DECONSTRUCTING EMOTION REGULATION IN SCHIZOPHRENIA: THE NATURE OF ABNORMALITIES AT THE SELECTION STAGE

by

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(Under the Direction of Gregory Strauss)

ABSTRACT

Past studies using trait self-report indicate that people with schizophrenia (SZ) are less likely to use adaptive emotion regulation strategies and more likely to use maladaptive emotion regulation strategies than controls (CN). However, more recent evidence using ecological momentary assessment (EMA) indicates that regulation effectiveness and adaptiveness may vary across strategies. The present study aimed to systematically understand abnormalities in state-level emotion regulation strategy selection, effectiveness, and adaptiveness in SZ compared to CN using EMA. Participants (n = 50 SZ; n = 53 CN) completed six days of EMA assessment of emotional experience, emotion regulation, and symptoms. Results indicated that SZ selected interpersonal emotion regulation and avoidance more often than CN. Overall, strategies were effective at reducing negative emotion and adaptive for reducing delusions over time. Strategy selection appears relatively normal in SZ compared to CN. The present results have implications for how cognitive therapy for psychosis may target delusions.

INDEX WORDS: Schizophrenia, Emotion regulation, Psychosis, Extended process model

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CHAPTER 1

INTRODUCTION

Overview

Abnormalities in emotion regulation are transdiagnostic factors influencing the onset and maintenance of psychiatric disorders (Aldao et al., 2010, 2016), including schizophrenia (SZ) (Khoury & Lecomte, 2012). Emotion regulation is the process of engaging in behaviors (implicitly or explicitly) to influence emotional experience in oneself or others (Gross, 1998, 2015a, 2015b; McRae & Gross, 2020). The Extended Process Model (Gross, 2015b, 2015a) is a conceptual framework used to systematically study emotion regulation that has applicability for understanding factors underlying psychiatric disorders. The model proposes distinct but interactive systems which unfold over time to generate and regulate emotions. Emotion generation is the first-order cycle, containing four components: The *World* state composed of current internal and external stimuli, the *Perception* of those stimuli, the *Valuation* of the perceived stimuli as positive or negative relative to current or goal state, and the *Action* that this cycle results in (Gross & Thompson, 2015). This first-order cycle can be subjected to a second-order emotion regulation system composed of three sequential stages: *identification* (i.e., perceiving an emotion and generating the goal to regulate), *selection* (i.e., determining how to act on a regulatory goal, including situation selection, situation modification, attentional deployment, cognitive change, and response modulation), and *implementation* (i.e., executing the tactics for the selected strategies) (Gross, 2015b, 2015a). Abnormalities at any of these three stages could contribute to dysfunction in psychopathology (Sheppes et al., 2015), and there is increasing interest in deconstructing abnormalities of each stage in various disorders. Identifying the nature and consequences of abnormalities in emotion regulation may improve psychosocial interventions that target emotion regulation by allowing them to target identified abnormalities more effectively (Fairholme et al., 2010; Mennin & Fresco, 2014).

Emotion Regulation in Schizophrenia

Implementation

Leading stress-vulnerability models of psychosis propose that heightened negative emotion reactivity and HPA axis dysfunction are associated with the onset and maintenance of psychotic disorders (Myin-Germeys et al., 2003; Walker & Diforio, 1997; Walker et al., 2004, 2008). However, it is possible that the way people manage their reactions to negative experiences (emotion regulation) accounts for additional variance in outcomes above and beyond reactivity alone. This possibility is borne out in studies supporting the association between emotion regulation and clinical outcomes in SZ (e.g., positive symptoms, negative symptoms, functional outcome) (Bahlinger et al., 2020; Horan & Blanchard, 2003; Krkovic et al., 2018; Lincoln et al., 2015; Myin-Germeys & van Os, 2007). However, relatively few studies have systematically explored emotion regulation in SZ.

