



universität
wien

MASTERARBEIT | MASTER'S THESIS

Titel | Title

Cognitive-Reappraisal and Music-Listening Interventions for Acute Symptom
Management in Somatic Symptom Disorder

A preliminary analysis

verfasst von | submitted by

Alexander Paul Schröder BSc

angestrebter akademischer Grad | in partial fulfilment of the requirements for the degree of

Master of Science (MSc)

Wien | Vienna, 2026

Studienkennzahl lt. Studienblatt |

UA 066 840

Degree programme code as it appears on the
student record sheet:

Studienrichtung lt. Studienblatt | Degree

Masterstudium Psychologie

programme as it appears on the student record
sheet:

Betreut von | Supervisor:

Dipl.-Psych. Dr. Dr. Ricarda Nater-Mewes Privatdoz.

Table of Contents

1. Introduction.....	4
2. Theoretical Background.....	6
2.1 Core Influential Factors in Genesis and Maintenance of SSD.....	7
2.1.1. Chronic Perceived Stress and SSD.....	9
2.1.2. Emotion Regulation and SSD.....	10
2.2. Psychological Treatment of SSD	11
2.3. Ecological Momentary Assessment and Intervention	14
2.3.1. Cognitive Reappraisal Intervention	16
2.3.2. Music-Based Intervention.....	17
2.4 Factors Influencing Treatment Efficacy.....	20
2.4.1. Chronic Perceived Stress and Treatment Efficacy.....	20
2.4.2. Emotion Regulation and Treatment Efficacy.....	21
3. Research Question and Hypotheses.....	23
4. Method	24
4.1. Participants	24
4.2. Enrolment: Eligibility and Exclusion Criteria	24
4.3. Research Design.....	25
4.4. Procedure	25
4.4.1. Ethical Considerations.....	25
4.4.2. Recruitment and Baseline Assessment of Moderators	26
4.4.3. Study Procedure.....	26
4.5. Assessment Instruments and Measurement.....	27
4.6. Statistical Analysis	30
5. Results.....	31
5.1. Descriptives.....	31
5.2. Inferential Statistics.....	33
5.2.1. Hypothesis 1: Treatment Efficacy of SoMi	33
5.2.2. Hypothesis 2a: Chronic Perceived Stress and Treatment Efficacy	34
5.2.3. Hypothesis 2b: Expressive Suppression and Treatment Efficacy.....	35
5.2.4. Hypothesis 2c: Cognitive Reappraisal and Treatment Efficacy.....	37
6. Discussion.....	38
6.1. SoMi Effectiveness.....	39

6.2. Individual Factors Influencing Treatment Efficacy.....	41
6.2.1. Chronic Perceived Stress and Treatment Efficacy.....	41
6.2.2. Expressive Suppression and Treatment Efficacy.....	42
6.2.3. Cognitive Reappraisal and Treatment Efficacy.....	43
6.3. Methodological Considerations and Limitations.....	45
6.3.1. Sample Size.....	45
6.3.2. Assessment Mismatches	46
6.4. Future Directions.....	47
References.....	48
Appendix A: Study Design.....	67
Appendix B: Model Fit Comparisons.....	68
Appendix C: MLM Requirements.....	69
Appendix D: Study Outcomes.....	71
Appendix E: Abstract.....	73
Appendix F: KI-Verwendungserklärung.....	74

Introduction

Somatic symptom disorder (SSD) is a relatively new disorder that was only recently introduced in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (American Psychiatric Association, 2013). SSD is characterized by one or more persistent and distressing physical symptoms, accompanied by exaggerated and maladaptive psychological and behavioral responses. Affected individuals commonly report severe and persistent pain, exhaustion, dizziness, or other bodily complaints such as back pain, migraines, or digestive issues (Henningsen, 2018; Löwe et al., 2024). Importantly, these physical sensations are associated with disproportionate feelings, thoughts, or behaviors related to symptoms or health concerns, leading to significant psychological distress, functional impairment, and a reduced overall quality of life (American Psychiatric Association, 2013).

SSD and related disorders are among the most prevalent psychiatric conditions in the general population. Toussaint and Herzog (2020) state these disorders rank as the fourth most common based on 12-month prevalence: German population data shows a prevalence of 4.5 % of SSD (Häuser et al., 2020), matching international estimates of 4.5% (Wu et al., 2023) to 12,9 % (Löwe, Levenson, et al., 2022). Additionally, SSD typically manifests in early adulthood and is more frequent among women than men (Toussaint & Herzog, 2020). Clinical prevalence rates in medical settings appear to be even higher. A meta-analysis of 32 studies across 24 countries, including 70,085 patients, found that 26.2%-34.8% of individuals in primary care met criteria for somatoform disorder (Haller et al., 2015). Similarly, a comprehensive review by Wu et al. (2023) reported average rates of 25% in primary care and 33 % in specialized medical settings, such as cardiology or rheumatology.

Longitudinal studies suggest that SSD usually follows a chronic or fluctuating course, rather than resolving on its own. For example, SSD symptoms persisted in 82% of patients with vertigo and dizziness after one year (Limburg et al., 2017). In a psychosomatic outpatient sample, 30.4% of participants still met SSD criteria after four years, while 21.4% experienced remission (Behm et al., 2021). Comorbid conditions, such as depression and anxiety, and a negative self-concept of bodily weakness, are thought to be linked to the persistence of SSD (Smakowski et al., 2024).

SSD imposes many everyday limitations and places a burden on individuals and the healthcare system. Patients with high somatic symptom burden (measured via SSD-12) often

undergo multiple diagnostic procedures and visit various medical specialists (Kop et al., 2019). This results in high public healthcare costs and economic issues for the welfare state. Konnopka et al. (2013) found that patients with medically unexplained symptoms had average 6-month direct costs of 1098 EUR and indirect costs of 7645 EUR. These indirect costs include loss of productivity at work and early retirement.

Although treatment costs may decrease following psychotherapy, existing evidence-based interventions show only low to moderate effects (Van Dessel et al., 2014) and are often fairly limited in accessibility (Henningsen, 2018). This highlights the need for innovative treatments that reach beyond traditional formats. As noted in a paper discussing a European research agenda for SSD (Van Der Feltz-Cornelis et al., 2018), the development and assessment of new, effective interventions remains consequently a primary research priority in this field.

Ecological Momentary Interventions (EMIs) represent a suitable alternative, utilizing mobile technology to deliver therapeutic strategies in real time, within individuals' everyday lives (Heron & Smyth, 2010). These micro-interventions can occur repeatedly during moments of heightened symptom perception and acute emotional distress, aiding individuals in applying coping strategies during periods of increased stress. EMIs have demonstrated high feasibility and acceptance in other psychiatric conditions, such as bipolar disorder and schizophrenia (Myin-Germeys et al., 2016), and have shown promising effects in treating anxiety and depressive disorders (Schueller et al., 2017). Given these encouraging results, it is reasonable to consider that EMIs could be effective in treating SSD.

At the same time, factors that hinder or facilitate treatment success in SSD remain relatively unknown, presenting a key research gap. Addressing this gap is crucial, stressing the need for new methodological designs to identify and explore mediators and moderators of clinical course and treatment outcomes (Van Der Feltz-Cornelis et al., 2018).

Since EMIs heavily rely on participants' involvement and motivation, it is important to identify individual differences that may influence treatment outcomes. Examining these factors could lead to more tailored and effective interventions in the future, ultimately advancing patient outcomes. With this in mind, the present thesis specifically discusses these issues.

Theoretical Background

SSD and its predecessors have long caused challenges for research and diagnostics due to conceptual ambiguity and persistent debates over diagnostic criteria. Earlier “somatoform” classifications focused primarily on the presence of physical symptoms and their medical inexplicability. This approach often led to diagnostic uncertainty and frequently stigmatized affected individuals (Rief & Martin, 2014). In contrast, the DSM-5 shifts the focus to patients’ maladaptive cognitive, affective, and behavioral patterns – denoting a significant move away from mind-body dualism and towards a biopsychosocial conceptualization of the disorder (Löwe, Levenson, et al., 2022).

According to DSM-5, SSD requires three core criteria (American Psychiatric Association, 2013):

Criterion A is met when any somatic complaint qualifies as distressing and leads to significant functional or occupational impairment, even if the complaint has a clear medical explanation.

Criterion B represents the psychological core of the disorder. Affected individuals must demonstrate excessive, disproportionate, and persistent thoughts, feelings, or behaviors relating to their symptoms or health concerns (American Psychiatric Association, 2013). Specifically, only one of the following manifestations is required for fulfillment of criteria B: first, affected individuals may exhibit exaggerated preoccupation and beliefs about the seriousness of symptoms; second, they may experience persistent and distressing anxiety concerning their own health and physical symptoms; and finally, they may devote excessive time and energy to their symptoms or health concerns.

Criterion C is fulfilled when individuals have been symptomatic for more than six months (Löwe, Levenson, et al., 2022), though the number and nature of the symptoms can vary over time.

Overall, the improvements in the DSM-5 enhance conceptual clarity, as the focus on positive psychological criteria (Criterion B) provides greater clinical utility (Rief & Martin, 2014). This new framework encourages a more integrated mind-body understanding and a less stigmatizing approach to patients in primary care, a strategy recommended in contemporary diagnostic approaches (e.g., by Davidsen et al., 2016). Empirical evidence supports the validity, reliability, and clinical utility of the DSM-5 framework, while also

noting the need for more precise and measurable Criterion B (Löwe, Levenson, et al., 2022; Smakowski et al., 2024). Nevertheless, diagnostic accuracy, early detection, and effective treatment continue to pose challenges (Henningesen, 2018; Rief & Martin, 2014). For instance, in many affected individuals, symptoms are primarily interpreted as physical, and medical professionals often hesitate to refer these patients for psychological or psychiatric care (as discussed in the case study by Sardesai et al., 2023). As a result, affected individuals frequently undergo repeated medical examinations before receiving appropriate psychological treatment (Henningesen, 2018).

In summary, SSD represents a complex clinical condition characterized by an active interplay between psychological processes and physical sensations, leading to considerable subjective suffering and severe functional impairment (American Psychiatric Association, 2013). At the same time, SSD poses specific and serious clinical, economic, and social challenges. Understanding this complex disorder is key to interpreting the current investigation.

Core Influential Factors in Genesis and Maintenance of SSD

The biopsychosocial model, first described by George Engel in 1977, represented a significant conceptual shift from purely organic views of illness toward an understanding that biological, psychological, and social elements interact dynamically in the development and course of disease (Papadimitriou, 2017).

Building on this perspective, Löwe et al. (2024) conceptualize persistent somatic symptoms as the result of multiple biological, psychological, and social mechanisms that jointly determine symptom persistence, rather than being fully explained by a single domain, such as an initial organic disease process. Symptoms may begin following an injury, infection, or illness, or stressful events, but as they persist, risk and maintenance factors become central.

The SOMACROSS research unit demonstrated that different psychobehavioral factors like early life adversity, depression, anxiety, dysfunctional expectations, symptom focus, avoidance behaviors, and dysregulation of biological systems all play important roles in the chronicity of symptoms (Löwe, Andresen, et al., 2022). For instance, Maunder et al. (2017) showed that lower maternal sensitivity in infancy predicted somatization at age 5, while early life adversity and attachment insecurity were linked to greater physical symptoms and health anxiety in adulthood. This illustrates how early experiences can shape stress-regulation

systems and emotional coping abilities in later life, thereby ultimately increasing vulnerability to psychosomatic distress (Lüönd et al., 2025).

Accordingly, cognitive-perceptual and emotional mechanisms substantially influence symptom experience (Löwe, Andresen, et al., 2022; Löwe et al., 2024): Individuals affected by SSD commonly exhibit maladaptive emotional and cognitive-perceptual patterns. These may include excessive attention to somatic sensations, catastrophic interpretations of benign symptoms, heightened (illness-) related anxiety, alexithymia, and difficulties in coping with distress (Smakowski et al., 2024). Such processes foster lasting threat appraisal and are often accompanied by difficulties in emotion awareness and regulation (Okur Güney et al., 2019; Schnabel, Petzke, et al., 2022).

Negative affect also plays an important role in SSD. Benign or everyday body sensations, such as heart palpitations, muscle twitching, or nerve tingling, can trigger catastrophic thoughts and anxiety (Seto & Nakao, 2017). This activation leads to physiological arousal, creating a self-perpetuating cycle between arousal and physical discomfort, which ultimately contributes to symptom intensity and persistence (Löwe et al., 2024). This enhances vigilance along with physiological reactivity, further intensifying the symptoms (Barsky & Silbersweig, 2023). Given that SSD is defined by excessive cognitive, behavioral, and emotional responses to bodily sensations or health concerns (American Psychiatric Association, 2013), this is especially worrisome and gives an explanation why symptoms can persist even when medical reassurance and physical treatment are repeatedly provided.

Understanding SSD as a complex biopsychosocial condition provides the theoretical foundation for this thesis and justifies the examination of chronic stress and emotion regulation as important influential factors.

Chronic Perceived Stress and SSD

Perceived stress is fundamentally understood as the degree to which the demands of a situation are appraised as exceeding one's available resources, that is, the situation is experienced as unpredictable, uncontrollable, and overwhelming (Cohen et al., 1983). According to the transactional model of stress (Lazarus & Folkman, 1984), stress arises through two stages of cognitive appraisal: In the first stage, called primary appraisal, a situation is evaluated as threatening or harmful. In the second stage, known as secondary appraisal, individuals assess their perceived coping abilities. This theory is crucial because it

explains why individuals exposed to similar circumstances can have entirely different stress responses: It is not the objective nature of the stressor but its subjective interpretation that determines the stress reaction (Biondi & Picardi, 1999).

A distinction between acute and chronic stress is essential: acute stress is an adaptive response that involves activation of the sympathetic nervous system. This activation promotes alertness and performance and is typically followed by a return to baseline once the stressor subsides (Dhabhar, 2014). In contrast, chronic stress occurs when stressors persist over time and perceived coping resources remain insufficient. This leads to sustained activation of stress systems (Herman et al., 2016). Over time, chronic stress is associated with a wide range of adverse outcomes, including sleep difficulties, impaired immune functioning, anxiety and depressive disorders, cardiovascular and metabolic disease, and an increased risk of cancer (Agorastos & Chrousos, 2022; Alalhareth et al., 2024; Dai et al., 2020).

Chronic perceived stress (CPS) is particularly relevant in the context of SSD and pain sensation, as it intensifies key biopsychosocial processes involved in persistent and distressing somatic symptoms (Eller-Smith et al., 2018). Thus, one can argue that, through autonomic dysregulation, for instance, CPS is closely related to central SSD mechanisms such as somatic sensory amplification and catastrophizing. Stress-related physiological arousal heightens the perception of bodily sensations, thereby increasing symptom-related distress and, along with body-related misinterpretations (e.g., somatosensory catastrophization), reinforcing further autonomic arousal and discomfort (Seto & Nakao, 2017). Empirical findings support the just-mentioned relationship between stress and somatic symptoms; for instance, Nakao and Takeuchi (2018) found that perceived psychosocial stress was associated with the total number of reported somatic symptoms among a sample of psychosomatic outpatients. This relationship was mediated by somatosensory amplification and alexithymia. Similarly, Elsenbruch (2011) demonstrated that stress and negative emotions were linked to increased symptom frequency and severity in patients with irritable bowel syndrome. A large population-based study ($n = 9656$) also showed that perceived stress increased the risk of developing functional somatic disorder, while self-efficacy diminished the odds (Petersen et al., 2023).

Together, these findings indicate that CPS is an important factor in the genesis and maintenance of SSD. Importantly, individual differences in perceived stress are likely to shape responses to symptom-related challenges and may moderate the effectiveness of

psychological interventions. This highlights the importance of targeting stress regulation in both research and clinical practice.

Emotion Regulation and SSD

Another key factor in the genesis and maintenance of SSD is maladaptive *emotion regulation* (ER) or the lack of choosing adequate emotion regulation strategies (Okur Güney et al., 2019; Schnabel, Schulz, et al., 2022).

ER refers to the process by which individuals influence which emotions they experience, when they experience them, and how they are felt and expressed (Gross, 1998). Extensive research demonstrates that ER substantially affects mental health, showing robust associations between ER strategies and various mental disorders, including depression, anxiety, eating, and substance-use disorders (Aldao et al., 2010).

Two major ERS are commonly distinguished, and although these strategies constitute distinct psychological constructs, both share the goal of reducing the frequency and intensity of unpleasant emotional states (Gross, 2015). *Cognitive reappraisal* (CR) involves changing the interpretation of a situation to change its emotional impact without altering the situation itself (Schnabel, Schulz, et al., 2022). Reframing a stressful event by focusing on less distressing factors or potential benefits can substantially reduce negative affect (Gross, 2015; Hu et al., 2014). CR is regarded as an adaptive ER strategy associated with benevolent psychological outcomes and lower symptom severity across various forms of psychopathology: A meta-analysis of 48 studies including 21,150 participants found positive correlations between CR and indicators of well-being, and negative associations with depression, anxiety, and negative affect (Hu et al., 2014). In contrast, *expressive suppression* (ES) refers to the inhibition of unwanted emotional experiences and outward emotional expressions (Gross, 2015). While ES can reduce visible emotional displays, it typically fails to diminish internal emotional experience and is considered maladaptive. In contrast, the same meta-analysis revealed that ES was associated with lower psychological adjustment and greater emotional distress (Hu et al., 2014). Similarly, Troy et al. (2018) showed that CR, compared to acceptance, is associated with larger decreases in negative and larger increases in positive emotions during and after showing sad film clips.

ER is particularly important in the context of SSD, as affected individuals often struggle to identify, label, and appropriately modulate affective states (Schnabel, Schulz, et al., 2022). Furthermore, the authors showed in a systematic review comprising 105 studies

and over 29,000 participants that SSD is associated with reduced emotional clarity, low regulatory self-efficacy, and frequent reliance on maladaptive strategies such as rumination and worry. In contrast, adaptive strategies are used less often.

Despite the central role of ER in psychopathology, research in SSD remains limited. The lack of longitudinal, fine-grained data ultimately limits understanding of how ER and symptom perception unfold in daily life among affected individuals (Schnabel, Petzke, et al., 2022). However, despite extensive EMA research in affective and anxiety disorders, there is very little literature specifically addressing ER in SSD in participants' natural environment.

Psychological Treatment of SSD

The prior chapter illustrated that psychological processes, particularly perceived stress and ER, have a decisive role in the genesis and maintenance of SSD. Given that psychological factors help maintain symptoms, an obvious next step is to examine the literature on the efficacy of psychological treatments in SSD.

In short, empirical studies confirm that psychological treatment can improve clinical outcomes. A meta-analysis comparing 890 patients undergoing psychotherapy with 548 patients receiving treatment as usual (TAU) in secondary/tertiary care in severe SSD. They found that psychotherapy was more effective than TAU in reducing physical symptoms and functional impairment (Koelen et al., 2014). Another meta-analysis of 17 RCTs found that short-term psychodynamic therapy significantly reduced physical symptoms compared to the minimal treatment, treatment as usual, and waitlist conditions (Abbass et al., 2021). These findings show that psychological interventions clearly add substantial therapeutic value to standard medical care and emphasize psychotherapy as a central treatment option (Henningsen, 2018).

