers the potential to study processes that change with treatment in order to identify potential mechanisms. However, future research will need to overcome several challenges and methodical barriers. One significant challenge, especially for processing spoken language in therapy, is the time-consuming nature of converting audio recordings into written transcriptions for subsequent text analysis, which can be aided by automated speech-to-text programs. Another significant concern is the construct validity of linguistic measures, as exemplified by the unclear meaning of first-person pronouns use. As opposed to relying upon single metrics such as word count for individual variables, natural language processing approaches which use machine learning to train on large datasets of naturalistic human text (e.g., tweets, stories) may be more comprehensive and sensitive measures. Additionally, non-verbal communication is lost during text analysis alone. Multimodal approaches that incorporate vocal qualities (tone, pace, pitch) may be useful to combine with analyzing the content of the text (Cannizzaro et al., 2004). Language use is thought to exert effects of a small magnitude, and therefore large datasets are required to detect patterns (Nook et al., 2022). Another limitation of Studies 1 and 2 is that we only examined language use within one treatment group; future work should compare language use between different conditions or forms of treatment to make claims about treatment-specific versus more general mechanisms. Lastly, in order to establish treatment mechanisms, temporal precedence is required, therefore future research should employ designs multiple assessment points throughout treatment.

Study 3

Study 3 aimed to experimentally test the impact of experiential versus analytical processing mode on affect, dampening, and meaning. To connect experiential and analytical processing modes conceptually with the linguistic features of imaginal recounting from Studies 1 & 2, text analysis was conducted on the written recalls. Contrary to hypotheses there were no differences in any of the linguistic variables between processing mode conditions except for detail, which was greater for experiential versus analytical processing. This further calls into question the ability for these linguistic variables to assess constructs of interests. Study 3 sought to address limitations of the previous two studies by taking an experimental approach to test causal relationships between processing mode and affect while assessing features of recounting using self-report rather than text analysis.

Overall, primary hypotheses were supported in that experiential processing of autobiographical memory led to greater positive affect, less negative affect, less dampening, and greater meaning at the level of a trend. To date, no previous studies have identified strategies to mitigate dampening appraisals, which is an important clinical target insofar as renders positive affect interventions such as behavioral activation to be less effective. Extended clinically, these findings suggest that interventions should encourage individuals with anhedonia to process positive events with attention to concrete, sensory experience rather than abstract, conceptual discussion, which may be more likely to inadvertently prompt dampening appraisals, which can blunt positive affect.

Conclusion

Collectively, the studies of this dissertation highlight that the way in which positive memories are recalled may have consequences for emotional experience in individuals with anhedonia. Clinical interventions that encourage experiential processing with attention to pleasant sensory details may be the most beneficial for enhancing positive affect.

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