The majority of research on stage-specific emotion regulation abnormalities in SZ has focused on the implementation stage. Electroencephalography and eye-tracking/pupillometry indicates that the implementation of various strategies (e.g., reappraisal, distraction) is impaired in people with SZ (Bartolomeo et al., 2020; Horan et al., 2013; Strauss et al., 2013, 2015; Sullivan & Strauss, 2017). Specifically, studies investigating the late positive potential (LPP) as an index of emotion regulation (Hajcak et al., 2010) find greater amplitude of the LPP in SZ relative to CN when participants are tasked with using various strategies to decrease negative emotion (Bartolomeo et al., 2020; Horan et al., 2013; Strauss et al., 2013, 2015; Sullivan & Strauss, 2017). Implementation difficulties have also been assessed using eye-tracking and pupillometry as measures of visual attention and cognitive control (Beatty, 1982; Bradley et al., 2008). SZ participants demonstrate abnormal visual attention patterns (i.e., fixation patterns that differ from CN) and reduced effort toward implementation (Bartolomeo et al., 2020; Strauss et al., 2013, 2015; Sullivan & Strauss, 2017). These findings are replicated by fMRI research, which indicates that these neurophysiological abnormalities reflect hypofrontality and reduced cortico-limbic coupling in SZ (van der Meer et al., 2014; Zhang et al., 2020). These same regions are implicated in the broad range of cognitive deficits observed in SZ (Lesh et al., 2011) and may suggest that difficulties with neurocognition contribute to problems with implementing emotion regulation strategies effectively.

Additionally, these findings extend to ecological momentary assessment (EMA) studies. Specifically, time-lagged analyses indicate that SZ are less effective at down-regulating negative emotion than CN (Raugh & Strauss, 2021; Visser et al., 2018). This implementation deficit has been reported as even more pronounced in the presence of hallucinations and delusions in one recent study (Strauss et al., 2019). Furthermore, some EMA research has found that the use of reappraisal and suppression are positively associated with concurrent (i.e., sampled at the same instance) positive symptoms (i.e., delusions, hallucinations), suggesting that the implementation of emotion regulation strategies may not only be ineffective but critically linked to momentary fluctuations in psychotic symptoms (Kimhy et al., 2020).

However, not all EMA findings have consistently reported ineffective implementation in SZ (Ludwig et al., 2020). Specifically, Ludwig et al. (2020) identified that several strategies can be effectively implemented (e.g., reappraisal, acceptance), while other strategies (e.g., interpersonal, distraction) are ineffective. Furthermore, their results suggest that the effectiveness of emotion regulation may be moderated by the intensity of negative emotion to be regulated, although they did not explicitly evaluate moderation. Other research has evaluated this moderation effect and found that emotion regulation was most effective at down-regulating negative emotion, down-regulating delusions, and upregulating positive emotion when negative emotion was high (Raugh & Strauss, 2021). However, they did not examine how effectively SZ can implement specific strategies to down-regulate negative emotion and upregulate positive emotion.

Identification

Fewer studies have directly examined the identification or selection stages of the extended process model in SZ. Studies examining the identification stage using EMA have used one of two approaches: 1) probing if emotion regulation was initiated or not (Raugh & Strauss, 2021) or 2) probing emotion regulation effort for each strategy and dichotomizing momentary surveys based on whether any strategies had self-reported emotion regulation effort greater than zero (Visser et al., 2018). Of the two studies directly examining identification, results indicated that people with SZ are inefficient in their regulatory efforts. Specifically, they identify the need to regulate when negative emotion is low (i.e., low threshold), identify the need to regulate at a higher rate, and exert more effort towards regulating their emotions compared to healthy controls (CN) (Raugh & Strauss, 2021; Visser et al., 2018). This abnormality is specifically maladaptive as people with SZ are less likely to attempt to regulate in instances where regulatory attempts would be most effective (Raugh & Strauss, 2021).

Selection

Existing research has typically examined the selection stage in terms of either: 1) the effectiveness of specific strategies for managing negative emotion (an affective science approach) or 2) the associations of habitual use of specific strategies (i.e., selection frequency) and clinical outcomes (a clinical approach). Both of these lines of research have identified certain strategies that are generally “adaptive” or “maladaptive,” although the criteria by which those designations are made differ.

Within the affective science approach, adaptive and maladaptive are typically determined based on effectiveness of a given strategy for regulating emotions (Gross, 2002). Effectiveness in affective science is often operationalized as successful modulation of subjective negative emotion or psychophysiology in response to standardized stimuli such as the International Affective Picture System (Bradley & Lang, 1994, 2000; Campbell-Sills et al., 2006; Dan-Glauser & Gross, 2015; Lang et al., 2008; Sheppes et al., 2009). Specifically, strategies that are ineffective at decreasing negative emotional responses (via self-report or psychophysiology) or increasing positive emotional responses (via self-report or psychophysiology) compared to a passive viewing (i.e., reactivity) condition are identified as maladaptive, while strategies that are effective at modulating positive and negative emotional responses compared to a reactivity condition are adaptive. In a meta-analysis on the effectiveness of emotion regulation strategies in the general population, Webb and colleagues (2012) observed that concentration and experiential suppression were ineffective strategies while distraction, expressive suppression, and cognitive change (e.g., reappraisal) strategies were effective at regulating emotions in laboratory experiments.