In recent years, several evidence-based psychological interventions have been developed for SSD. These include cognitive-behavioral, psychodynamic, and mindfulness-based approaches (Henningsen, 2018). Among all approaches, *Cognitive Behavioral Therapy* (CBT) has received the strongest empirical support. A comprehensive meta-analysis of 15 RCTs including 1,671 participants revealed robust effects of CBT on reducing somatic symptom severity, depressive and anxiety symptoms, and improving physical functioning, with these positive outcomes remaining stable for up to 12 months (Liu et al., 2019).

CBT is grounded in the assumption that cognitions, emotions, and behaviors interact dynamically over time and jointly determine subjective experience (Hayes & Hofmann, 2017). On a cognitive level, CBT targets maladaptive thought patterns such as catastrophizing and selective attention to bodily sensations. On a behavioral level, treatment aims to reduce safety behaviors such as repeated body checking, avoidance of activities, and reassurance seeking. All those mechanisms have been shown to reinforce symptom perception and distress (Henningsen, 2018; Löwe et al., 2024). Moreover, individuals with SSD commonly exhibit deficits in emotion regulation; therefore, enhancing adaptive strategies, such as CR, should be a therapeutic focus (Okur Güney et al., 2019; Schnabel, Petzke, et al., 2022). By addressing maladaptive patterns and behaviors, CBT aims to reduce the negative impact of physical sensations and health anxiety (Liu et al., 2019).

Even though evidence-based psychological treatments can reduce symptom severity in some individuals, many affected by SSD receive little or no adequate treatment. Several barriers drive this treatment gap. Public access to psychological treatment remains strongly limited, due to low uptake, structural barriers, and long waiting times (Henningsen, 2018; Kohlmann et al., 2018). This is notably concerning given that earlier treatment initiation is associated with enhanced treatment outcomes (Berezowski et al., 2022). Second, fragmented communication between medical disciplines often results in missing coordination of follow-up care (Kustra-Mulder et al., 2025) and inconsistent and inaccurate diagnostic feedback. Finally, persistent illness beliefs among affected individuals, especially the tendency to attribute somatic symptoms to physical causes and disease, contribute to repeated reassurance-seeking (e.g., “doctor-shopping”) and avoidance behaviors (Neng & Weck, 2015).

Ultimately, such factors contribute to delayed psychological referral, continued personal suffering, and increased healthcare utilization (Henningsen, 2018; Löwe et al., 2024; Smakowski et al., 2024). This shows that SSD requires a holistic treatment approach with integrated “stepped” care (Henningsen, 2018) and more physicians who will not hesitate to refer patients to a psychologist or psychiatrist rather than risk unnecessary medical interventions or repeated medical testing (Malas et al., 2017). This is of great importance, as SSD-typical behaviors and cognitions, combined with structural behaviors in the healthcare system, often prevent the initiation of adequate treatment, even when it is urgently needed.

To overcome these challenges, treatment conceptualization should shift toward integrative, flexible care that enables continuous therapeutic support beyond traditional formats (Ibeziako et al., 2019). Many symptom-maintaining mechanisms, such as stress reactivity, emotional suppression, and attentional shifts toward symptoms, predominantly occur in everyday life (Löwe et al., 2024; Seto & Nakao, 2017) rather than during treatment sessions.

Also, traditional psychotherapy remains constrained by its context: While CBT aims to modify everyday processes, transferring therapeutic strategies into patients' lives is often difficult and relies heavily on between-session homework assignments (e.g., Jongasma et al., 2023). Because the effective application of adequate strategies to reduce symptom intensity and preoccupation is learned in a safe environment, they can rarely be activated at the very moments they are most needed - namely, during acute episodes of symptom perception.

Applying CR effectively in real-world situations remains quite challenging. According to Wang & Yin (2023), transferring the skill from the therapy session into everyday life is constrained because reappraisal does not erase preexisting threat associations *per se* but rather introduces new, competing interpretations that require repeated reinforcement in real-world contexts. In this sense, the activation of newly learned interpretations is highly context-dependent and relies on environmental cues and repeated real-world experiences. Thus, in critical moments of heightened distress, immediate therapeutic support would be especially helpful (Kelly et al., 2012) but is typically unavailable.

This application gap highlights the need for real-time, context-sensitive interventions capable of counteracting maladaptive patterns precisely when they emerge (Kelly et al., 2012). Recent advances in digital technology have created new opportunities to deliver evidence-based therapeutic support outside of standard therapy settings.

Internet-based CBT programs have already shown promise in SSD populations. In an RCT, the therapist-guided, the unguided, and the bibliotherapy conditions all effectively reduced health anxiety compared to the waitlist control group (Hedman et al., 2016). Similarly, online adaptations of Emotional Awareness and Expression Therapy significantly reduced somatic symptoms at post-treatment and also at 4-month follow-up assessment compared to the control condition (Maroti et al., 2022).

Building upon these developments, *Ecological Momentary Interventions* (EMIs) offer an opportunity to move conventional therapy into participants' everyday lives. EMIs can deliver brief, adaptive therapeutic exercises at moments of heightened symptom perception when distress is high (McDevitt-Murphy et al., 2018). Thereby, it operationalizes core CBT mechanisms in real-world contexts. By targeting psychological distress as it occurs, EMIs can bridge this gap by enabling patients to apply learned techniques immediately during acute moments of distress, reinforcing therapeutic learning, and eventually enhancing self-efficacy. This pattern has been shown in substance-use disorder (Parmar & Sharma, 2017). Consequently, micro-interventions that repeatedly support the application of processes such as CR in everyday situations may strengthen adaptive schemas through bottom-up learning, increase their automatic accessibility, and ultimately facilitate transfer beyond clinical contexts (Wang & Yin, 2023).

Against this background, the following section introduces theoretical foundations and empirical evidence for EMIs, setting the stage for an exploration of how this innovative approach can specifically address core mechanisms of SSD.

Ecological Momentary Assessment and Intervention

EMIs have gained considerable attention in recent years due to rapid technological advancements, growing societal acceptance of digital data collection, and the growing integration of digital tools into psychological research and clinical practice (Balaskas et al., 2021). EMIs are conceptually grounded in EMA, which was originally designed to capture psychological states, behaviors, and contextual factors in real time within participants' naturalistic environments (Shiffman et al., 2008). By capturing experiences as they occur, EMA minimizes recall bias and enhances ecological validity, resulting in more accurate representations of dynamic psychological processes (Solhan et al., 2009).

EMA typically involves repeated brief assessments via smartphones or other wearable devices multiple times per day, allowing for examination of within-person fluctuations (Balaskas et al., 2021). This approach is particularly promising for SSD, a disorder characterized by dynamic interactions between symptoms and other factors. For instance, EMA has generated important insights into symptom variability and daily affect in anxiety disorders (Walz et al., 2014) and has been used to study affect, stress responses, and behaviors associated with depressive episodes (Armey et al., 2015).

Building on EMA, *Ecological Momentary Interventions* (=EMIs) extend this approach as “treatments that are provided to people during their everyday lives (i.e., in real time) and in natural settings (i.e., real world)” (Balaskas et al., 2021; Heron & Smyth, 2010). They deliver brief, context-sensitive therapeutic strategies directly into individuals' everyday lives. EMIs aim to intervene at moments of heightened distress by providing timely support when it is most needed (Heron & Smyth, 2010; Walz et al., 2014). EMIs can include elements such as psychoeducation, cognitive restructuring, mindfulness practice, relaxation techniques, or music-based exercises, delivered via brief notifications, audio instructions, or video prompts (Colombo et al., 2019). By providing critical support at moments of need, this approach offers low-threshold, personalized psychological support.

The feasibility and acceptance of EMI have been demonstrated across diverse clinical populations with severe mental illnesses like schizophrenia, bipolar disorder, and major depression (Myin-Germeys et al., 2018) and psychotic disorders (Bell et al., 2017) while showcasing preliminary evidence for improved clinical outcomes. For instance, in an uncontrolled pilot study, a compassion-focused EMI for help-seeking youth was feasible and safe and was associated with reductions in stress sensitivity, momentary negative affect, psychotic experiences, alongside increased positive affect and reductions in psychotic, anxiety, and depressive symptoms at post-intervention and follow-up (Rauschenberg et al., 2021). These findings demonstrate that EMIs have clinical potential but require additional large, controlled trials.

Despite its potential, research applying EMIs to SSD populations remains scarce. Schnabel, Petzke, et al. (2022) highlight this gap in their systematic review, noting the need for longitudinal, ecologically valid approaches to investigate everyday emotion regulation in SSD. By addressing this research gap, the current investigation examines an EMI specifically designed for individuals with SSD.

The EMI developed in this investigation (SoMi) integrates two complementary components targeting cognitive and affective maintenance mechanisms: A cognitive-reappraisal-based intervention and a music-based intervention. The former focuses on restructuring maladaptive interpretations and fostering adaptive ER, whereas the latter aims to induce distraction, positive affect, and relaxation. Together, they operationalize core CBT principles and affect-regulation mechanisms within participants' regular environment.

Cognitive-reappraisal Intervention

As previously stated, CR is defined as an ER strategy through which an individual modifies the interpretation of a situation to modify its emotional impact (Schnabel, Schulz, et al., 2022). CR plays a central role in adaptive ER and is a key target in CBT. It helps reduce maladaptive processes such as catastrophizing and rumination (Cutuli, 2014). By reframing threatening interpretations, CR can weaken dysfunctional beliefs about one's own somatic symptoms and their accompanying biopsychosocial consequences.

In the therapeutic context, CR is typically introduced first in collaboration between therapist and patient. Together, they identify automatic thoughts – often referred to as “hot thoughts”- that trigger negative affect (Safran & Greenberg, 1982). These cognitions are then examined and challenged, and more realistic, adaptive, and reassuring alternatives are developed (Santos et al., 2024). Over time, adaptive interpretations become more automatic, ultimately reducing the negative impact of maladaptive thoughts.

Cognitive restructuring of dysfunctional health beliefs and the processes of catastrophizing are central modules in CBT. For instance, the CR-module has been shown to reduce the tendency to attribute negative everyday events to self-related causes (Norbury et al., 2024). Goldin et al. (2012) found that enhanced self-efficacy was mediated by enhanced CR for social anxiety disorders. The author's subsequent work showed that CR-focused CBT sessions significantly lowered emotional reactions (Goldin et al., 2014).

Furthermore, current evidence on medically unexplained symptoms (MUS) and SSD suggests that CBT, with its aim of fostering CR, is a promising intervention point for improving distress, symptoms, and overall functioning in affected individuals (Liu et al., 2019). A pilot study with 11 total participants showed that CBT incorporating CR reported reductions in somatic symptom severity, depressive symptomatology, anxiety, perceived stress, perceived disability related to pain, and healthcare utilization (Jongsma et al., 2023). The *cognitive-reappraisal intervention* (CR-I) used in this investigation is based on a quasi-experimental trial conducted by Kleinstäuber et al. (2019) with participants with MUS and a healthy control group. The authors showed that applying CR after symptom induction in the MUS condition was associated with significantly lower symptom-annoyance scores than the compassionate self-support condition.

To conclude, CR represents a promising technique in SSD, as maladaptive cognitions to bodily symptoms play a central role in SSD (Löwe et al., 2024; Smakowski et al., 2024). Targeting maladaptive symptom appraisals through CR can not only alter immediate

subjective symptom experience but also alter subsequent symptom experience. However, it can also contribute to broader improvements in emotional well-being and functioning in SSD (e.g., Jongasma et al., 2023). Therefore, this section underscores CR as a key therapeutic goal when treating affected individuals.

Despite this, longitudinal evidence on CR's effectiveness in SSD is extremely limited, and more training studies are needed (Kleinstäuber et al., 2019). SoMi intends to fill this research gap by applying CR-I as an ecological, momentary intervention that strengthens adaptive cognitive processing in everyday contexts.

Music-based Interventions

The other intervention used in SoMi will be a *music-based intervention* (MB-I). Due to promising findings in depression, anxiety, and stress-related disorders, MB-Is have gained increasing attention in the scientific community (De Witte et al., 2020). Furthermore, MB-Is have demonstrated beneficial effects in chronic pain (Arnold et al., 2024; Brazoloto & Fajarra, 2024; Cournoyer, Lemaire, & Perreault, 2024), while Lee (2016) demonstrated, in a meta-analysis of 97 RCTs, that MB-Is significantly reduced emotional distress related to pain. Notably, music interventions delivered during heightened distress appear to relax and distract affected individuals immediately (Feneberg & Nater, 2022). A subsequent interview showed that the intervention was easy to use and that MB-I at these moments was a new and pleasant activity. Given their low threshold, non-invasiveness, and high feasibility, MB-Is appear particularly suitable for SSD.

The MB-I in SoMi is based on Feneberg et al. (2021), in which they examined *music-listening* (ML) in 58 women with SSD and depressive disorder in a 14-day-long EMA. Participants had to repeatedly report somatic symptoms, subjective stress, and stress biomarkers (namely salivary cortisol and salivary alpha-amylase). A subsequent multilevel analysis showed that ML predicted lower levels of subjective stress, and in turn, lower stress predicted reduced somatic symptom severity. Thus, the beneficial effect of ML on somatic symptoms was indirect, via a reduction in subjective stress. Interestingly, the type of music mattered, too. Music perceived as high in valence (happy) was associated with lower somatic symptom intensity and impairment, whereas music perceived as sad was associated with the opposite effects. Music high in arousal predicted higher autonomic arousal (assessed via alpha-amylase) at the subsequent time point. As participants also reported high feasibility and acceptability of this study, the authors emphasize the need and potential of just-in-time, and

context-sensitive MB-Is that deliver individually chosen, pleasant, and calming music at moments of heightened distress or symptom burden. The current investigation will do the same.

MB-Is may affect individuals who suffer from SSD on multiple levels: on an affective level, ML can alter emotional states, evoke positive emotions, or induce entirely new mood states. For instance, a recent meta-analysis of schizophrenia patients found that music therapy was significantly better at reducing negative symptoms and mood symptoms and at enhancing positive symptoms than the treatment condition without music (Tseng et al., 2016); on a physiological level, it modulates autonomic nervous system activity and stress-related arousal (J. H. Lee, 2016). In a large meta-analysis comprising 104 RCTs with 9,617 participants, MB-I was found to significantly reduce psychological indicators of stress (De Witte et al., 2020). This is particularly important in SSD, as stress-related bodily symptoms and activation are central contributors. ML can shift attentional focus by interrupting ruminative processes and competing with interoceptive attention directed toward bodily sensations (Bigliassi et al., 2017). Given these findings, MB-I could contribute to decreased symptom monitoring and lower subjective symptom intensity, making it especially suited for individuals affected by SSD.

Given their ease of use, MB-Is hold considerable potential to complement traditional therapeutic approaches, underscoring the need for further examination of their effects on symptom perception and management (Arnold et al., 2024).

To summarize, CR-Is and MB-Is represent promising complementary approaches for reducing symptom perception in SSD. When symptoms occur, individuals are often in acute situations in which immediate therapeutic support is unavailable or inaccessible. SoMi addresses this treatment gap by providing timely, context-sensitive interventions precisely in moments of heightened symptom-related distress. By combining a top-down (CR-I) and a bottom-up (MB-I) strategy, SoMi targets the central maintenance mechanisms of SSD. Despite their substantial potential, longitudinal investigations and interventions in SSD remain scarce (Kleinstäuber et al., 2019; Schnabel, Petzke, et al., 2022). Based on the aforementioned theoretical background, both EMI components are expected to effectively reduce perceived somatic symptom intensity. Specifically, it is hypothesized that participants will report lower symptom intensity 20 minutes after the intervention compared to pre-intervention levels.

Nonetheless, the intervention effect may not be uniform across all individuals. Previous research has demonstrated substantial variability in treatment success across different baseline characteristics: A meta-analysis that included 31 RCTs evaluating the efficacy of psychological interventions for grief in bereaved adults found larger post-intervention effects in studies that included participants with high baseline grief symptom levels (Johannsen et al., 2019). Another review and meta-analysis totaling 51 studies showed that, with multivariate meta-regression, childhood-onset trauma was associated with poorer outcomes (smaller treatment effects) across PTSD interventions (Karatzias et al., 2019).

This leads to the idea that it is important to assess possible moderators to ensure more personalized and effective interventions in the future. By examining potential moderators, this study enables future interventions to be tailored to individual strengths and weaknesses. As previously stated, ER and CPS play a central role in SSD while simultaneously affecting key mechanisms that influence treatment outcomes. Thus, this study focuses on the influence of baseline CPS levels and habitual ERS tendencies. To clarify their relevance, the following chapter outlines why these factors may play a crucial role in determining intervention effectiveness.

Factors Influencing Treatment Efficacy of SoMi

Chronic Perceived Stress and Treatment Efficacy

As previously explained, *chronic perceived stress* (=CPS) refers to the ongoing subjective experience of being overloaded or unable to cope with persistent life demands (Cohen et al., 1983). CPS thus reflects perceived and actual life strain - an experience particularly characteristic of individuals with SSD, in which persistent stress serves both as a precipitating vulnerability factor and a maintaining amplifier of bodily signals and distress. Given the overall context of this investigation, this positions CPS as a prime candidate for examination, as the aforementioned mechanisms are suggested to influence how effectively participants respond to psychological interventions, particularly brief, self-guided treatments delivered in participants' natural environments without therapeutic support. The following section will disclose in detail why that may be the case.

First, CPS heightens sympathetic activation and disrupts HPA-axis balance, resulting in increased arousal and heightened sensitivity to bodily sensations (McEwen & Gianaros, 2011), which may make intervention success more difficult. In addition, CPS impairs multiple cognitive-emotional domains essential for the success of the current investigation,

including cognitive flexibility, attentional processes, coping capabilities, and ER (Girotti et al., 2024; Qin et al., 2009). Under persistent stress, individuals are more prone to maladaptive thought patterns like rumination, which can reduce their ability to engage with EMI prompts effectively. Given that the success of this investigation crucially depends on participants' ability to actively pay attention to each intervention condition in distressing moments of symptom experience, CPS must be considered as an influencing force. Finally, CPS can foster avoidance patterns and undermine treatment adherence, both of which are critical barriers for self-guided digital interventions (Karekla et al., 2019). Participants with elevated CPS levels at baseline may be more likely to skip EMI prompts during acute symptom episodes, anticipating that consciously dealing with bodily complaints will intensify their discomfort. Such avoidance behavior directly limits exposure to therapeutic input and prevents extinction learning of CR (Wang & Yin, 2023).