Within the clinical approach, adaptive and maladaptive are determined based on associations with clinical outcomes. Such studies often rely on trait self-report measures and clinical interviews (Aldao et al., 2010; Cludius et al., 2020; Naragon-Gainey et al., 2017). Specifically, strategies associated with greater psychiatric symptoms and poorer functional impairment are deemed maladaptive (e.g., expressive suppression, rumination, distraction, and avoidance); however, strategies associated with lower levels of psychiatric symptoms and functional impairment are considered adaptive (e.g., cognitive reappraisal, acceptance, mindfulness, problem solving) (Aldao et al., 2010, 2016; Cludius et al., 2020; Kraiss et al., 2020; Naragon-Gainey et al., 2017; Sloan et al., 2017).

These two approaches provide convergence for some strategies but diverge regarding others. Specifically, reappraisal is adaptive by both criteria of effectiveness (McRae, 2016; Webb et al., 2012) and negative associations with psychopathology (Aldao et al., 2010) . In contrast, distraction may be effective (McRae, 2016; Webb et al., 2012), but habitual use may be positively associated with greater psychiatric symptoms (Naragon-Gainey et al., 2017; Sheppes et al., 2014). Suppression findings differ based on whether suppression targets the expression of emotion (i.e., experiential) versus the experience of emotion (i.e., expressive). Studies examining suppression typically do not use facial coding to evaluate how effectively the suppression occurs and focus on how effectively suppression manages the internal experience. Expressive suppression appears to be effective while experiential suppression is not (Webb et al., 2012) ; however, habitual use of suppression (broadly defined) is positively associated with psychopathology (Aldao et al., 2010; Gross, 2002; Naragon-Gainey et al., 2017).

While it is useful to label strategies as adaptive or maladaptive, this consideration has limited utility for understanding how strategies are selected or how they act on emotional experience. In particular, it does not address the means by which strategies manage emotions or symptoms and does not capture moment-to-moment (i.e., state-level) variations. The Extended

Process Model explicitly describes emotion regulation as constantly unfolding and therefore lends itself to the examination of state-level antecedents and consequences of emotion regulation. The Extended Process Model proposes four classes of emotion regulation strategies that act on different stages of the emotion generation process (see Figure 1, shaded areas) (Gross, 2015a). Situation selection and modification involve changing the world state, such as through avoiding unwanted situations or solving a problem that is creating a negatively valued world state. Attentional deployment engages attention in response to the world to either attend more (such as through rumination) or less (such as through distraction) to the world state. Cognitive change strategies intervene in the valuation of the world state through changing the meaning of a stimulus (reappraisal) or one's relationship to that stimulus (acceptance) (McRae & Gross, 2020; Webb et al., 2012). Response modulation strategies act upon the response to the valued world state such as through suppressing an emotional response. One common form of emotion regulation that is not clearly represented by the Extended Process Model is interpersonal emotion regulation, which refers to engaging in social interactions in order to change emotions (Dixon-Gordon et al., 2015; Zaki & Williams, 2013). Strategies are also not mutually exclusive; a person can select a number of strategies in concert or sequentially (i.e., polyregulation) (Ford et al., 2019). As strategies act on different stages of emotion generation, they may be selected at different intensities of negative emotion, be differentially effective in regulating emotion, and have different clinical outcomes.

Numerous studies have used trait self-report questionnaires to examine emotion regulation in SZ. These studies generally indicate that people with SZ endorse more maladaptive strategy use (e.g., suppression) and less adaptive strategy use (e.g., reappraisal, acceptance) than CN (Chapman et al., 2020; Kimhy et al., 2012; Ludwig et al., 2019; O'Driscoll et al., 2014;

Perry et al., 2011; van der Meer et al., 2009). This pattern of abnormalities is associated with important clinical outcomes, including social functioning (Henry et al., 2008; Kimhy et al., 2012, 2014; Moran et al., 2018), positive symptoms (Badcock et al., 2011; Liu et al., 2020; Ludwig et al., 2019), negative symptoms (Chapman et al., 2020; Liu et al., 2020), stress reactivity (Krkovic et al., 2018), and general psychopathology/ emotional wellbeing (Moran et al., 2018; Perry et al., 2011). While these can be interpreted as abnormalities in selection, it is unclear whether this interpretation is correct. Stage-specific (i.e., identification, selection, implementation) conclusions cannot be drawn from these studies due to limitations of the measures used.