Collectively, these explanations identify CPS as a clinically meaningful moderator: Stress-reduction modules – such as mindfulness or relaxation training have been shown to enhance treatment efficacy when integrated into existing programs, confirming stress as a modifiable, treatment-relevant factor (Hofmann & Gómez, 2017). This is particularly relevant for EMIs, which operate in everyday contexts without constant therapeutic guidance or contextual support. In such self-directed environments, individual levels of CPS likely determine how effectively participants can engage with and profit from momentary regulation strategies. That being said, no prior study has explicitly examined the moderating role of CPS in EMI efficacy for SSD populations- making the current investigation the first to address this crucial research gap.

Building on this theoretical and empirical foundation, it is hypothesized that high baseline CPS reduces the efficacy of both EMI components. In the CR-I, elevated CPS likely has an impeding function, hindering the shift from catastrophic to adaptive appraisals. In the MB-I, CPS-induced tonic arousal and dysregulation may hinder relaxation and emotional recovery. Thus, it is anticipated that CPS will moderate EMI-efficacy, such that higher CPS values will lead to smaller short-term reductions in perceived somatic symptom intensity following each intervention module.

Emotion Regulation and Treatment Efficacy

Similar to CPS, individual differences in habitual tendencies of certain ERS may moderate how effectively study participants engage with and benefit from this EMI.

Extensive research has highlighted the close link between ERS and SSD (Okur Güney et al., 2019; Schnabel, Petzke, et al., 2022), showing that individuals affected by SSD often perceive ER as more effortful and demanding. The following section will therefore disclose its potential moderating role in greater detail.

After all, the habitual use of specific ERS can influence treatment efficacy through two proposed distinct pathways: First, the CR-I directly targets ER-related processes by encouraging reinterpretation of bodily signals and increasing tolerance of unpleasant sensations. Second, the MB-I aims to down-regulate physiological tension and distract from acute moments of heightened symptom perception without the need for explicit cognitive processing.

Taking these considerations into account, individuals who tend to apply CR more often are expected to benefit more strongly from the CR-I. Supporting this notion, Pizzie and Kraemer (2021) found that high reappraisal use mitigated the negative associations between physiological arousal and task performance in participants with math anxiety, demonstrating CR's potential to influence physiological processes. Applied to SSD, greater habitual tendencies should facilitate effortful "top-down" regulation, allowing participants to modify maladaptive cognitions more easily and thereby achieving larger reductions in symptom intensity.

By contrast, frequent reliance on ES is associated with less adaptive outcomes. To recapitulate, ES involves inhibiting emotional expression while leaving internal response largely unchanged (Gross, 2015). This strategy increases physiological arousal and promotes cognitive avoidance, which can interfere with effective engagement in the CR-I. In veterans with PTSD, for instance, ES was associated with increased psychological symptoms like cognitive avoidance (Khan et al., 2021). Consequently, greater habitual ES is expected to impede the effects of CR-I, as attention is diverted away from this process.

In the light of the MB-I, the relationship is less clear. Interestingly, participants high in ES-values could profit more from the MB-I than individuals with low tendencies of ES or the other way round, as music-listening can reduce core mechanisms of SSD (e.g., reducing physiological arousal and interoceptive attention) without requiring the participant to "talk through" or consciously analyze their feelings, compared to the CR-I (Che et al., 2015).

To conclude, individual differences in ERS may substantially influence how effectively an intervention is used and how receptive an individual is to its content. This

consideration is particularly relevant for SoMi, as it operates in acute, real-time contexts and is self-guided and effortful. Furthermore, SoMi explicitly relies on participants' compliance to be effective. Without continuous guidance or reinforcement from therapists or physicians, achieving this will be even more difficult. These challenges highlight the importance of understanding for whom and under which circumstances such interventions are most beneficial.

Thus, it is hypothesized that greater habitual use of CR at baseline will facilitate EMI effectiveness in both intervention conditions by enhancing engagement with intervention prompts, thereby supporting reinterpretation of bodily symptoms and contributing to faster symptom de-escalation. In contrast, a stronger tendency toward ES may hinder the process of effectively dealing with the intervention contents of CR. In MB-I, the direction of possible moderation is not as clear as it could facilitate or hinder treatment success. By investigating these interactions, the present study aims to improve the personalization of momentary interventions in the future, thereby improving long-term feasibility, acceptance, and therapeutic impact for individuals suffering from SSD.

Taken together, treatment efficacy in SoMi is expected to be determined not only by its intervention content but also by certain individual differences. In particular, baseline levels of CPS and habitual use of ERS emerge as theoretically meaningful moderators that can facilitate or hinder engagement with and responsiveness to this EMI. With these considerations in mind, the following chapter introduces the research questions and specific hypotheses of the current investigation.

Research Question and Hypotheses

As outlined in the preceding chapters above, a primary treatment goal in SSD is to reduce subjective somatic symptom severity. Through this reduction, psychological distress, functional or occupational impairment may be alleviated, and the diminished quality of life may be restored (Henningsen, 2018). EMIs are emerging as a new treatment method that can deliver brief interventions in daily life. EMIs have already shown promising findings across depression, anxiety, and other conditions, but evidence on mechanisms and moderators remains limited. For SSD specifically, SoMi appears feasible and has the potential to substantially reduce somatic symptom intensity, but research on brief, event-based EMIs targeting acute symptom episodes is limited. Again, with open questions about who benefits most

Against this background, the present study aims to evaluate the immediate application of brief CR-Is and MB-Is, which can effectively reduce momentary symptom intensity in individuals with SSD. This corresponds to *research question 1* (RQ1). Subsequently, it was hypothesized that:

H1a: The Music-Based intervention will lead to a greater short-term reduction in somatic symptom intensity compared to the control condition without intervention.

H1b: The Cognitive-Reappraisal intervention will lead to a greater short-term reduction in somatic symptom intensity compared to the control condition without intervention.

Furthermore, as presented in the prior chapters, identifying psychological factors that promote or impede treatment success is of central importance and represents a key goal in SSD (Smakowski et al., 2024). Certain individual differences can determine whether participants engage with and benefit from digital, momentary, low-threshold interventions, especially those lacking constant therapeutic guidance. Accordingly, the *second research question* (RQ2) examines whether baseline CPS and habitual use of ER strategies (CR and ES) moderate the effectiveness of this EMI and whether these moderation effects differ across the intervention conditions.

H2a: Higher baseline chronic perceived stress will be associated with smaller symptom reductions following the EMI conditions. This moderation effect is expected to emerge in both intervention types relative to the control condition.

H2b: Higher baseline tendencies of emotional suppression will be associated with smaller symptom reductions following the EMI conditions. This moderation effect is expected to emerge in both intervention types relative to the control condition.

H2c: Higher baseline tendencies of cognitive reappraisal will be associated with higher symptom reductions following the EMI conditions. This moderation effect is expected to emerge in both intervention types relative to the control condition.

Method

Participants

SoMi targets adults aged 18-65 suffering from SSD whose somatic complaints cause substantial distress and functional impairment in daily functioning.

Enrolment: Eligibility and Exclusion Criteria

Enrolment takes place in Vienna and is conducted primarily via flyers distributed in (a) sample-specific places (e.g., hospitals, physical therapy centers, or adequate online forums) and (b) sample-non-specific places (e.g., universities, libraries, or supermarkets). Flyers include basic study information and provide contact information, along with a QR code that links to an initial screening survey for eligibility assessment. Primary exclusion criteria are:

- prior SSD diagnosis
- presence of chronic physical illnesses that could fully account for somatic symptoms
- current psychosis, current bipolar disorder, current self-injurious behavior, current suicidality, current psychotherapy
- alcohol, drug, or medication dependence within the past six months

Research Design

This investigation is being conducted as part of an ongoing project that aims to improve symptomatology associated with SSD. The project utilizes an EMI, using MB-I and CR-I, and investigates whether this can reduce symptom severity and related impairment among adults with SSD.

The SoMi study follows a longitudinal within-subject design spanning six weeks per participant. Because of daily repeated assessments, SoMi can assess quantitatively both immediate (within 20 minutes after each intervention) and longer-term effects (changes across pre- and post-study assessments). During the 4-week intervention phase, allocation to the intervention conditions is randomized at each eligible assessment event. Thus, all participants are exposed to both active interventions and the control condition. Overall, SoMi represents a within-subjects format embedded in a quantitative experimental research design. SoMi is implemented in participants' everyday lives, combining event-based and time-based assessments, with multiple measurements per day.

The parent project aims to recruit around 50 participants to achieve adequate statistical power and generalizability. The present investigation serves as a preliminary exploratory analysis based on data from the first 10 participants who have already completed the entire study protocol.

Procedure

Ethical Considerations

The SoMi-study was approved by the responsible Ethics Committee and conducted in accordance with the Declaration of Helsinki and applicable data protection regulations (World Medical Association, 2013). The study is non-invasive, and there are unlikely to be negative consequences or risks, as the program can be integrated into everyday life. Rather, engagement is expected to positively impact participants as the present study intends to improve symptoms and general well-being. Another clearly stated goal is to gain new knowledge of intervention programs specifically designed for SSD. Apart from individuals suffering from SSD, no other vulnerable populations are intentionally included.

Before study initiation, participants are extensively informed on multiple occasions about the general aim and topic of this investigation, inclusion and exclusion criteria, duration, content, voluntariness of participation, and monetary compensation of 120 EUR in the case of full compliance. Furthermore, they are informed that their data will be used for research purposes only and handled confidentially.

During the baseline screening, participants are instructed to create a personal code. By this, all datasets are anonymized, and privacy is secured, as participants' study responses are not linkable to their identities. All this information is presented verbally to participants again during a personal meeting when distributing the study material in the psychological faculty. Finally, all participants provide written informed consent prior to participation and are informed of their right to withdraw at any time without penalty.

Recruitment and Baseline Assessment of Moderators

Individuals who fully complete the initial online screening via the QR code on distributed flyers and meet all initial criteria are then contacted by the research team. During a subsequent phone call, they are then interviewed in greater depth regarding their bodily complaints and are provided with detailed information about the study. SSD diagnosis is established using a semi-structured clinical telephone interview. Once an SSD diagnosis is made, participants are informed in detail about the study and, after giving verbal consent to participate, an appointment is scheduled to receive the study materials. Following the phone call and prior to the personal meeting, participants are sent a comprehensive baseline battery and are instructed to complete it before initiation of the EMI. In addition to sociodemographic

information (e.g., age, gender, education level), the full assessment includes the German versions of multiple psychological measures. Here, the baseline assessments of CPS, ES, and CR are conducted.

During the personal meeting, participants sign the informed consent, receive the study smartphone (if needed), the study manual, and, if necessary, access to a Spotify account to ensure ML without interruptions.

Study Procedure

As noted above, this investigation uses an intra-individual randomized experimental design. The actual EMI comprises a three-phase assessment period totaling 42 days: a 7-day baseline phase, a 28-day intervention phase, and a 7-day post-intervention phase. Data are collected multiple times per day via the mobile application *movisensXS* (movisens GmbH, 2023).

Across all three phases, participants are instructed to complete time-based assessments at 11:00 A.M., 4 P.M., and in the evening before going to sleep. Here, time-based prompts are delivered by the application. The evening survey can be self-initiated by pressing a button on the *movisensXS* app on the mobile device before going to sleep. If it is not initiated, a reminder is sent at 9 P.M.

In addition to these time-based assessments, participants complete event-based assessments whenever they experience distressing bodily complaints or when these complaints are felt more strongly than usual. These self-initiated reports are completed in real time, as closely as possible to the onset of increased symptom distress. Immediately after each event-based report, participants receive a brief questionnaire, followed by a second questionnaire 20 minutes after the self-initiated report. This procedure allows for short-term pre-post comparisons around each intervention event.

During the 4-week-long intervention phase, on each day with an eligible event-based report or at the evening assessment, participants are randomly assigned to one of the following three conditions. (1) MB-I (2) CR-I (3) no intervention (control condition). At each randomization, there is a 25 % chance of assignment to MB-I, a 25 % chance of receiving CR-I, or a 50 % chance of assignment to the control condition. As explained above, these event-based measurements occur after the self-initiated report of bodily symptoms that are more distressing than usual, or before going to bed/at 9 P.M. When assigned to MB-I or CR-

I, participants complete the respective exercises and then receive a follow-up questionnaire 20 minutes later. Comparable brief digital interventions have demonstrated efficacy throughout various mental health domains (see reviews by Kurth et al., 2020; Morello et al., 2023). In the control condition, participants receive no instructions and are instructed to continue with their current activity. Overall, this procedure results in repeated within-participant randomization across the entire study period. Appendix A depicts a detailed graphic visualization of SoMi.

Assessment Instruments and Measurement

Intervention

The type of intervention (MB-I, CR-I, or control) serves as the central independent variable and is randomized within participants following a within-subject design. Each intervention condition will be presented to all participants repeatedly during the 4-week intervention phase.

Music-based Intervention. Participants are instructed to create a personalized playlist containing 25-30 music pieces they themselves perceive as happy. Following moments of distressing physical symptoms and associated heightened impairment due to their symptom experience, they listen to their self-selected playlist for approximately ten minutes. This intervention builds on Feneberg et al. (2021), who showed good feasibility and positive qualitative results, with feedback indicating that the intervention was experienced as “easy to use, novel, and pleasant”. While various forms of MB-I have been investigated, approaches that incorporate individual preferences and promote autonomy and self-management appear to be particularly effective (Cournoyer, Lemaire, & Perreault, 2024). Supporting this notion, Garza-Villarreal et al. (2017) demonstrated that self-selected music elicits stronger emotional and regulatory effects than researcher-selected music.

Cognitive Reappraisal Intervention. The CR-I is adapted from Kleinstäuber et al. (2019). Participants write down thoughts related to their somatic symptoms, then actively reinterpret them from a more constructive, less threatening perspective. They subsequently reread their written symptom description while applying alternative, more adaptive cognitions. The intervention lasts about 5 minutes and is delivered in participants’ everyday lives, making it a low-threshold, highly feasible strategy.

For instance, the thought “my muscle twitching is a serious sign of disease from which I will die, and it will never go away” may be reappraised as “This is likely tension- or stress-related, as I have been repeatedly medically examined; it is very unlikely to indicate a fatal nerve disease”. Such restructuring can break the cycle of catastrophic interpretations, anxiety, and hypervigilance towards somatic sensation, ultimately helping to reduce perceived symptom intensity.

Control Condition. In the control condition, participants are instructed to continue what they were doing before, and no intervention will occur.

Intervention Condition Coding. Because each intervention condition is analyzed independently, it is treated as a categorical predictor. It will be coded as follows: 1 = Music Listening Intervention (MB-I); 2 = Cognitive-Reappraisal Intervention (CR-I); and 3 = Control Condition (no intervention).

Somatic symptom intensity

Momentary somatic symptom intensity is assessed using a *visual analog scale* (VAS; 0 = “not intense at all”, 100 = “extremely intense”). This approach is consistent with the recommendations of the EURONET-SOMA group for assessing somatic symptom burden in clinical and research settings (Rief et al., 2017). The scale defaults to 50, and participants adjust the slider to reflect their current subjective experience of symptom intensity.

Participants were instructed to complete the VAS before and 20 minutes after each assigned intervention condition.

Short-term treatment efficacy is operationalized as the numerical change in VAS score from pre-intervention to 20 minutes post-intervention. This difference score constitutes the variable “treatment efficacy” used in subsequent analysis. By modeling change scores rather than raw post-intervention values, potential confounding from baseline intensity differences at the start of each intervention is reduced. Treatment efficacy is the sole dependent variable in this analysis.

For example, if the VAS score is 87 before the intervention and 56 afterward, the treatment efficacy score is 31. If the pre-score were 91, raw scores would not account for the greater reduction in somatic symptom intensity. This conceptualization, on the other hand, accounts for the greater reduction, as treatment efficacy in this case would be 60.

Thus, higher values indicate greater reductions in somatic symptom intensity and, consequently, better short-term treatment efficacy.

Only intervention units with complete pre- and post-intervention VAS ratings of somatic symptom intensity are included in the analysis (complete case approach). If pre-, post-, or both measurements are missing, treatment efficacy cannot be estimated, and the corresponding intervention event will be excluded without exception.

Chronic Perceived Stress

CPS is measured via the German version of the *Perceived Stress Scale* (PSS-10; Cohen et al., 2014), a widely used and well-validated instrument assessing subjective stress levels (E.-H. Lee, 2012): The PSS-10 captures the extent to which situations are appraised as unpredictable, uncontrollable, and overwhelming over the past month.

The scale consists of 10 items on a 5-point Likert scale ranging from 0 (“never”) to 4 (“very often”). An example item is: “How often have you been upset in the last month because something unexpected happened?” / “Wie oft waren Sie im letzten Monat aufgewühlt, weil etwas Unerwartetes passiert ist?”. Four positively worded items are reverse-scored: (e.g., “In the last month, how often did you feel that things were developing in your favor?” / “Wie oft hatten Sie im letzten Monat das Gefühl, dass sich die Dinge zu Ihren Gunsten entwickeln?”).

Item scores are summed to a total score ranging from 0 to 40, with higher scores indicating greater perceived chronic stress. The PSS-10 has demonstrated good psychometric properties and is suitable for both clinical and non-clinical populations (Cohen et al., 2014).

Emotion Regulation

Emotion regulation is assessed using the German adaptation of the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). The ERQ measures dispositional use of specific ER strategies and comprises two distinct subscales: Cognitive Reappraisal (CR) and Expressive Suppression (ES).

The ES-subscale contains four items: (e.g., “I keep my emotions to myself” / “Ich behalte meine Gefühle für mich”). The CR-subscale consists of six items (e.g., “When I want to feel less negative emotion, I change the way I’m thinking about the situation” / “Wenn ich

weniger negative Emotionen empfinden möchte, ändere ich meine Sichtweise auf die Situation”).

All items are rated on a 7-point Likert scale ranging from 1 (“strongly disagree”) to 7 (“strongly agree”) with higher scores reflecting greater habitual use of the respective strategy.

The CR-subscale shows excellent reliability ($\alpha = .89-.90$), while the ES-subscale exhibits acceptable reliability ($\alpha = .76-.80$; Preece et al., 2020). Moreover, the ERQ is appropriate for use across all age groups and is therefore suitable for the present sample.

All moderators (CPS, CR, ES) were assessed at baseline using validated German-language versions of the respective questionnaires prior to the start of the EMI.

Statistical Analysis

Five variables were operationalized for the present analysis. Intervention condition and treatment efficacy were used to address RQ1. For RQ2, the baseline moderators CPS, ES, and CR were included as between-subject predictors.

All analyses were conducted in IBM SPSS Statistics, Version 31.0.1.0 (IBM Corp., 2024). After data were downloaded from the movisensXS application, intervention-level data were merged with baseline ERQ and PSS-10 scores to create the final analysis data set.

Data were analyzed using *linear mixed models* (LMMs). This approach was chosen because the within-subject randomization of the intervention conditions (MB-I, CR-I, and control) provided a two-level hierarchical structure, with repeated measurement occasions (Level 1) nested within participants (Level 2) over time. At Level 1, within-subject variables included intervention condition and pre-post changes in somatic symptom intensity (treatment efficacy). At Level 2, between-subject predictors included CPS, ES, and CR.

LMMs allow for simultaneous estimation of within-subject effects (e.g., intervention vs. control), between-subject predictors (CPS, CR, and ER), and also their interactions (e.g., CR x intervention condition 1) (Brauer & Curtin, 2018). Furthermore, LMMs are well-suited for intensive repeated-measure designs with nested data structure (Magezi, 2015). This is the case in SoMi, as measurement occasions are nested within individuals, and conditions are nested within multiple days or weeks. Finally, this method can flexibly accommodate possible unequal numbers of observations (e.g., unequal numbers of intervention events per participant) (Singmann & Kellen, 2019).

Only intervention units with complete pre- and post-intervention data were included in the analysis, using a complete-case approach. Model assumptions were evaluated using graphical diagnostics of residuals and random effects (Magezi, 2015). Effect sizes and 95% confidence intervals were reported for all primary and secondary effects. All parameter estimations were on *restricted maximum likelihood* (REML).

To evaluate the short-term efficacy of SoMi (RQ1), pre- to post-intervention changes in somatic symptom intensity served as the dependent variable. Fixed effects included intervention conditions (MB-I, CR-I, Control). Random intercepts for participants were specified. Random slopes were added when supported by the data, and when model fit values indicated a better fit (see Appendix B)

In a second step, baseline moderator variables, which are CPS, ES, and CR, were added as between-subject predictors (RQ2). Cross-level interaction terms (e.g., ES x CR-I) tested whether these baseline characteristics moderated short-term intervention effects. Each moderator was analyzed in a separate LMM for reasons of multicollinearity, convergence, statistical power, and finally, interpretation of the subsequent findings (Montoya, 2019). Again, random intercepts for participants were specified to account for the nested data structure. As in RQ1, random slopes were added when justified by the data and model fit indices (see Appendix B).

Results

Descriptives

SoMi – as a preliminary analysis from the parent-study - included N = 10 participants who completed the full 6-week EMI prior to this analysis, and the closing date was 01/01/2026. The final sample consisted of 3 men and 7 women aged 22-39 years ($M = 26.2$). All participants had at least a high school diploma, and five held a university degree.

Across all 10 participants, a total of 306 intervention events triggered by self-initiated reports of somatic distress or by the evening assessment during the 4-week-long intervention phase were recorded. No intervention events were included in the baseline or post-intervention period.

77 events were in the MB-I condition, 78 in the CR-I condition, and 151 in the control condition. This shows that randomization worked, given the previously established quota. However, because many events lacked either a pre- or post-intervention entry, only 42

complete intervention events were available for analysis of treatment efficacy. Of these, 23 corresponded to the control condition, 9 to the music-listening condition, and 10 to the cognitive reappraisal condition (see Table 1).

Table 1

Processed Cases for Each Intervention Condition

Intervention Condition	Valid Cases (N)	%Valid	Missing Cases (N)	% Missing	Total (N)	% Total
Music-Based	9	11.7	68	88.3	77	100.0
Cognitive-Reappraisal	10	12.8	68	87.2	78	100.0
Control (no intervention)	23	15.2	128	84.8	151	100.0

Descriptive statistics and boxplots were used to examine perceived treatment efficacy (i.e., short-term pre-post symptom change) across the three experimental conditions. Across all conditions combined, the overall mean treatment efficacy score was $M = 8.12$; $SD = 11.59$. Scores ranged from -12.00 (meaning a short-term increase in somatic symptom intensity after intervention condition) up to 43.00 . A more detailed descriptive analysis of treatment efficacy indicated that the CR-I showed the highest mean symptom reduction ($M = 12.50$, $SD = 15.35$, $95\% CI [1.52, 23.48]$, range = -12.00 to 43.00). The MB-I showed a lesser reduction of symptoms ($M = 9.67$ ($SD = 12.81$, $95\% CI [-0.18, 19.51]$, range = -8.00 to 31.00). The control condition demonstrated the lowest mean change ($M = 5.61$, $SD = 8.84$, $95\% CI [1.79, 9.43]$, range = -10.00 to 23.00). Visual inspection of the boxplots suggested that CR produced the greatest symptom reduction but also the widest range of individual responses, whereas control condition outcomes were smaller and more consistent. Thus, estimated marginal means indicated a descriptive pattern in the expected direction, with the highest treatment efficacy observed for cognitive reappraisal ($M = 12.50$), followed by music listening ($M = 9.67$), and the lowest success in the control condition ($M = 5.61$).

Regarding all baseline predictors, participants exhibited average habitual use of CR ($M = 3.62$, $SD = 1.69$, $95\% CI [2.41, 4.82]$, range: 1.0-6.5) and ES ($M = 4.08$, $SD = 0.88$ $CI [3.44, 4.71]$, range: 3.0-6.55) on the ERQ subscales. This interpretation is based on community

percentile norms established in a Polish sample, which classify scores below the 15th percentile as low, scores between the 16th and 84th percentile as average/typical, and scores at or above the 85th percentile as high use of strategy (Larionow et al., 2025). Reappraisal scores were approximately symmetrically distributed, whereas suppression scores displayed slight positive skew.

CPS on the PSS-10 displayed high descriptive values ($M = 30.00$, $SD = 6.91$, $CI [25.06, 34.95]$, range: 21-42), surpassing established cutoffs for high stress (≥ 27) (Cohen et al., 2014) and, with moderate right skew, indicating the sample's elevated load of distress.

Inferential statistics

Hypothesis 1: Treatment Efficacy of SoMi

To test the first hypothesis, an MLM with random participant intercepts was estimated. Treatment efficacy was entered as the dependent variable, and intervention conditions (control, MB-I, CR-I) were included as fixed effects.

First, an unconditional null model with random intercepts for participants was fitted to estimate the *intraclass correlation coefficient* (ICC). The ICC was 0.20, indicating that approximately 20 % of the variance in treatment efficacy was attributable to between-person differences, with the remaining 80% at the within-person level. This value justifies the use of MLMs, as ignoring this dependency could increase Type I error rates in single-level models (Devine et al., 2024).

Assumptions of normality were evaluated by visual inspection of histograms and Q–Q plots of the model residuals (see Appendix C). Q–Q plots showed that points closely followed the expected diagonal line, supporting approximate normality. Formal tests further confirmed this: The Shapiro–Wilk test was non-significant, $W = .98$, $df = 42$, $p = .49$, and the Kolmogorov–Smirnov test with Lilliefors correction was also non-significant, $D = .09$, $df = 42$, $p = .20$. These results show that the residuals did not significantly deviate from a normal distribution.

Because a random-intercept random-slope model did not provide a better fit (Appendix B), only a random-intercept model was retained, with intervention condition (control, MB-I, CR-I) entered as a fixed effect and participants as a random effect. The multilevel model revealed no significant effect of intervention on treatment efficacy, $F(2, 36.86) = 1.31$, $p = .28$.

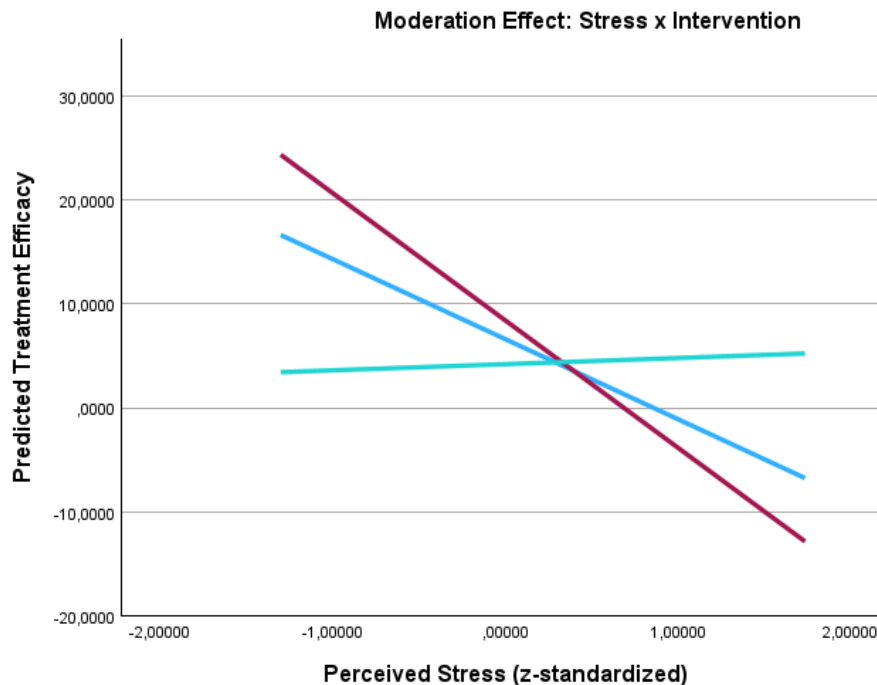
Furthermore, parameter estimates indicated that neither music listening ($\beta = 3.20$, $SE = 4.13$, $p = .46$) nor cognitive reappraisal ($\beta = 5.71$, $SE = 3.90$, $p = .17$) differed significantly from the control condition. Bonferroni-corrected pairwise comparisons showed no significant differences between interventions. Thus, Hypothesis 1 was not supported.

Hypothesis 2a: Chronic Perceived Stress and Treatment Efficacy of SoMi

To test whether baseline CPS moderated the effect of intervention condition on treatment efficacy, an MLM was estimated with treatment efficacy as the dependent variable. The model included CPS (PSS-10 total score, z-standardized), intervention condition, and their interaction as fixed effects, along with a random participant intercept to account for the nested data structure. Again, the random-intercept model showed better fit than the corresponding random-slope model (see Appendix B).

There was no significant main effect of intervention conditions, $F(2, 33.88) = 0.63$, $p = .54$, nor a significant main effect of CPS, $F(1, 18.09) = 2.95$, $p = .10$. Furthermore, the interaction term between intervention conditions and CPS did not reach statistical significance $F(2, 34.36) = 2.53$, $p = .95$, indicating that baseline CPS did not significantly moderate the effect of intervention condition on treatment efficacy.

No significant interaction between CPS and the MB-I was observed ($t[34.75] = -1.23$, $p = .23$, 95% $CI[-21.96, 5.41]$) nor for the reference group. Importantly, however, a significant interaction between CR-I and baseline CPS ($t[35.18] = -2.09$, $p = .044$, 95% $CI[-25.50, -0.35]$). Higher baseline stress was thus associated with reduced treatment efficacy, specifically in this intervention condition (see Figure 1). However, given the non-significant overall interaction ($F[2, 34.19] = 2.12$, $p = .135$), the subgroup effects should be interpreted with caution as exploratory findings.

Figure 1***Moderation of Intervention Condition 2 (CR-I) by Baseline Perceived Stress (CPS)***

Note: MB-I = blue; CR-I = red; Control = turquoise

Hypothesis 2b: Suppression and Treatment Efficacy of SoMi

To examine whether ES moderated the relationship between intervention condition and treatment efficacy, an MLM was estimated with treatment efficacy as the dependent variable. Fixed effects included intervention group, ES (z-standardized ERQ suppression mean score), and their interaction. A random intercept for participants was included to account for repeated measurements.

The random-intercept-random-slope model for intervention failed to converge and showed signs of overparameterization (Appendix B). Due to insufficient model convergence and unstable variance–covariance estimates, these results were not further interpreted. All substantive conclusions regarding the moderating role of suppression are based on the converged random-intercept model, which will be presented in the following:

The analysis first showed a significant main effect of intervention condition, $F(2,35.40) = 4.31, p = .021$. This indicates that, when holding ES constant (i.e., evaluated at

its mean), treatment efficacy differed between the three intervention conditions. This reflects the overall (“real”) intervention effect in the model.

The main effect of ES was not statistically significant, $F(1,24.65) = 2.78, p = .11$, suggesting that ES was not directly associated with treatment efficacy; averaged across intervention conditions, ES was not associated with treatment.

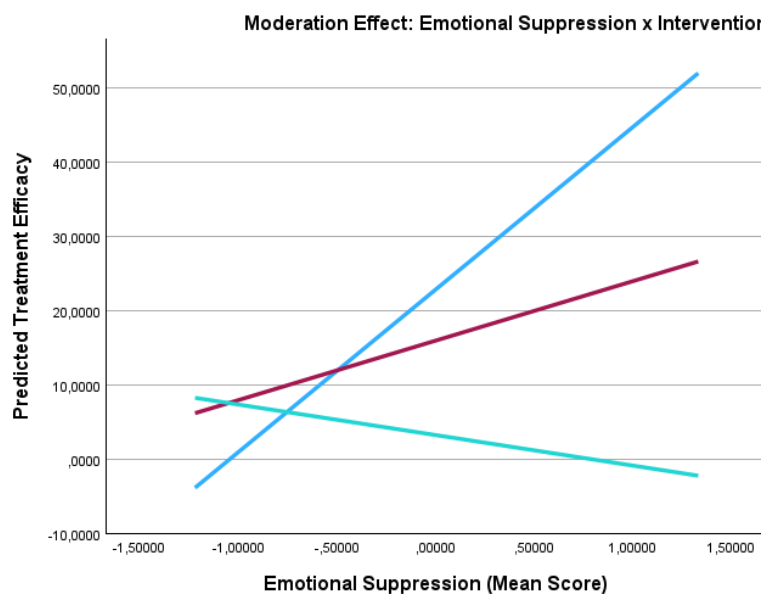
Importantly, in the next step, the interaction between intervention condition and ES was significant, $F(2,23.56) = 3.35, p = .046$, indicating that the effect of intervention condition on treatment efficacy is dependent on the individual's level of ES.

To give a more detailed picture of the specific interaction effects, a significant positive interaction was found between suppression and Intervention Condition 1 (MB-I) ($t[35.73] = 2.33, p = .025, 95\% CI [3.33, 47.86]$). This indicates that higher baseline ES were associated with greater treatment efficacy in this condition (see Figure 2). The corresponding interaction for Intervention Group 2 (CR-I) was not statistically significant ($t[35.99] = 1.54, p = .131, 95\% CI [-3.82, 28.21]$).

This evidence indicates that higher baseline suppression enhanced short-term treatment efficacy in the MB-I. This finding is contrary to the anticipated results. Thus, H2b was not supported.

Figure 2

Moderation of Intervention Condition 1 (MB-I) by Baseline ES



Note: MB-I = blue; CR-I = red; Control = green

Hypothesis 2c: Cognitive Reappraisal and Treatment Efficacy of SoMi

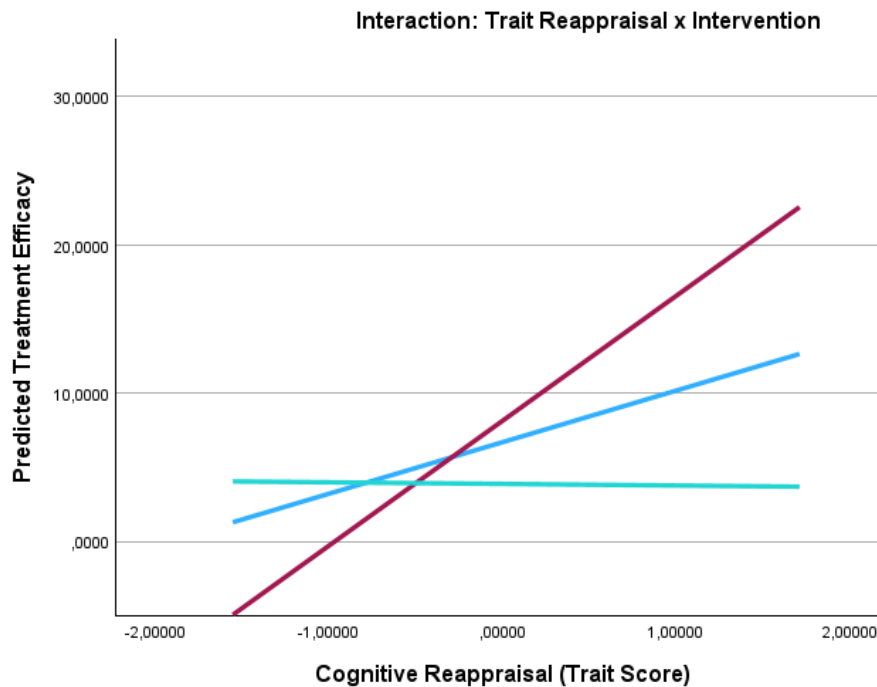
To examine whether cognitive reappraisal moderated the relationship between the intervention conditions and treatment efficacy, a linear mixed-effects model with a random participant intercept was estimated. Fixed effects included intervention conditions, CR (z standardized ERQ reappraisal mean score), and their interaction.

Again, the model with random intervention slopes failed to converge and showed signs of overparameterization (see Appendix B). Because of the lack of convergence and unstable variance–covariance estimates, those results were not interpreted further. All substantive conclusions regarding the moderating role of cognitive reappraisal are based on the converged random-intercept model, which will be presented in the following:

There was no significant main effect of intervention conditions, $F(2,34.04) = 0.71, p = .50$, indicating that – at the mean level of CR - treatment efficacy did not differ between intervention conditions. The main effect of CR was also not significant, $F(1,15.75) = 1.96, p = .18$, suggesting that CR was not directly associated with treatment efficacy.

The overall interaction between intervention conditions and CR was not statistically significant, $F(2, 34.19) = 2.12, p = .14$, indicating that CR did not reliably moderate the effect of intervention conditions on treatment efficacy.

Although inspection of the fixed-effect estimates revealed a significant coefficient for Intervention Condition 2 (CR-I) relative to the reference group ($t[33.89] = 2.05, p = .048, 95\% CI [0.07, 17.19]; b = 8.63$), and a smaller, non-significant positive interaction ($t[34.29] = 0.66, p = .513$) for intervention condition 1 (MB-I), those subgroup effects should be interpreted with caution as exploratory findings only, given the non-significant overall interaction ($F[2,34.19] = 2.12, p = .135$). Thus, these outcomes are not taken as evidence for a moderating effect of CR on the short-term efficacy of SoMi. For a full inspection of all study outcomes, see Appendix D.

Figure 3***Moderation of Intervention Condition 2 (CR-I) by Baseline CR (ZERQ-CR)***

Note: MB-I = blue; CR-I = red; Control = green

Discussion

The current investigation examined whether an EMI, including MB-I and CR-I, could reduce acute symptom intensity among individuals affected by SSD. Both micro-interventions were delivered repeatedly in moments of heightened bodily discomfort, when distress and worry are most pronounced. Thus, RQ1 emerged to determine if each intervention condition produced meaningful, acute somatic symptom reductions in individuals' everyday lives.

A second aim was to examine three variables that might influence EMI-effectiveness. The development of new methodological designs to identify and explore mediators and moderators of clinical course and the development of new, effective interventions to personalize treatment (Van Der Feltz-Cornelis et al., 2018) have been identified as key research targets in SSD. Accordingly, the current investigation focused on three clinically relevant candidates: chronic perceived stress (CPS), expressive suppression (ES), and cognitive reappraisal (CR). Results indicate that this EMI is not universally effective for reducing acutely experienced symptoms in SSD. Moreover, results showed that the

effectiveness of these micro-interventions depends on emotion-regulatory profiles and tonic stress levels.