The primary measure used in these studies is the Emotion Regulation Questionnaire (ERQ) (Gross & John, 2003). The ERQ items aim to examine habitual use of reappraisal (e.g., “When I want to feel less negative emotion, I change the way I’m thinking about the situation”) and suppression (e.g., “I control my emotions by not expressing them”). However, the items are limited to only those two strategies. While the items do capture selection, they are confounded by components of other stages. Several items involve regulatory goals (e.g., “When I want to feel less negative emotion…” or “When I want to feel more positive emotion…”), which are components of the identification stage. The items may also be confounded by the effectiveness with which an individual applies a given strategy (i.e., “I control my emotions by…”). The Cognitive Emotion Regulation Questionnaire (Garnefski et al., 2001) is also confounded in that the items assess thoughts that occur in response to negative experiences independent of regulatory goals or behaviors. These are common limitations of trait emotion regulation questionnaires: they cannot disentangle selection frequency from strategy effectiveness (McRae, 2013). Further, these trait self-report questionnaires probe a broad period of time (“what you generally think” in the Cognitive Emotion Regulation Questionnaire) that is insensitive to state-level fluctuations. The low temporal resolution of trait self-report questionnaires likely contributes to the mixed correlations between habitual emotion regulation and EMA (i.e., state emotion regulation) (Ludwig et al., 2020; McMahon & Naragon-Gainey, 2020).

Methods with greater temporal resolution, such as EMA (Cohen et al., 2020, 2021), may allow for greater specificity than trait scales and allow for an examination of temporally proximal antecedents and consequences. A small number of EMA studies have directly examined selection in SZ (Ludwig et al., 2020; Strauss et al., 2019; Visser et al., 2018). Visser et al. (2018) found that people with SZ reported more use of reappraisal, distraction, suppression, soothing, and situation modification than CN and selected more strategies at the same instance (i.e., greater polyregulation) than CN. Further, polyregulation is greater when people with SZ are experiencing psychosis (i.e., hallucinations, delusions) (Strauss et al., 2019). Strauss et al. (2019) also observed that psychotic experiences moderated the effort with which individuals regulated their emotions using specific strategies. Ludwig et al. (2020) found that daily use of reappraisal, distraction, rumination, and suppression was greater in SZ compared to CN. Further, they found that negative emotion at time t - 1 predicted the use of reappraisal, rumination, and suppression at time t, but not acceptance, awareness, or distraction. Ludwig et al. (2020) also observed greater polyregulation in SZ with a different set of strategies than Visser et al. (2018) and Strauss et al. (2019). Collectively, these findings suggest that the nature of the selection stage abnormality may be best characterized by contextually inappropriate strategy selection and greater polyregulation. However, several questions still remain to be answered. First, how does negative emotion predict strategy use in SZ? Second, how is the implementation of specific strategies impaired in SZ (strategy effectiveness)? Third, to what extent do specific strategies impact clinical symptoms across time (strategy adaptiveness)?

Specific Aims and Hypotheses

The current study aimed to systematically explore the nature of selection abnormalities in SZ using EMA and evaluated the following specific aims and hypotheses:

Aim 1: To determine the nature of abnormalities at the selection stage in schizophrenia.

Based on evidence from state self-reported EMA (Ludwig et al., 2020; Visser et al., 2018) indicating more frequent selection of strategies in SZ relative to CN and increased polyregulation, it was hypothesized that: A) SZ would endorse selecting all strategies (reappraisal, interpersonal, distraction, avoidance, suppression) at a higher rate than CN; B) SZ would report more effort toward emotion regulation than CN, replicating Visser et al. (2018) and Ludwig et al. (2020); C) SZ would demonstrate greater polyregulation as indicated by selecting more strategies than CN. Furthermore, based on evidence that people with SZ demonstrate a low identification threshold relative to CN (Raugh & Strauss, 2021; Visser et al., 2018), it was hypothesized that D) SZ would select strategies at lower levels of negative emotion compared to CN. Hypotheses A, B, and D extend previous research (Raugh & Strauss, 2021) by allowing examination of strategy specific thresholds.