SoMi-effectiveness

The first research question (RQ1) examined overall effectiveness by comparing treatment efficacy following repeated music listening and cognitive reappraisal against a no-intervention control condition.

As described above, across 42 interventions with complete data, no statistically reliable differences emerged between intervention conditions. Thus, no significant short-term reduction in somatic symptom intensity was detected when interventions were delivered during acute moments of symptom perception. Nevertheless, descriptive analyses revealed a pattern in line with theoretical expectations: CR-I showed the highest average treatment efficacy (i.e., the greatest short-term reductions in somatic symptom intensity), followed by MB-I, and finally the control condition. Although these differences did not reach statistical significance, they may still reflect intervention effects that are difficult to detect. Rather than indicating a lack of SoMi effectiveness, these null findings can be explained by several methodological and theoretical considerations:

First, the small sample and limited compliance substantially reduced statistical power and the ability to detect small to medium-sized effects (Oleson et al., 2022). This is problematic because a comprehensive review by Schueller et al. (2017) found, for instance, that EMIs yielded only small to medium effects on within-person change in depressive and anxiety symptoms. Small effect sizes are rather the norm than an exception in this specific methodological design. Adding evidence, a meta-analysis by Versluis et al. (2016) including 33 studies (43 samples; $N = 1301$) using either a within- or between-subject design found a small-to-medium effect of EMIs on mental health and positive psychological well-being, with no differences between outcome types. Thus, even after accounting for the nested data structure using MLM (Magezi, 2015), the limited sample size ($N = 10$) and the limited number of analyzable events ($N = 42$) reduced the ability to detect small but meaningful EMI effects.

Supporting this rationale, an exploratory study testing an EMI to reduce perceived stress during workdays among 15 workers (10 in the experimental group and 5 in the control) found no quantitative effects on stress. However, subsequent qualitative interviews revealed promising "somatic, behavioral, and cognitive evolution" despite these null findings (Perreau

et al., 2023). The authors concluded that EMIs often require a greater sample and prolonged, repeated use to yield measurable quantitative benefits. As a preliminary SoMi analysis within the larger parent study, this investigation was clearly underpowered. If low compliance rates persist in subsequent analyses, this should be assessed qualitatively in follow-up analyses. Future investigations should therefore prioritize larger samples and strategies to improve compliance.

Furthermore, micro-interventions like these may unfold cumulatively over time rather than instantaneously. Thus, findings may be significant in pre-post and follow-up comparisons of the variables of interest, as both intervention conditions in SoMi aim to promote habitual, long-lasting changes in emotion regulation and coping behavior. Such regulatory patterns typically require repeated use across different rather than emerging after just a handful of applications (Wang & Yin, 2023). Thus, more data and a post-EMI follow-up could better capture cumulative effects.

There are also important situational factors that may explain why immediate intervention effects did not emerge: SoMi was designed to intervene precisely in moments of heightened symptom distress. These moments represent the most challenging context for intervention in SSD because individuals often experience disorder-specific distress, anxiety, emotional overload, and reduced cognitive capacity (Löwe et al., 2024). At the same time, an experimental study by Schnabel, Schulz, et al. (2022) showed that SSD individuals were just as effective as the control group in implementing ER strategies. However, the SSD group found this implementation significantly more effortful. This increased effort further constrains deliberate reframing during intense states, even if such strategies may function in less intense contexts. This means that SoMi micro-interventions may be delivered in a poor setting, without prior therapist instructions or real-time support.

Supporting this idea, behavioral and neural data show that ER strategy use shifts with emotional intensity (Shafir et al., 2015): in high-intensity states, distraction is preferred and more effective than CR in reducing negative affect and neural emotional processing for short-term modulation because it blocks highly potent information early. Neural measures indicated that it requires less cognitive effort than CR. In lower-intensity contexts, on the other hand, CR is considered more beneficial for long-term emotional processing and adaptation. Furthermore, during the anticipation stage of ER, participants favored CR in low-intensity situations and distraction in high-intensity situations. Thus, emotional intensity systematically

shapes both *the* strategy people choose and *how well* it works. SoMi intervened exactly at these high-intensity moments. This may have been a big problem and represents an intervention-design misfit.

Finally, EMIs are, by definition, designed to operate in highly variable, real-world contexts (Balaskas et al., 2021) and often lack internal validity. Therefore, SoMi effectiveness may depend more strongly on individual characteristics and situational factors that influence responsiveness to treatment. The absence of a significant overall main effect suggests that EMIs may not exert uniform benefits across individuals. Instead, these findings are consistent with the notion that momentary interventions are most effective when personalized to individual needs (Dao et al., 2021; Lai-Tan et al., 2023), a conclusion further supported by the section below.

Individual differences influencing treatment efficacy

RQ2 examined how individual factors influence treatment efficacy, aiming to generate insights for personalizing SSD therapies in real-world ecological contexts. The moderation analyses demonstrated intervention-specific sensitivity to baseline individual differences, providing partial support for H2. While omnibus interaction effects were often marginal, simple slopes consistently revealed condition-specific moderation patterns (see Appendix C)

Chronic Perceived Stress and Treatment Efficacy

While the overall interaction of CPS and intervention conditions demonstrated a non-significant trend, a specific, significant interaction emerged between CR-I and CPS. High baseline CPS made the CR counterproductive, showcasing an increase in symptom intensity after intervention prompts. Individuals with SSD who experience high CPS may struggle to execute resource-demanding CR-I. Consequently, although CPS does not appear to be a robust moderator in SoMi, these findings indicate that its impact varies significantly across intervention conditions. The following section aims to give some theoretical explanations:

Why SSD-affected individuals cannot effectively use CR under high stress is likely due to several factors: Higher perceived uncontrollable stress is associated with increased use of non-executive strategies and decreased use of executive strategies (e.g., CR) (Miklósi et al., 2014). Stress has been shown to affect executive functions like cognitive flexibility, behavioral inhibition, and working memory (Girotti et al., 2024). Finally, experimental

evidence suggests that CR is cognitively taxing and depends on limited executive resources. In an event-related potential investigation, high working memory load impaired CR but facilitated distraction compared to low working memory load (Adamczyk et al., 2022). This led to the conclusion that the successful implementation of CR depends on available working memory resources and fails when these resources are already depleted.

Supporting the above-presented relationships, Quinn & Joormann (2020) showed that acute stress impaired executive control, and lower executive control levels under stress were associated with reduced CR-ability and predicted higher depressive symptoms. In short, CR-implementation requires resources that are difficult to access under high tonic or state stress.

In a sample with people affected by depression, for instance, Troy et al. (2013) highlighted this context-dependent adaptiveness of ER as CR reduced depression symptoms in uncontrollable stress but increased them in controllable stress. In SoMi, self-reported somatic symptom burden likely reflects an uncontrollable situation. This leads to the idea that when somatic symptoms persist, and the individual cannot implement CR, negative cascades – such as overthinking or feelings of inadequacy – can arise, increasing tension and intensifying symptoms. This may explain why, in the CR-I-CPS interaction, the CR-I has contradictory effects: it appears to increase somatic symptom intensity after application.

Taken together, these findings suggest that CPS does not necessarily determine whether SoMi was effective, but rather for whom and when it can be most effective. Work on stress and cognitive control has repeatedly shown similar patterns (Adamczyk et al., 2022; Girotti et al., 2024; Quinn & Joormann, 2020). The present results extend this literature to SSD and to an EMI context, suggesting that under high CPS, CR-I-based micro-interventions may not only lose efficacy but can even become counterproductive in moments of acute symptom perception

This shows that interventions do not affect everyone equally, underscoring the critical need for future research to account for individual differences and move toward more tailored, personalized treatment approaches.

Expressive Suppression and Treatment Efficacy: A Surprising Interaction

Across all three moderators, ES and its interactions with intervention conditions emerged interestingly as the most robust findings. While ES alone was not directly associated with treatment efficacy, there was a significant main effect of intervention (that means

intervention conditions differ in treatment efficacy at average suppression). Furthermore, its interaction with intervention conditions was statistically significant. Higher ES-values were associated with substantially greater efficacy in the MB-I (see Figure 2). By contrast, ES showed no significant relation or a weak negative relation with efficacy in the CR-I or control condition. These results indicated that the effectiveness of the interventions varied according to individuals' baseline suppression scores.

This is a surprising but pivotal finding: ES is mostly viewed as maladaptive and has been linked to psychopathology, even though the evidence regarding its broader effects is mixed (Aldao et al., 2010; Chin & Rickard, 2014; Cutuli, 2014; Okur Güney et al., 2019). Thus, in the absence of guidance, participants scoring above the sample on the ERQ-suppression subscale were predicted to show smaller reductions in somatic symptoms of SoMi, although longitudinal evidence remains limited. Nevertheless, these results may imply that ES can be a resource in SSD when paired with adequate external regulatory tools, such as music listening (Cai et al., 2019). Chin & Rickard (2014), for instance, showed that the impact of music on well-being depended on how and why people use it, and which ER strategy between ES or CR they used.

When an intervention such as music listening is available, it may offer an alternative regulatory pathway that does not require explicit emotional engagement, thereby providing a regulatory strategy that helps to relax and distract adaptively. Unlike cognitively demanding "top-down" strategies such as CR, music primarily operates via bottom-up pathways (Lai-Tan et al., 2023). It facilitates an immediate, physiological shift in arousal and reduces attentional shifts towards threats without requiring active emotional processing (Graham et al., 2009).

The finding that higher habitual suppression predicts a better response to MB-I shows that bottom-up regulatory tools—such as music—can support individuals affected by SSD who otherwise rely on response-focused, effortful control. In this sense, suppression may function as a context-dependent resource when paired with suitable external aids rather than as a uniformly dysfunctional tendency.

Cognitive Reappraisal and Treatment Efficacy

Unlike ES, CR did not reliably moderate the effect of intervention conditions on treatment efficacy. All fixed effects, including the omnibus interaction term, were non-significant, suggesting that CR does not consistently alter the effectiveness of intervention conditions. However, there was a specific significant interaction between the CR-I and

habitual CR use (see Figure 3): Participants with higher baseline reliance on CR tended to benefit more from this intervention compared to the control condition.

Even though these findings should only be interpreted with caution and exploratory, this pattern aligns with the previously introduced idea that CR is cognitively demanding, requiring reflective processing, perspective shifting, and executive control (Adamczyk et al., 2022; Girotti et al., 2024; Strauss et al., 2016). Thus, the necessary tools for execution may be limited during moments of acute symptom perception. The ERQ is operationalized to assess the frequency of trait use, which means that higher scores indicate greater habitual use of a certain strategy (Gross & John, 2003) rather than state-execution ratios of ES or CR. Thus, even high habitual CR users may experience resource constraints in moments of distress, reducing the utility of CR-based strategies independently of habitual tendencies (Shermohammed et al., 2017).

Another possibility is that CR enhances SoMi efficacy. Participants with a high ERQ score among CR users may be more experienced. Therefore, it is easier for them than for individuals who do not regularly rely on this strategy, despite the mismatch between the situation and the task (Troy et al., 2013). Thus, unlike ES, CR showed no reliable moderation, suggesting that cognitively demanding strategies may be less effective in acute EMI contexts.

Aside from methodological constraints, the largely null and only exploratory moderating role of cognitive reappraisal is consistent with work showing that habitual use of reappraisal does not guarantee successful state implementation under high load or distress (Strauss et al., 2016). Together with evidence that the adaptiveness of reappraisal depends on personal and situational factors (Troy et al., 2013), the current findings support a shift away from global labels of “adaptive” and “maladaptive” ER strategies toward a more differentiated, precision-oriented perspective. Thus, these findings support a theoretical approach in which particular ER strategies are not adaptive or maladaptive per se; rather, their adaptiveness relies on their context (Troy et al., 2013)

In sum, SoMi adds to emerging research in the SSD and EMI fields by moving beyond average treatment approaches and systematically considering individual emotion-regulatory profiles and stress levels when designing and deploying micro-interventions. Rather than assuming that a given strategy (e.g., CR-I) will benefit all patients equally, the present results

underscore the importance of identifying “for whom” and “under which conditions” specific micro-interventions are likely to be helpful—or potentially harmful.

Methodological Considerations and Limitations

Sample Size

The present study aimed to provide nuanced insights into how individual differences moderate the effects of SoMi. Several methodological limitations should be considered when interpreting these findings.

A major limitation is the small sample size and, most of all, the limited number of analyzable intervention events (Webb et al., 2025). Although the study initially included a sufficient number of intervention events, only 42 complete cases were available for the final analysis due to missing pre- or post-VAS ratings. Excluding the control condition, only 10 and 9 intervention events across all 10 participants remained (see Table 1).

The small sample size ($N = 10$) ultimately restricts the external validity and generalizability of the findings to the broader SSD population. This young sample ($M = 26.2$) exhibited particularly high PSS-values ($M = 30$). Thus, drawing definitive and far-reaching conclusions about population-level associations is inappropriate. Observed effects – or, frankly, their absence – in this specific context do not necessarily translate into meaningful influences in broader SSD populations.

Furthermore, the low number of observations per intervention condition likely contributed to unexpected poor model fit (Schuster et al., 2020). Some models were overly complex and produced unexpectedly poor fit (higher AIC/BIC, lower R^2) compared to simpler specifications (e.g., only random-intercept models) (see Appendix A). Even more, in the moderation analysis of ES and CR, complex random-slope models failed to converge, indicating overparameterization relative to the available data structure. Thereby, simpler models that did not account as well for nested data structures had to be used for analysis. This is methodologically speaking appropriate but ultimately limits conclusions about individual differences in intervention responsiveness and may underestimate slope variability across participants (Schuster et al., 2020; Singmann & Kellen, 2019). The subsequent parent study will hopefully achieve a higher compliance rate and generate more data, providing clearer insights into these relationships. This is probable because it will have more than four times as many participants, aiming for a sample of 50.

Assessment Mismatches

In addition to limitations due to the small sample size, several mismatches between the assessment format and the nature of this investigation likely reduced the observed effects. The following section will discuss in detail why that is:

A general mismatch refers to the timing and overall context of intervention delivery across all conditions: Interventions were administered during acute symptom perception and bodily discomfort, a context characterized by heightened emotional arousal and reduced cognitive capacity (Girotti et al., 2024; Liu et al., 2019). In such moments, cognitive demanding strategies may be difficult to implement. Thus, null findings may reflect contextual constraints rather than a general lack of efficacy. This preliminary analysis examined only acute intervention effects, potentially missing a more holistic picture of SoMi's effectiveness.

Another mismatch refers to the poor fit between the assessment of treatment efficacy and the effectiveness of CR-I. CR is a strategy that requires time and practice to develop (Wang & Yin, 2023). Maladaptive cognitive structures, such as a negative perception of your own vulnerability, are unlikely to change following a few micro-interventions (Rodriguez et al., 2020). Assessing intervention effects at the level of acute, single-event responses may therefore underestimate the potential benefits that emerge only after prolonged, cumulative exposure (Perreau et al., 2023). Thus, CR could not produce measurable change regarding RQ1 even though there were theoretically plausible explanations for this interaction effect.

Finally, baseline moderator variables (CPS, ES, CR) were only assessed at the trait level. Thus, they likely failed to capture momentary fluctuations during specific EMI events fully. This trait-state mismatch likely reduced the magnitude of moderation effects. Supporting this idea, Gross showed that ERS shows stronger effects when measured at matching timescales (Gross, 1998, 2015; Gross & John, 2003). Momentary ERQ-like measures, such as “Right now, did you suppress your emotions,” would better align with the intervention context. Manipulation checks like this could help in the future to verify that participants actually used their strategies in an expected ratio.

Luckily, the following study will assess these relationships across multiple variables and more time points with a greater sample. Thereby, it will provide an urgently needed comprehensive and detailed assessment of MB-Is and CR-Is on SSD.

Future Directions

The current investigation aimed to advance understanding of SSD treatment by showing how individual differences shape the effectiveness of repeated micro-interventions during episodes of bodily discomfort. In light of the current findings, several future directions for research and clinical practice emerge.

Rather than demonstrating universal intervention effects, the results suggest that the interaction between intervention conditions and individual profiles may shape treatment efficacy. The identification of moderators and mediators of SSD, as well as the search for treatment methods with high intervention success, has been highlighted as a key priority in contemporary SSD research (Van Der Feltz-Cornelis et al., 2018). Through this, low-threshold, easily assessable, profile-matched interventions, namely “just-in-time adaptive interventions,” will become increasingly important and powerful in the next decade (Nahum-Shani et al., 2018). These interventions emphasize tailoring intervention delivery to momentary needs and individual vulnerabilities: For instance, if an individual has a certain profile – such as high values in CPS and ES – the intervention will be adjusted accordingly. In the specific case of SoMi, participants would then receive a higher ratio of MB-I and, less often, CR-I. AI-driven algorithms represent the next logical step, adapting interventions in real time based on individual prompts and overall well-being. Schueller et al. (2017) further support this perspective, noting that future EMIs might become more “personalized and sophisticated” by leveraging advanced technologies, potentially enhancing their cumulative effectiveness.

Finally, this could substantially improve the odds of successful treatment, enhance user friendliness and acceptance, and overall feasibility, ultimately leading to better treatment outcomes. Lower symptom severity has been consistently associated with improved quality of life and reduced disability (Henningsen, 2018; Sollmann, 2025). If advances in the treatment of SSD can be made, affected individuals can ultimately regain their lives and experience less distress and impairment than before. This has enormous clinical and societal implications, as future research could significantly improve SSD symptomatology and its psychobehavioral concomitants in affected individuals, and reduce healthcare costs.

References

- Abbass, A., Lumley, M. A., Town, J., Holmes, H., Luyten, P., Cooper, A., Russell, L., Schubiner, H., De Meulemeester, C., & Kisely, S. (2021). Short-term psychodynamic psychotherapy for functional somatic disorders: A systematic review and meta-analysis of within-treatment effects. *Journal of Psychosomatic Research*, *145*, 110473.
<https://doi.org/10.1016/j.jpsychores.2021.110473>
- Adamczyk, A. K., Wyczesany, M., & Van Peer, J. M. (2022). High working memory load impairs reappraisal but facilitates distraction – An event-related potential investigation. *Biological Psychology*, *171*, 108327. <https://doi.org/10.1016/j.biopsycho.2022.108327>
- Agorastos, A., & Chrousos, G. P. (2022). The neuroendocrinology of stress: The stress-related continuum of chronic disease development. *Molecular Psychiatry*, *27*(1), 502–513.
<https://doi.org/10.1038/s41380-021-01224-9>
- Ajluni, V. (2025). Integrating psychiatry and family medicine in the management of somatic symptom disorders: Diagnosis, collaboration, and communication strategies. *Journal of General and Family Medicine*, *26*(1), 12–18. <https://doi.org/10.1002/jgf2.725>
- Alalhareth, A. S. M., Alghubari, H. A. Y., Alsharman, B. S. M., Al Faraj, A. M. A., Alyami, H. M. A., Alsalem, I. Y. Y., Al Bouzbedah, H. M., Al Ajje, A. N. A., Alfuhayd, H. R. H., & Alswedan, M. A. (2024). Chronic occupational stress and health outcomes: A systematic review of recent findings. *Journal of Ecohumanism*, *3*(8), 909–917.
<https://doi.org/10.62754/joe.v3i8.4777>
- Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review*, *30*(2), 217–237.
<https://doi.org/10.1016/j.cpr.2009.11.004>
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). American Psychiatric Publishing.

- Arney, M. F., Schatten, H. T., Haradhvala, N., & Miller, I. W. (2015). Ecological momentary assessment (EMA) of depression-related phenomena. *Current Opinion in Psychology*, 4, 21–25. <https://doi.org/10.1016/j.copsyc.2015.01.002>
- Arnold, C. A., Bagg, M. K., & Harvey, A. R. (2024). The psychophysiology of music-based interventions and the experience of pain. *Frontiers in Psychology*, 15, 1361857. <https://doi.org/10.3389/fpsyg.2024.1361857>
- Balaskas, A., Schueller, S. M., Cox, A. L., & Doherty, G. (2021). Ecological momentary interventions for mental health: A scoping review. *PLOS ONE*, 16(3), e0248152. <https://doi.org/10.1371/journal.pone.0248152>
- Barsky, A. J., & Silbersweig, D. A. (2023). The amplification of symptoms in the medically ill. *Journal of General Internal Medicine*, 38(1), 195–202. <https://doi.org/10.1007/s11606-022-07699-8>
- Behm, A., Hüsing, P., Löwe, B., & Toussaint, A. (2021). Persistence rate of DSM-5 somatic symptom disorder: 4-year follow-up in patients from a psychosomatic outpatient clinic. *Comprehensive psychiatry*, 110, 152265. <https://doi.org/10.1016/j.comppsy.2021.152265>.
- Bell, I. H., Lim, M. H., Rossell, S. L., & Thomas, N. (2017). Ecological momentary assessment and intervention in the treatment of psychotic disorders: A systematic review. *Psychiatric Services*, 68(11), 1172–1181. <https://doi.org/10.1176/appi.ps.201600523>
- Berezowski, L., Ludwig, L., Martin, A., Löwe, B., & Shedden-Mora, M. C. (2022). Early psychological interventions for somatic symptom disorder and functional somatic syndromes: A systematic review and meta-analysis. *Psychosomatic Medicine*, 84(3), 325–338. <https://doi.org/10.1097/PSY.0000000000001011>

- Bigliassi, M., Karageorghis, C. I., Wright, M. J., Orgs, G., & Nowicky, A. V. (2017). Effects of auditory stimuli on electrical activity in the brain during cycle ergometry. *Physiology & Behavior*, *177*, 135–147. <https://doi.org/10.1016/j.physbeh.2017.04.023>
- Biondi, M., & Picardi, A. (1999). Psychological stress and neuroendocrine function in humans: The last two decades of research. *Psychotherapy and Psychosomatics*, *68*(3), 114–150. <https://doi.org/10.1159/000012323>
- Brauer, M., & Curtin, J. J. (2018). Linear mixed-effects models and the analysis of nonindependent data: A unified framework to analyze categorical and continuous independent variables that vary within-subjects and/or within-items. *Psychological Methods*, *23*(3), 389–411. <https://doi.org/10.1037/met0000159>
- Brazoloto, T. M., & Fujarra, F. J. C. (2024). Music therapy and music-based interventions in the treatment of pain: State of the art. *Brazilian Journal of Pain*, *7*, 1–10. <https://doi.org/10.5935/2595-0118.20240040-en>
- Cai, R. Y., Richdale, A. L., Dissanayake, C., Trollor, J., & Uljarević, M. (2019). Emotion regulation in autism: Reappraisal and suppression interactions. *Autism*, *23*(3), 737–749. <https://doi.org/10.1177/1362361318774558>
- Che, X., Luo, X., Tong, D., Fitzgibbon, B. M., & Yang, J. (2015). Habitual suppression relates to difficulty in regulating emotion with cognitive reappraisal. *Biological Psychology*, *112*, 20–26. <https://doi.org/10.1016/j.biopsycho.2015.09.011>
- Chin, T., & Rickard, N. S. (2014). Emotion regulation strategy mediates both positive and negative relationships between music uses and well-being. *Psychology of Music*, *42*(5), 692–713. <https://doi.org/10.1177/0305735613489916>
- Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, *24*(4), 385. <https://doi.org/10.2307/2136404>

Cohen, S., Kamarck, T., & Mermelstein, R. (2014). Perceived Stress Scale [Data set].

<https://doi.org/10.1037/t02889-000>

Colombo, D., Fernández-Álvarez, J., Patané, A., Semonella, M., Kwiatkowska, M., García-Palacios, A., Cipresso, P., Riva, G., & Botella, C. (2019). Current state and future directions of technology-based ecological momentary assessment and intervention for major depressive disorder: A systematic review. *Journal of Clinical Medicine*, 8(4), 465.

<https://doi.org/10.3390/jcm8040465>

Cournoyer Lemaire, E., & Perreault, M. (2024). The use of music in the treatment of chronic pain: A scoping review. *Pain Management*, 14(10–11), 579–589.

<https://doi.org/10.1080/17581869.2024.2435243>

Cutuli, D. (2014). Cognitive reappraisal and expressive suppression strategies role in the emotion regulation: An overview on their modulatory effects and neural correlates. *Frontiers in Systems Neuroscience*, 8, 175. <https://doi.org/10.3389/fnsys.2014.00175>

Dai, S., Mo, Y., Wang, Y., Xiang, B., Liao, Q., Zhou, M., Li, X., Li, Y., Xiong, W., Li, G., Guo, C., & Zeng, Z. (2020). Chronic stress promotes cancer development. *Frontiers in Oncology*, 10, 1492. <https://doi.org/10.3389/fonc.2020.01492>

Dao, K. P., De Cocker, K., Tong, H. L., Kocaballi, A. B., Chow, C., & Laranjo, L. (2021).

Smartphone-delivered ecological momentary interventions based on ecological momentary assessments to promote health behaviors: Systematic review and adapted checklist for reporting ecological momentary assessment and intervention studies. *JMIR mHealth and uHealth*, 9(11), e22890. <https://doi.org/10.2196/22890>

Davidson, A. S., Guassora, A. D., & Reventlow, S. (2016). Understanding the body–mind in primary care. *Medicine, Health Care and Philosophy*, 19(4), 581–594.

<https://doi.org/10.1007/s11019-016-9710-9>

- De Witte, M., Spruit, A., Van Hooren, S., Moonen, X., & Stams, G.-J. (2020). Effects of music interventions on stress-related outcomes: A systematic review and two meta-analyses. *Health Psychology Review, 14*(2), 294–324. <https://doi.org/10.1080/17437199.2019.1627897>
- Devine, S., Uanhero, J. O., Otto, A. R., & Flake, J. K. (2024). Approaches for quantifying the ICC in multilevel logistic models: A didactic demonstration. *Collabra: Psychology, 10*(1), 94263. <https://doi.org/10.1525/collabra.94263>
- Dhabhar, F. S. (2014). Effects of stress on immune function: The good, the bad, and the beautiful. *Immunologic Research, 58*(2–3), 193–210. <https://doi.org/10.1007/s12026-014-8517-0>
- Eller-Smith, O. C., Nicol, A. L., & Christianson, J. A. (2018). Potential mechanisms underlying centralized pain and emerging therapeutic interventions. *Frontiers in Cellular Neuroscience, 12*, 35. <https://doi.org/10.3389/fncel.2018.00035>
- Elsenbruch, S. (2011). Abdominal pain in irritable bowel syndrome: A review of putative psychological, neural and neuro-immune mechanisms. *Brain, Behavior, and Immunity, 25*(3), 386–394. <https://doi.org/10.1016/j.bbi.2010.11.010>
- Feneberg, A. C., Mewes, R., Doerr, J. M., & Nater, U. M. (2021). The effects of music listening on somatic symptoms and stress markers in the everyday life of women with somatic complaints and depression. *Scientific Reports, 11*(1), 24062. <https://doi.org/10.1038/s41598-021-03374-w>
- Feneberg, A. C., & Nater, U. M. (2022). An ecological momentary music intervention for the reduction of acute stress in daily life: A mixed methods feasibility study. *Frontiers in Psychology, 13*, 927705. <https://doi.org/10.3389/fpsyg.2022.927705>
- Garza-Villarreal, E. A., Pando, V., Vuust, P., & Parsons, C. (2017). Music-induced analgesia in chronic pain conditions: A systematic review and meta-analysis. *Neuroscience*. <https://doi.org/10.1101/105148>

- Girotti, M., Bulin, S. E., & Carreno, F. R. (2024). Effects of chronic stress on cognitive function – From neurobiology to intervention. *Neurobiology of Stress*, 33, 100670. <https://doi.org/10.1016/j.ynstr.2024.100670>
- Goldin, P. R., Lee, I., Ziv, M., Jazaieri, H., Heimberg, R. G., & Gross, J. J. (2014). Trajectories of change in emotion regulation and social anxiety during cognitive-behavioral therapy for social anxiety disorder. *Behaviour Research and Therapy*, 56, 7–15. <https://doi.org/10.1016/j.brat.2014.02.005>
- Goldin, P. R., Ziv, M., Jazaieri, H., Werner, K., Kraemer, H., Heimberg, R. G., & Gross, J. J. (2012). Cognitive reappraisal self-efficacy mediates the effects of individual cognitive-behavioral therapy for social anxiety disorder. *Journal of Consulting and Clinical Psychology*, 80(6), 1034–1040. <https://doi.org/10.1037/a0028555>
- Graham, R., Robinson, J., & Mulhall, P. (2009). Effects of concurrent music listening on emotional processing. *Psychology of Music*, 37(4), 485–493. <https://doi.org/10.1177/0305735608099689>
- Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, 2(3), 271–299. <https://doi.org/10.1037/1089-2680.2.3.271>
- Gross, J. J. (2015). Emotion regulation: Current status and future prospects. *Psychological Inquiry*, 26(1), 1–26. <https://doi.org/10.1080/1047840X.2014.940781>
- Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, 85(2), 348–362. <https://doi.org/10.1037/0022-3514.85.2.348>
- Haller, H., Cramer, H., Lauche, R., & Dobos, G. (2015). Somatoform disorders and medically unexplained symptoms in primary care. *Deutsches Arzteblatt International*, 112(16), 279–287. <https://doi.org/10.3238/arztebl.2015.0279>

- Häuser, W., Hausteiner-Wiehle, C., Henningsen, P., Brähler, E., Schmalbach, B., & Wolfe, F. (2020). Prevalence and overlap of somatic symptom disorder, bodily distress syndrome and fibromyalgia syndrome in the German general population: A cross sectional study. *Journal of Psychosomatic Research*, *133*, 110111. <https://doi.org/10.1016/j.jpsychores.2020.110111>
- Hayes, S. C., & Hofmann, S. G. (2017). The third wave of cognitive behavioral therapy and the rise of process-based care. *World Psychiatry*, *16*(3), 245–246. <https://doi.org/10.1002/wps.20442>
- Hedman, E., Axelsson, E., Andersson, E., Lekander, M., & Ljótsson, B. (2016). Exposure-based cognitive-behavioural therapy via the internet and as bibliotherapy for somatic symptom disorder and illness anxiety disorder: Randomised controlled trial. *British Journal of Psychiatry*, *209*(5), 407–413. <https://doi.org/10.1192/bjp.bp.116.181396>
- Henningsen, P. (2018). Management of somatic symptom disorder. *Dialogues in Clinical Neuroscience*, *20*(1), 23–31. <https://doi.org/10.31887/DCNS.2018.20.1/phenningsen>
- Herman, J. P., McKlveen, J. M., Ghosal, S., Kopp, B., Wulsin, A., Makinson, R., Scheimann, J., & Myers, B. (2016). Regulation of the hypothalamic-pituitary-adrenocortical stress response. In Y. S. Prakash (Ed.), *Comprehensive Physiology* (1st ed., pp. 603–621). Wiley. <https://doi.org/10.1002/cphy.c150015>
- Heron, K. E., & Smyth, J. M. (2010). Ecological momentary interventions: Incorporating mobile technology into psychosocial and health behaviour treatments. *British Journal of Health Psychology*, *15*(Pt 1), 1–39. <https://doi.org/10.1348/135910709X466063>
- Hofmann, S. G., & Gómez, A. F. (2017). Mindfulness-based interventions for anxiety and depression. *Psychiatric Clinics of North America*, *40*(4), 739–749. <https://doi.org/10.1016/j.psc.2017.08.008>
- Hu, T., Zhang, D., Wang, J., Mistry, R., Ran, G., & Wang, X. (2014). Relation between emotion regulation and mental health: A meta-analysis review. *Psychological Reports*, *114*(2), 341–362. <https://doi.org/10.2466/03.20.PR0.114k22w4>

- Hüsing, P., Smakowski, A., Löwe, B., Kleinstäuber, M., Toussaint, A., & Shedden-Mora, M. C. (2023). The framework for systematic reviews on psychological risk factors for persistent somatic symptoms and related syndromes and disorders (PSY-PSS). *Frontiers in Psychiatry, 14*, 1142484. <https://doi.org/10.3389/fpsy.2023.1142484>
- Ibeziako, P., Brahmhatt, K., Chapman, A., De Souza, C., Giles, L., Gooden, S., Latif, F., Malas, N., Namerow, L., Russell, R., Steinbuchel, P., Pao, M., & Plioplys, S. (2019). Developing a clinical pathway for somatic symptom and related disorders in pediatric hospital settings. *Hospital Pediatrics, 9*(3), 147–155. <https://doi.org/10.1542/hpeds.2018-0205>
- Johannsen, M., Damholdt, M. F., Zachariae, R., Lundorff, M., Farver-Vestergaard, I., & O'Connor, M. (2019). Psychological interventions for grief in adults: A systematic review and meta-analysis of randomized controlled trials. *Journal of Affective Disorders, 253*, 69–86. <https://doi.org/10.1016/j.jad.2019.04.065>
- Jongsma, K., Darboh, B. S., Davis, S., & MacKillop, E. (2023). A cognitive behavioural group treatment for somatic symptom disorder: A pilot study. *BMC Psychiatry, 23*(1), 896. <https://doi.org/10.1186/s12888-023-05141-9>
- Karatzias, T., Murphy, P., Cloitre, M., Bisson, J., Roberts, N., Shevlin, M., Hyland, P., Maercker, A., Ben-Ezra, M., Coventry, P., Mason-Roberts, S., Bradley, A., & Hutton, P. (2019). Psychological interventions for ICD-11 complex PTSD symptoms: Systematic review and meta-analysis. *Psychological Medicine, 49*(11), 1761–1775. <https://doi.org/10.1017/S0033291719000436>
- Karekla, M., Kasinopoulos, O., Neto, D. D., Ebert, D. D., Van Daele, T., Nordgreen, T., Höfer, S., Oeverland, S., & Jensen, K. L. (2019). Best practices and recommendations for digital interventions to improve engagement and adherence in chronic illness sufferers. *European Psychologist, 24*(1), 49–67. <https://doi.org/10.1027/1016-9040/a000349>

- Kelly, J., Gooding, P., Pratt, D., Ainsworth, J., Welford, M., & Tarrier, N. (2012). Intelligent real-time therapy: Harnessing the power of machine learning to optimise the delivery of momentary cognitive-behavioural interventions. *Journal of Mental Health, 21*(4), 404–414. <https://doi.org/10.3109/09638237.2011.638001>
- Khan, A. J., Maguen, S., Straus, L. D., Nelyan, T. C., Gross, J. J., & Cohen, B. E. (2021). Expressive suppression and cognitive reappraisal in veterans with PTSD: Results from the mind your heart study. *Journal of Affective Disorders, 283*, 278–284. <https://doi.org/10.1016/j.jad.2021.02.015>
- Kleinstäuber, M., Gottschalk, J.-M., Ruckmann, J., Probst, T., & Rief, W. (2019). Acceptance and cognitive reappraisal as regulation strategies for symptom annoyance in individuals with medically unexplained physical symptoms. *Cognitive Therapy and Research, 43*(3), 570–584. <https://doi.org/10.1007/s10608-018-9973-y>
- Koelen, J. A., Houtveen, J. H., Abbass, A., Luyten, P., Eurelings-Bontekoe, E. H. M., Van Broeckhuysen-Kloth, S. A. M., Bühring, M. E. F., & Geenen, R. (2014). Effectiveness of psychotherapy for severe somatoform disorder: Meta-analysis. *British Journal of Psychiatry, 204*(1), 12–19. <https://doi.org/10.1192/bjp.bp.112.121830>
- Kohlmann, S., Löwe, B., & Shedden-Mora, M. C. (2018). Health care for persistent somatic symptoms across Europe: A qualitative evaluation of the EURONET-SOMA expert discussion. *Frontiers in Psychiatry, 9*, 646. <https://doi.org/10.3389/fpsy.2018.00646>
- Konnopka, A., Kaufmann, C., König, H., Heider, D., Wild, B., Szecsenyi, J., Herzog, W., Heinrich, S., & Schaefer, R. (2013). Association of costs with somatic symptom severity in patients with medically unexplained symptoms. *Journal of psychosomatic research, 75* 4, 370-5. <https://doi.org/10.1016/j.jpsychores.2013.08.011>.
- Kurth, K., Priesterroth, L., Kunzler, A. M., Tuescher, O., & Kubiak, T. (2020). Cognitive reappraisal in smartphone-based interventions to foster mental health in adults: A systematic literature

review and meta-analysis (Preprint). *Journal of Medical Internet Research*.

<https://doi.org/10.2196/preprints.24627>

Kustra-Mulder, A., McGhie-Fraser, B., Petzke, T., Fila-Pawłowska, K., Rosmalen, J., Cosci, F., Löwe, B., & Weigel, A. (2025). Healthcare professionals' views on healthcare-related factors influencing symptom course in persistent somatic symptoms: A qualitative study of four European countries. *BMC Health Services Research*, 25(1), 823.

<https://doi.org/10.1186/s12913-025-12986-1>

Lai-Tan, N., Philiastides, M. G., Kawsar, F., & Deligianni, F. (2023). Toward personalized music-therapy: A neurocomputational modeling perspective. *IEEE Pervasive Computing*, 22(3), 27–37. <https://doi.org/10.1109/MPRV.2023.3285087>

Larionow, P., Mudło-Głagolska, K., & Preece, D. A. (2025). Latent structure and profiles of emotion regulation: Reappraisal and suppression patterns with the Polish version of the Emotion Regulation Questionnaire. *Journal of Clinical Medicine*, 14(2), 587.

<https://doi.org/10.3390/jcm14020587>

Lazarus, R., & Folkman, S. (1984). *Stress, Appraisal, and Coping*. New York, NY: Springer;. .