Aim 2: To determine how strategy implementation is impaired in schizophrenia.

The existing literature suggests that emotion regulation strategy implementation is impaired in schizophrenia (Bartolomeo et al., 2020; Ludwig et al., 2020; Raugh & Strauss, 2021; Strauss et al., 2013, 2015, 2019; Sullivan & Strauss, 2017; Visser et al., 2018), but it is unclear how the effectiveness of specific strategies may be moderated by the intensity of negative emotion to be regulated. Specifically, the findings in Ludwig et al. (2020) indicate that the effectiveness of reappraisal, interpersonal, and suppression strategies may vary based on the intensity of negative emotion, while distraction does not. However, they did not explicitly evaluate this moderation effect. Based on the aforementioned literature, it was hypothesized that: A) regardless of negative emotion at *t*, interpersonal and distraction strategies would be less effective at regulating emotion than reappraisal, suppression, and distraction; all strategies would be less effective in SZ compared to CN; and B) the implementation of reappraisal, interpersonal, and suppression on regulating positive and negative emotion at *t* + 1 would be moderated by negative emotion at *t*; however, distraction will not be moderated (per results in Ludwig et al., 2020).

Aim 3: To determine the adaptiveness of strategy selection in schizophrenia.

Evidence from trait self-report suggests that the greater habitual use of maladaptive strategies (e.g., suppression) is associated with elevated symptoms, while greater habitual use of adaptive strategies (e.g., reappraisal) is associated with reduced symptom severity (Badcock et al., 2011; Chapman et al., 2020; Henry et al., 2008; Kimhy et al., 2012, 2014; Krkovic et al., 2018; Liu et al., 2020; Ludwig et al., 2019; Moran et al., 2018; Perry et al., 2011). Based on this evidence, it was hypothesized that: A) adaptive strategies (reappraisal and interpersonal) would evidence a greater reduction in delusions and negative symptoms from *t* to *t* + 1 compared to maladaptive strategies (distraction, avoidance, suppression); B) Based on findings from Raugh and Strauss (2021) indicating that emotion regulation is most effective at higher levels of negative emotion, it was hypothesized that adaptive strategies would be most adaptive (i.e., be most associated with lower delusional and negative symptom severity) at higher levels of negative emotion.

CHAPTER 2

METHODS

Participants

Participants included 52 individuals meeting DSM-5 (American Psychiatric Association, 2013) criteria for schizophrenia, schizoaffective disorder, or bipolar disorder with psychotic features (SZ) and 55 CN. EMA days with fewer than 25% of surveys completed (two of eight) were excluded from analyses, in line with recommendations to maximize available EMA samples (Raugh et al., 2021). The final sample consisted of 50 SZ (schizophrenia n = 21, schizoaffective disorder n = 26, bipolar disorder with psychotic features n = 3) and 53 CN. The groups did not significantly differ on age, sex, parental education, or race; however, SZ had lower personal education and EMA survey adherence than CN (see Table 1).

Individuals were recruited for the SZ group from local community outpatient mental health centers and advertisements. The Structured Clinical Interview for DSM-5 (SCID-5) (First, Williams, et al., 2015) was used to determine clinical diagnosis; all diagnoses were established by consensus between a trained rater and the PI (a licensed clinical psychologist). CN participants were recruited from the local community using posted flyers, online advertisements, and word of mouth. CN denied family history of psychosis, denied being prescribed psychotropic medications, did not meet criteria for any current DSM-5 diagnosis, and did not meet criteria for paranoid, schizotypal, or schizoid personality disorder as established by the SCID-5 for personality disorders (First, Spitzer, et al., 2015). All participants denied lifetime neurological disorders and substance use disorder (except tobacco) within the last six months.

All participants consented to the protocol approved by the University of Georgia Institutional Review Board. Participants were compensated $20 per hour of time in the laboratory, $1 per EMA survey, and $80 for returning the study phone.

Procedures

The study was conducted over three stages consisting of an initial laboratory visit, six days of EMA, and a return visit. Protocol and data from this study has been reported elsewhere (Raugh & Strauss, 2021; Raugh et al., 2021); relevant details are presented below.