Lee, E.-H. (2012). Review of the psychometric evidence of the Perceived Stress Scale. *Asian Nursing Research*, 6(4), 121–127. <https://doi.org/10.1016/j.anr.2012.08.004>

Lee, J. H. (2016). The effects of music on pain: A meta-analysis. *Journal of Music Therapy*, 53(4), 430–477. <https://doi.org/10.1093/jmt/thw012>

Liu, J., Gill, N. S., Teodorczuk, A., Li, Z., & Sun, J. (2019). The efficacy of cognitive behavioural therapy in somatoform disorders and medically unexplained physical symptoms: A meta-analysis of randomized controlled trials. *Journal of Affective Disorders*, 245, 98–112.

<https://doi.org/10.1016/j.jad.2018.10.114>

Löwe, B., Andresen, V., Van Den Bergh, O., Huber, T. B., Von Dem Knesebeck, O., Lohse, A. W., Nestoriuc, Y., Schneider, G., Schneider, S. W., Schramm, C., Ständer, S., Vettorazzi, E.,

- Zapf, A., Shedden-Mora, M., & Toussaint, A. (2022). Persistent SOMatic symptoms ACROSS diseases — from risk factors to modification: Scientific framework and overarching protocol of the interdisciplinary SOMACROSS research unit (RU 5211). *BMJ Open*, *12*(1), e057596. <https://doi.org/10.1136/bmjopen-2021-057596>
- Löwe, B., Levenson, J., Depping, M., Hüsing, P., Kohlmann, S., Lehmann, M., Shedden-Mora, M., Toussaint, A., Uhlenbusch, N., & Weigel, A. (2022). Somatic symptom disorder: A scoping review on the empirical evidence of a new diagnosis. *Psychological Medicine*, *52*(4), 632–648. <https://doi.org/10.1017/S0033291721004177>
- Löwe, B., Toussaint, A., Rosmalen, J. G. M., Huang, W.-L., Burton, C., Weigel, A., Levenson, J. L., & Henningsen, P. (2024). Persistent physical symptoms: Definition, genesis, and management. *The Lancet*, *403*(10444), 2649–2662. [https://doi.org/10.1016/S0140-6736\(24\)00623-8](https://doi.org/10.1016/S0140-6736(24)00623-8)
- Lüönd, A. M., Ayas, G., Bachem, R., Carranza-Neira, J., Eberle, D. J., Fares-Otero, N. E., Hashim, M., Iqbal, N., Jenkins, D., Kamari Songhorabadi, S., Ledermann, K., Makhshvili, N., Martin-Soelch, C., Nebioğlu, E., Oe, M., Olayinka, J. N., Olf, M., Picot, L., Seedat, S., ... Ceylan, D. (2025). Childhood maltreatment and somatic symptoms in adulthood: Establishing a new research pathway. *Neuropsychobiology*, *84*(2), 113–120. <https://doi.org/10.1159/000543438>
- Limburg, K., Sattel, H., Dinkel, A., Radziej, K., Becker-Bense, S., & Lahmann, C. (2017). Course and predictors of DSM-5 somatic symptom disorder in patients with vertigo and dizziness symptoms - A longitudinal study.. *Comprehensive psychiatry*, *77*, 1-11 . <https://doi.org/10.1016/j.comppsy.2017.05.003>.
- Magezi, D. A. (2015). Linear mixed-effects models for within-participant psychology experiments: An introductory tutorial and free, graphical user interface (LMMgui). *Frontiers in Psychology*, *6*, 2. <https://doi.org/10.3389/fpsyg.2015.00002>

- Malas, N., Ortiz-Aguayo, R., Giles, L., & Ibeziako, P. (2017). Pediatric somatic symptom disorders. *Current Psychiatry Reports*, 19(2), 11. <https://doi.org/10.1007/s11920-017-0760-3>
- Maroti, D., Lumley, M. A., Schubiner, H., Lilliengren, P., Bileviciute-Ljungar, I., Ljótsson, B., & Johansson, R. (2022). Internet-based emotional awareness and expression therapy for somatic symptom disorder: A randomized controlled trial. *Journal of Psychosomatic Research*, 163, 111068. <https://doi.org/10.1016/j.jpsychores.2022.111068>
- Maunder, R. G., Hunter, J. J., Atkinson, L., Steiner, M., Wazana, A., Fleming, A. S., Moss, E., Gaudreau, H., Meaney, M. J., & Levitan, R. D. (2017). An attachment-based model of the relationship between childhood adversity and somatization in children and adults. *Psychosomatic Medicine*, 79(5), 506–513. <https://doi.org/10.1097/PSY.0000000000000437>
- McDevitt-Murphy, M. E., Luciano, M. T., & Zakarian, R. J. (2018). Use of ecological momentary assessment and intervention in treatment with adults. *Focus*, 16(4), 370–375. <https://doi.org/10.1176/appi.focus.20180017>
- McEwen, B. S., & Gianaros, P. J. (2011). Stress- and allostasis-induced brain plasticity. *Annual Review of Medicine*, 62(1), 431–445. <https://doi.org/10.1146/annurev-med-052209-100430>
- Miklósi, M., Martos, T., Szabó, M., Kocsis-Bogár, K., & Forintos, D. (2014). Cognitive emotion regulation and stress: A multiple mediation approach. *Translational Neuroscience*, 5(1), 1–7. <https://doi.org/10.2478/s13380-014-0207-9>
- Montoya, A. K. (2019). Moderation analysis in two-instance repeated measures designs: Probing methods and multiple moderator models. *Behavior Research Methods*, 51(1), 61–82. <https://doi.org/10.3758/s13428-018-1088-6>
- Morello, K., Schäfer, S. K., Kunzler, A. M., Priesterroth, L.-S., Tüscher, O., & Kubiak, T. (2023). Cognitive reappraisal in mHealth interventions to foster mental health in adults: A systematic review and meta-analysis. *Frontiers in Digital Health*, 5, 1253390. <https://doi.org/10.3389/fdgth.2023.1253390>

- Myin-Germeys, I., Kasanova, Z., Vaessen, T., Vachon, H., Kirtley, O., Viechtbauer, W., & Reininghaus, U. (2018). Experience sampling methodology in mental health research: New insights and technical developments. *World Psychiatry, 17*(2), 123–132.
<https://doi.org/10.1002/wps.20513>
- Myin-Germeys, I., Klippel, A., Steinhart, H., & Reininghaus, U. (2016). Ecological momentary interventions in psychiatry. *Current Opinion in Psychiatry, 29*(4), 258–263.
<https://doi.org/10.1097/YCO.0000000000000255>
- Nahum-Shani, I., Smith, S. N., Spring, B. J., Collins, L. M., Witkiewitz, K., Tewari, A., & Murphy, S. A. (2018). Just-in-time adaptive interventions (JITAI) in mobile health: Key components and design principles for ongoing health behavior support. *Annals of Behavioral Medicine, 52*(6), 446–462. <https://doi.org/10.1007/s12160-016-9830-8>
- Nakao, M., & Takeuchi, T. (2018). Alexithymia and Somatosensory Amplification Link Perceived Psychosocial Stress and Somatic Symptoms in Outpatients with Psychosomatic Illness. *Journal of Clinical Medicine, 7*. <https://doi.org/10.3390/jcm7050112>.
- Neng, J. M. B., & Weck, F. (2015). Attribution of somatic symptoms in hypochondriasis. *Clinical Psychology & Psychotherapy, 22*(2), 116–124. <https://doi.org/10.1002/cpp.1871>
- Norbury, A., Hauser, T. U., Fleming, S. M., Dolan, R. J., & Huys, Q. J. M. (2024). Different components of cognitive-behavioral therapy affect specific cognitive mechanisms. *Science Advances, 10*(13), eadk3222. <https://doi.org/10.1126/sciadv.adk3222>
- Okur Güney, Z. E., Sattel, H., Witthöft, M., & Henningsen, P. (2019). Emotion regulation in patients with somatic symptom and related disorders: A systematic review. *PLOS ONE, 14*(6), e0217277. <https://doi.org/10.1371/journal.pone.0217277>
- Oleson, J. J., Jones, M. A., Jorgensen, E. J., & Wu, Y.-H. (2022). Statistical considerations for analyzing ecological momentary assessment data. *Journal of Speech, Language, and Hearing Research, 65*(1), 344–360. https://doi.org/10.1044/2021_JSLHR-21-00081

Papadimitriou, G. N. (2017). The “Biopsychosocial Model”: 40 years of application in psychiatry.

Psychiatriki, 28(2), 107–110. <https://doi.org/10.22365/jpsych.2017.282.107>

Parmar, A., & Sharma, P. (2017). Ecological momentary interventions delivered by smartphone

apps: Applications in substance use treatment in Indian scenario. *Indian Journal of*

Psychological Medicine, 39(1), 102–103. <https://doi.org/10.4103/0253-7176.198942>

Perreau, E., Belouahchi, S., Castel, D., & Loup-Escande, E. (2023). Impact of ecological momentary

interventions on regulatory strategies of perceived stress at work: An exploratory study based on the application "MON SHERPA" used in an ecological context. *Review of European*

Studies, 15(4), 1. <https://doi.org/10.5539/res.v15n4p1>

Petersen, M. W., Carstensen, T. B. W., Frostholm, L., Wellnitz, K. B., Ørnbøl, E., Jørgensen, T.,

Eplov, L. F., Dantoft, T. M., & Fink, P. (2023). High perceived stress and low self-efficacy are associated with functional somatic disorders: The DanFunD Study. *Clinical*

Epidemiology, 15, 407–419. <https://doi.org/10.2147/CLEP.S399914>

Pizzie, R. G., & Kraemer, D. J. M. (2021). The association between emotion regulation,

physiological arousal, and performance in math anxiety. *Frontiers in Psychology*, 12,

639448. <https://doi.org/10.3389/fpsyg.2021.639448>

Preece, D. A., Becerra, R., Robinson, K., & Gross, J. J. (2020). The Emotion Regulation

Questionnaire: Psychometric properties in general community samples. *Journal of*

Personality Assessment, 102(3), 348–356. <https://doi.org/10.1080/00223891.2018.1564319>

Qin, S., Hermans, E. J., Van Marle, H. J. F., Luo, J., & Fernández, G. (2009). Acute psychological

stress reduces working memory-related activity in the dorsolateral prefrontal cortex.

Biological Psychiatry, 66(1), 25–32. <https://doi.org/10.1016/j.biopsych.2009.03.006>

Quinn, M. E., & Joormann, J. (2020). Executive control under stress: Relation to reappraisal ability and depressive symptoms. *Behaviour Research and Therapy*, 131, 103634.

<https://doi.org/10.1016/j.brat.2020.103634>

- Rauschenberg, C., Boecking, B., Paetzold, I., Schruers, K., Schick, A., Van Amelsvoort, T., & Reininghaus, U. (2021). A compassion-focused ecological momentary intervention for enhancing resilience in help-seeking youth: Uncontrolled pilot study. *JMIR Mental Health*, 8(8), e25650. <https://doi.org/10.2196/25650>
- Rief, W., Burton, C., Frostholm, L., Henningsen, P., Kleinstäuber, M., Kop, W. J., Löwe, B., Martin, A., Malt, U., Rosmalen, J., Schröder, A., Shedden-Mora, M., Toussaint, A., & Van Der Feltz-Cornelis, C. (2017). Core outcome domains for clinical trials on somatic symptom disorder, bodily distress disorder, and functional somatic syndromes: European Network on Somatic Symptom Disorders recommendations. *Psychosomatic Medicine*, 79(9), 1008–1015. <https://doi.org/10.1097/PSY.0000000000000502>
- Rief, W., & Martin, A. (2014). How to use the new DSM-5 somatic symptom disorder diagnosis in research and practice: A critical evaluation and a proposal for modifications. *Annual Review of Clinical Psychology*, 10(1), 339–367. <https://doi.org/10.1146/annurev-clinpsy-032813-153745>
- Rodriguez, L. M., Lee, K. D. M., Onufrak, J., Dell, J. B., Quist, M., Drake, H. P., & Bryan, J. (2020). Effects of a brief interpersonal conflict cognitive reappraisal intervention on improvements in access to emotion regulation strategies and depressive symptoms in college students. *Psychology & Health*, 35(10), 1207–1227. <https://doi.org/10.1080/08870446.2019.1711090>
- Safran, J. D., & Greenberg, L. S. (1982). Eliciting “hot cognitions” in cognitive behaviour therapy: Rationale and procedural guidelines. *Canadian Psychology/Psychologie Canadienne*, 23(2), 83–87. <https://doi.org/10.1037/h0081247>
- Santos, B., Pinho, L., Nogueira, M. J., Pires, R., Sequeira, C., & Montesó-Curto, P. (2024). Cognitive restructuring during depressive symptoms: A scoping review. *Healthcare*, 12(13), 1292. <https://doi.org/10.3390/healthcare12131292>

- Sardesai, A., Muneshwar, K. N., Bhardwaj, M., & Goel, D. B. (2023). The importance of early diagnosis of somatic symptom disorder: A case report. *Cureus*.
<https://doi.org/10.7759/cureus.44554>
- Schnabel, K., Petzke, T. M., & Witthöft, M. (2022). The emotion regulation process in somatic symptom disorders and related conditions—A systematic narrative review. *Clinical Psychology Review, 97*, 102196. <https://doi.org/10.1016/j.cpr.2022.102196>
- Schnabel, K., Schulz, S. M., & Witthöft, M. (2022). Emotional reactivity, emotion regulation, and regulatory choice in somatic symptom disorder. *Psychosomatic Medicine, 84*(9), 1077–1086.
<https://doi.org/10.1097/PSY.0000000000001118>
- Schueller, S. M., Aguilera, A., & Mohr, D. C. (2017). Ecological momentary interventions for depression and anxiety. *Depression and Anxiety, 34*(6), 540–545.
<https://doi.org/10.1002/da.22649>
- Schuster, R., Schreyer, M. L., Kaiser, T., Berger, T., Klein, J. P., Moritz, S., Laireiter, A.-R., & Trutschnig, W. (2020). Effects of intense assessment on statistical power in randomized controlled trials: Simulation study on depression. *Internet Interventions, 20*, 100313.
<https://doi.org/10.1016/j.invent.2020.100313>
- Seto, H., & Nakao, M. (2017). Relationships between catastrophic thought, bodily sensations and physical symptoms. *BioPsychoSocial Medicine, 11*(1), 28. <https://doi.org/10.1186/s13030-017-0110-z>
- Shafir, R., Schwartz, N., Blechert, J., & Sheppes, G. (2015). Emotional intensity influences pre-implementation and implementation of distraction and reappraisal. *Social Cognitive and Affective Neuroscience, 10*(10), 1329–1337. <https://doi.org/10.1093/scan/nsv022>
- Shermohammed, M., Mehta, P. H., Zhang, J., Brandes, C. M., Chang, L. J., & Somerville, L. H. (2017). Does psychosocial stress impact cognitive reappraisal? Behavioral and neural

evidence. *Journal of Cognitive Neuroscience*, 29(11), 1803–1816.

<https://doi.org/10.1162/jocn.a.01157>

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology*, 4, 1–32.

<https://doi.org/10.1146/annurev.clinpsy.3.022806.091415>

Singmann, H., & Kellen, D. (2019). An introduction to mixed models for experimental psychology.

In D. Spieler & E. Schumacher (Eds.), *New Methods in Cognitive Psychology* (1st ed., pp. 4–31). Routledge. <https://doi.org/10.4324/9780429318405-2>

Smakowski, A., Hüsing, P., Völcker, S., Löwe, B., Rosmalen, J. G. M., Shedden-Mora, M., &

Toussaint, A. (2024). Psychological risk factors of somatic symptom disorder: A systematic review and meta-analysis of cross-sectional and longitudinal studies. *Journal of Psychosomatic Research*, 181, 111608. <https://doi.org/10.1016/j.jpsychores.2024.111608>

Solhan, M. B., Trull, T. J., Jahng, S., & Wood, P. K. (2009). Clinical assessment of affective instability: Comparing EMA indices, questionnaire reports, and retrospective recall.

Psychological Assessment, 21(3), 425–436. <https://doi.org/10.1037/a0016869>

Sollmann, U. (2025). Body psychotherapy in somatic symptom disorder. *International Journal of*

Body, Mind and Culture, 12(1), 1–6. <https://doi.org/10.61838/ijbmc.v12i1.904>

Strauss, G. P., Ossenfort, K. L., & Whearty, K. M. (2016). Reappraisal and distraction emotion

regulation strategies are associated with distinct patterns of visual attention and differing levels of cognitive demand. *PLOS ONE*, 11(11), e0162290.

<https://doi.org/10.1371/journal.pone.0162290>

Troy, A. S., Shallcross, A. J., Brunner, A., Friedman, R., & Jones, M. C. (2018). Cognitive

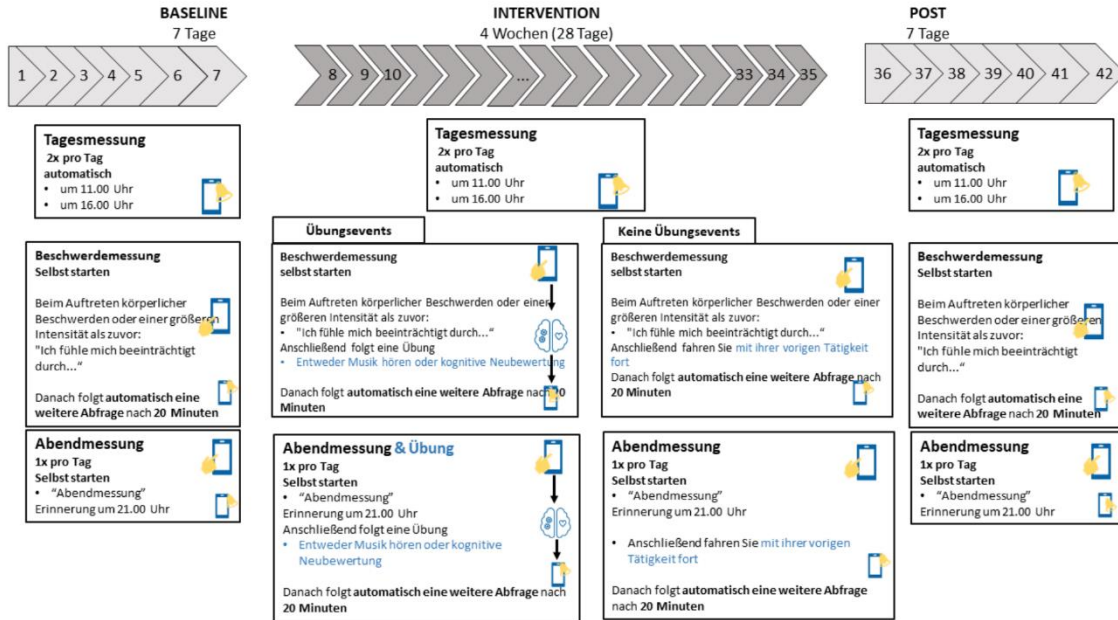
reappraisal and acceptance: Effects on emotion, physiology, and perceived cognitive costs. *Emotion*, 18(1), 58–74. <https://doi.org/10.1037/emo0000371>

- Troy, A. S., Shallcross, A. J., & Mauss, I. B. (2013). A person-by-situation approach to emotion regulation: Cognitive reappraisal can either help or hurt, depending on the context. *Psychological Science, 24*(12), 2505–2514. <https://doi.org/10.1177/0956797613496434>
- Tseng, P.-T., Chen, Y.-W., Lin, P.-Y., Tu, K.-Y., Wang, H.-Y., Cheng, Y.-S., Chang, Y.-C., Chang, C.-H., Chung, W., & Wu, C.-K. (2016). Significant treatment effect of adjunct music therapy to standard treatment on the positive, negative, and mood symptoms of schizophrenic patients: A meta-analysis. *BMC Psychiatry, 16*(1), 16. <https://doi.org/10.1186/s12888-016-0718-8>
- Toussaint, A., & Herzog, A. (2020). Einführung Somatoforme Störungen, Somatische Belastungsstörungen. <https://doi.org/10.36198/9783838553498>
- Van Der Feltz-Cornelis, C. M., Elfeddali, I., Werneke, U., Malt, U. F., Van Den Bergh, O., Schaefer, R., Kop, W. J., Lobo, A., Sharpe, M., Söllner, W., & Löwe, B. (2018). A European research agenda for somatic symptom disorders, bodily distress disorders, and functional disorders: Results of an estimate-talk-estimate Delphi expert study. *Frontiers in Psychiatry, 9*, 151. <https://doi.org/10.3389/fpsyt.2018.00151>
- Van Dessel, N., Den Boeft, M., Van Der Wouden, J. C., Kleinstäuber, M., Leone, S. S., Terluin, B., Numans, M. E., Van Der Horst, H. E., & Van Marwijk, H. (2014). Non-pharmacological interventions for somatoform disorders and medically unexplained physical symptoms (MUPS) in adults. *Cochrane Database of Systematic Reviews, 2014*(11), CD011142. <https://doi.org/10.1002/14651858.CD011142.pub2>
- Versluis, A., Verkuil, B., Spinhoven, P., Van Der Ploeg, M. M., & Brosschot, J. F. (2016). Changing mental health and positive psychological well-being using ecological momentary interventions: A systematic review and meta-analysis. *Journal of Medical Internet Research, 18*(6), e152. <https://doi.org/10.2196/jmir.5642>

- Walz, L. C., Nauta, M. H., & Aan Het Rot, M. (2014). Experience sampling and ecological momentary assessment for studying the daily lives of patients with anxiety disorders: A systematic review. *Journal of Anxiety Disorders*, 28(8), 925–937.
<https://doi.org/10.1016/j.janxdis.2014.09.022>
- Wang, Y.-X., & Yin, B. (2023). A new understanding of the cognitive reappraisal technique: An extension based on the schema theory. *Frontiers in Behavioral Neuroscience*, 17, 1174585.
<https://doi.org/10.3389/fnbeh.2023.1174585>
- Webb, C. A., Hilt, L. M., Swords, C. M., Bolt, D. M., Fisher, H., & Goldberg, S. B. (2025). Ecological momentary assessment as a measure of intervention change: Evaluation in 4 digital mental health trials. *Journal of Medical Internet Research*, 27, e69297.
<https://doi.org/10.2196/69297>
- World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. (2013). *JAMA*, 310(20), 2191.
<https://doi.org/10.1001/jama.2013.281053>
- Wu, H., Manglike, A., Chen, Y., Liu, Z., Fritzsche, K., & Lu, Z. (2023). Scoping review update on somatic symptom disorder that includes additional Chinese data. *General Psychiatry*, 36(3), e100942. <https://doi.org/10.1136/gpsych-2022-100942>
- IBM Corp. (2023). *IBM SPSS Statistics* (Version 29.0) [Computer software].
<https://www.ibm.com/products/spss-statistics>
- movisens GmbH. (2023). *movisensXS* [Mobile application software]. <https://www.movisens.com>

Appendix A

Study Design



Appendix B

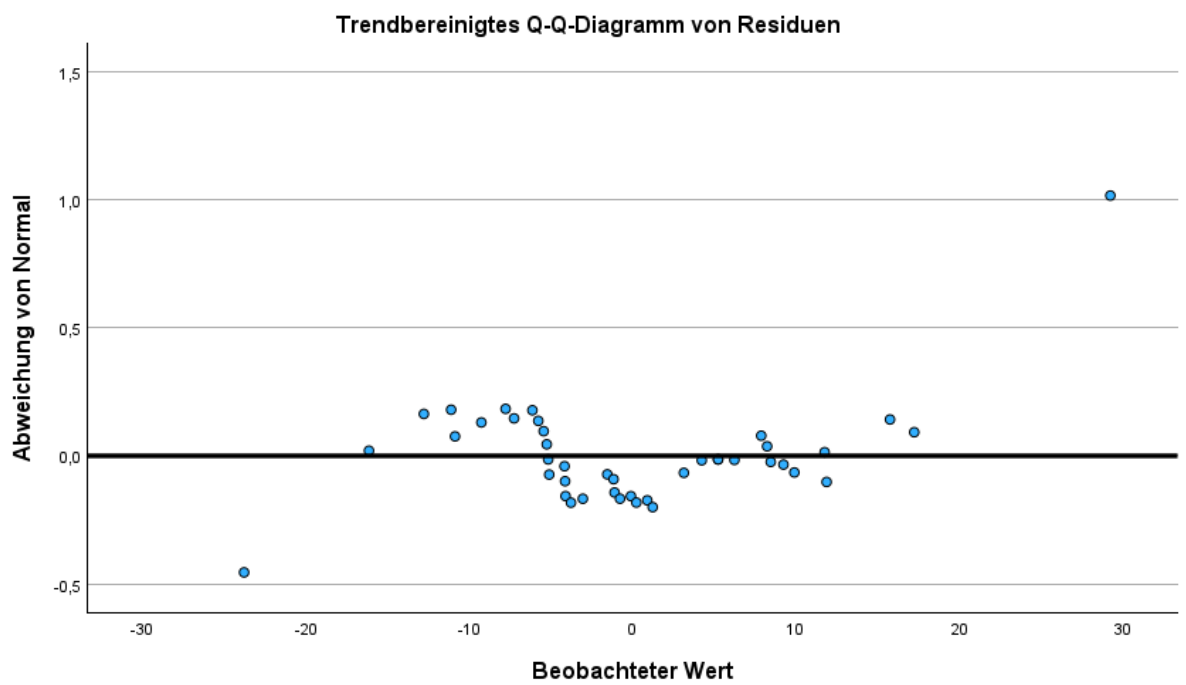
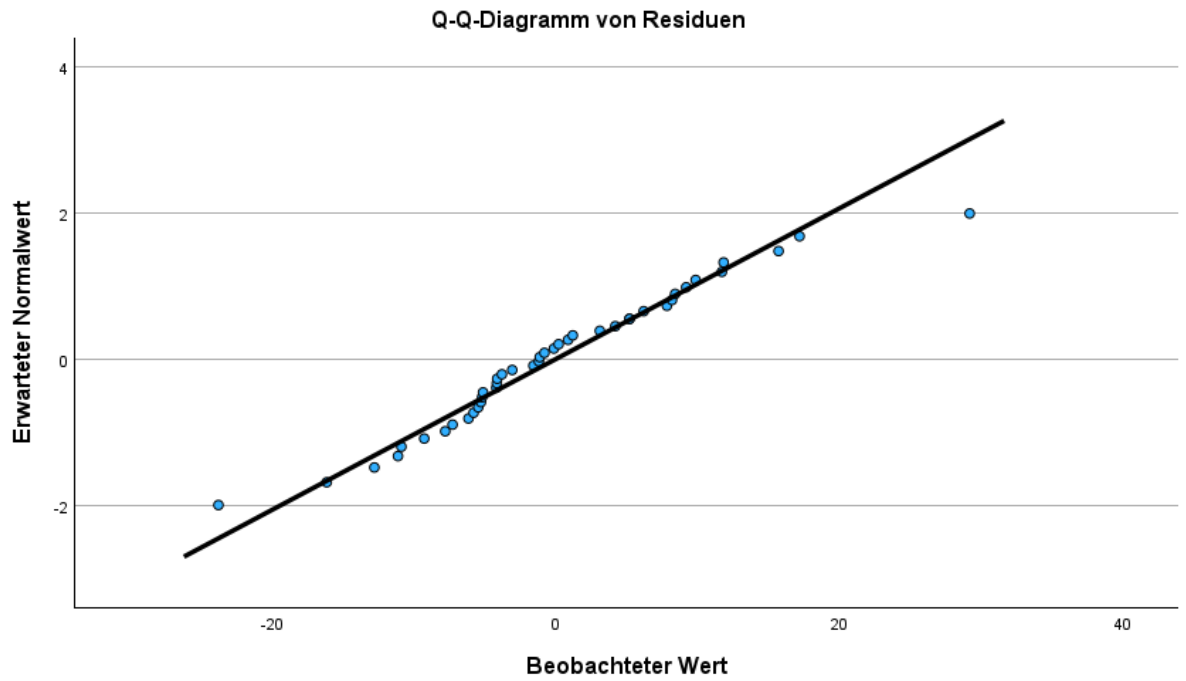
Model Fit Comparisons

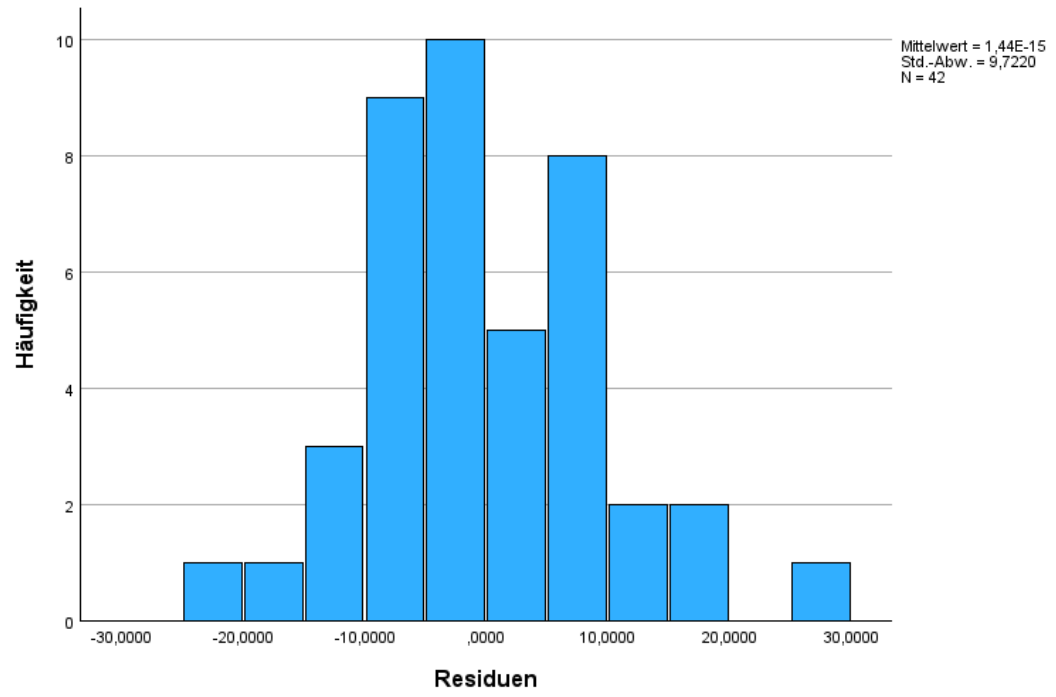
Hypothesis	Moderator	Model	Random Effects	-2LL	AIC	BIC
H1	none	M1	Intercept	303.68	307.68	311.01
H1	none	M2	Intercept + slope	316.27	328.27	338.70
H2a	Stress	M1	Intercept	283.44	287.44	290.60
H2a	Stress	M2	Intercept + slope	310.53	326.53	340.44
H2b	ES	M1	Intercept	280.19	284.19	287.36
H2b	ES	M2	Intercept + slope	—	—	—
H2c	CR	M1	Intercept	284.70	288.70	291.87
H2c	CR	M2	Intercept + slope	—	—	—

Note. M1 = random-intercept model; M2 = random-intercept + random-slope model. Lower AIC/BIC values indicate better model fit. Dashes indicate model convergence failure. Random-intercept models (M1) selected across all analyses due to superior fit indices and convergence reliability

Appendix C

MLM-requirements for RQ1





Appendix D

Summary of Results for RQ2

Predictor	<i>B</i>	<i>SE</i>	<i>df</i>	<i>t</i>	<i>p</i>	95% CI
Model 1: Reappraisal × Intervention						
Intercept	3.70	.75	4.90	1.34	199	[-2.17, 9.56]
Intervention 1	2.93	.12	4.32	0.71	482	[-5.44, 11.31]
Intervention 2	4.27	.85	3.81	1.11	276	[-3.56, 12.10]
Reappraisal	-0.14	.91	8.26	-0.05	961	[-6.25, 5.96]
Int. 1 × Reappraisal	3.73	.65	4.29	0.66	513	[-7.74, 15.20]
Int. 2 × Reappraisal	8.63	.21	3.89	2.05	048	[0.07, 17.19]
Model 2: Suppression × Intervention						
Intercept	3.13	.80	5.83	1.12	281	[-2.82, 9.08]
Intervention 1	19.40	.11	5.87	2.39	022	[2.95, 35.85]
Intervention 2	12.69	.00	5.75	2.12	041	[0.53, 24.85]
Suppression	-4.28	.36	8.41	-1.27	219	[-11.32, 2.77]
Int. 1 × Suppression	25.60	0.98	5.73	2.33	025	[3.33, 47.86]
Int. 2 × Suppression	12.19	.90	5.99	1.54	131	[-3.82, 28.21]
Model 3: Stress × Intervention						
Intercept	4.10	.75	3.14	1.49	160	[-1.84, 10.04]
Intervention 1	2.51	.09	4.18	0.61	544	[-5.79, 10.81]
Intervention 2	4.15	.89	3.61	1.07	294	[-3.76, 12.06]

Predictor	<i>B</i>	<i>SE</i>	<i>df</i>	<i>t</i>	<i>p</i>	95% CI
Stress	0.77	.99	6.54	0.26	799	[-5.55, 7.10]
Int. 1 × Stress	-8.28	.74	4.75	-1.23	228	[-21.96, 5.41]
Int. 2 × Stress	-12.93	.20	5.18	-2.09	044	[-25.50, -0.35]

Note. *B* = unstandardized coefficient; *SE* = standard error; *df* = Satterthwaite degrees of freedom; 95% CI = 95% confidence interval. Reference group = Intervention 3. All models estimated with random intercepts for participants using REML estimation.

Appendix E

Abstract

This thesis investigates the acute effects of two micro-interventions, namely cognitive reappraisal (CR-I) and music listening (MB-I), on somatic symptom intensity in individuals with Somatic Symptom Disorder (SSD) during 6-week-long ecological momentary interventions (EMI). Employing a within-subject, randomized design, adults with SSD received both interventions and a control condition during moments of heightened symptom distress in daily life. The study also examines whether baseline levels of chronic perceived stress and habitual emotion regulation strategies moderate short-term treatment efficacy. Results from this preliminary sample indicate no significant overall intervention effects, yet descriptive trends suggest greater symptom reduction following CR-I and MB-I than in the control condition. Furthermore, moderation analyses reveal that higher baseline suppression predicts greater benefit from music listening, while high chronic stress may impede the effectiveness of cognitive reappraisal. Findings highlight the importance of personalizing EMIs to individual profiles in SSD treatment and underscore the need for larger, longitudinal studies to clarify mechanisms and optimize intervention strategies.

Diese Masterarbeit untersucht die kurzfristigen Effekte zweier ökologischer Momentaninterventionen (EMIs), kognitive Neubewertung und das Hören von Musik, auf die Symptomintensität bei Personen mit somatischer Belastungsstörung (SSD). In einem randomisierten Within-Subject-Design erhielten Teilnehmende über 6 Wochen hinweg beide Interventionen sowie eine Kontrollbedingung während Phasen erhöhter Symptombelastung im Alltag. Zusätzlich wurde geprüft, ob das Ausmaß chronisch wahrgenommenen Stresses und die habitualisierten Emotionsregulationsstrategien der Teilnehmenden die Wirksamkeit der Interventionen moderieren. Die Ergebnisse der vorliegenden Stichprobe zeigen keine signifikanten Interventionseffekte, jedoch deuten deskriptive Trends auf eine stärkere Symptomreduktion nach kognitivem Reappraisal und Musik hören im Vergleich zur Kontrollbedingung hin. Moderationsanalysen zeigen, dass höhere Suppressionswerte mit größerem Nutzen durch Musik hören einhergehen, während hohe chronische Stressbelastung die Wirksamkeit des kognitiven Reappraisals einschränken kann. Die Ergebnisse unterstreichen die Bedeutung einer individualisierten EMI-Anpassung in der SSD-Behandlung und betonen die Notwendigkeit größerer, longitudinaler Studien zur weiteren Klärung der Wirkmechanismen und weiteren Optimierung von Interventionsstrategien.

Appendix F

Erklärung zur Verwendung von Künstlicher Intelligenz (KI)

Hiermit erkläre ich, dass ich die folgenden KI-Hilfsmittel zur Erstellung meiner [Seminararbeit, Bachelorarbeit, Masterarbeit etc.] mit dem Titel [A preliminary analysis of an EMI and SSD] verwendet habe. Ich versichere, dass die Kennzeichnung der verwendeten KI-Hilfsmittel vollständig ist, inkl. Verwendungszweck, Produktname, als auch ggfs. Prompts und Outputs des KI-Hilfsmittels. Ich verantworte die Auswahl und die Übernahme sämtlicher Ergebnisse der von mir verwendeten KI-Hilfsmittel vollumfänglich selbst.

Verwendungszweck*	Produktname des KI-Hilfsmittels	Ggfs. Prompt (Input) und Output des KI-Hilfsmittels
SPSS	Perplexity	„Wieso ist der Code falsch, gebe, mir Tips was da falsch gelaufen könnte, wie ein Lehrer“
Literaturrecherche	Elicit, ConsensusAI	Give me important papers for the relationship of SSD and ER, specifically CR.
Literaturrecherche und Tabellenerstellung	Perplexity	„Mache mir aus dem JASP OUTPUT eine kohärente Tabelle im APA format von“
Literaturrecherche	ChatGPT, Elicit, ConsensusA	Eher anfänglich, für „fine-grained / detailed literature“ nur Elicit und CONSENSUSAI
Academic Writing and Finetuning	Perplexity	“Is this (...) good acedemic writing in English, (grammar, spelling mistakes?) give me Feedback, tutor-style, any repetition errors”

	GRAMMARLY	GRAMMARLY was used for final stage: “fix critical mistakes”, and “improve accuracy and clarity”
Zotero	Schauen ob alles richtig zitiert wurde	Integriert in word

* Hilfsmittel zur Überprüfung von Grammatik und Rechtschreibung oder der automatisierten Erstellung des Literaturverzeichnisses sind von dieser Erklärung ausgenommen.