Phase 1. Initial Laboratory Visit

On the initial visit, participants were informed of the study procedures and provided informed consent. Diagnostic interviews were conducted with all participants. Participants were then provided a Blu Vivo 5R Android smartphone programmed with the mEMA application (Ilumivu, Inc., 2020) and trained in how to use the phone. Instructions included how to access the survey schedule, how to complete surveys, how to change the volume on the phone, and basic troubleshooting. Participants were provided with written instructions and asked to contact the researchers with any concerns or problems. They were also trained to understand the strategies assessed in the present study: distraction, reappraisal, suppression, interpersonal, and avoidance. Strategies were explained in plain language until participants could describe the strategy in their own words. EMA surveys also provided brief explanations (see Table 2). Participants were not trained in how to apply these strategies, only how to identify them.

Phase 2. Ecological Momentary Assessment

The six-day EMA phase consisted of surveys delivered quasi-randomly eight times per day. Surveys were scheduled to occur in 90-minute epochs between 0900 and 2100. Participants were notified to complete surveys by a tone at the programmed time and reminders at five and 10 minutes if the survey was not completed. Surveys took approximately three minutes to complete.

EMA items that were used to assess specific domains are presented in Table 2. Items for emotional experience (positive emotion, negative emotion) are derived from the Differential Emotions Scale (Fredrickson et al., 2003). Emotion regulation items were constructed based on the Extended Process Model (Gross, 2015a). If any emotion regulation was endorsed, participants were asked which strategies they used and how much effort they exerted with each strategy. Context items evaluated current location (e.g., home, work), current activity (e.g., work, errands, resting, nothing), and social interactions (e.g., significant other, friends, no one). Negative symptom items were based on internal experience and overt behaviors for avolition, asociality, and anhedonia, consistent with modern negative symptom assessment (Kirkpatrick et al., 2011). Delusion items (e.g., paranoia, thought control, mind reading) were based on probes from the Positive and Negative Syndrome scale (Kay et al., 1987). All items are scaled such that higher values indicate greater presence of a given construct (i.e., greater emotional intensity, greater effort, or more severe negative symptoms).

Phase 3. Return Visit

Participants returned to the lab after one week of EMA. All participants completed the MATRICS Consensus Cognitive Battery (MCCB) (Nuechterlein et al., 2008) to measure neuropsychological impairment. During this visit, participants returned the phone and were compensated for their participation.

Hypotheses and Data Analysis

Aim 1: To determine the nature of abnormalities at the selection stage in schizophrenia.

Hypothesis 1A: SZ would endorse selecting strategies at a higher rate than CN. This was evaluated as the probability of SZ selecting each strategy at a given EMA sample. Hierarchical binary logistic regression using the covariance structure with the best model fit was used to evaluate the effects of Group (CN, SZ), Strategy (reappraisal, interpersonal, distraction, avoidance, suppression), and Group X Strategy interaction on regulation endorsement. Data was nested within sample, day, and individual for random intercepts; random slopes were used for negative emotion. In the event of singular model fit, random slope and intercept terms were removed from most to least complex until model fit was no longer singular. A significant effect of Strategy was to be followed with post-hoc pairwise contrasts between each strategy averaged over the two groups. A significant Group X Strategy interaction was to be followed with post-hoc between-group contrasts of the likelihood of each group selecting a given strategy. Within-group pairwise contrasts were planned to evaluate the selection rate of each strategy within each group.

Hypothesis 1B: SZ would report more emotion regulation effort than CN for all six strategies evaluated. Hierarchical linear regression using the covariance structure with the best model fit were used to evaluate differences in regulation effort based on Group (CN, SZ), Strategy, and the Group X Strategy interaction. Data was nested within sample, day, and individual for random intercepts; random slopes were used for negative emotion. In the event of singular model fit, random slope and intercept terms were removed from most to least complex until model fit was no longer singular. A significant effect of Strategy was to be followed with post-hoc pairwise contrasts between each strategy averaged over the two groups. A significant Group X Strategy interaction was to be followed with post-hoc between-group contrasts of the effort each group exerted on each strategy. Within-group pairwise contrasts were planned to evaluate the effort exerted on each strategy within each group. To prevent confounding due to selection frequency, only observations where emotion regulation was selected were used in this model.

Hypothesis 1C: SZ would engage in greater polyregulation than CN, as indicated by selecting more strategies at each EMA sample. Hierarchical linear regression using an uncorrelated covariance structure was used to evaluate Group (CN, SZ) differences in the number of strategies selected. Data was nested within day and individual for random intercepts; negative emotion was modeled with a random slope unless it resulted in singular model fit. To prevent confounding due to selection frequency, only observations where emotion regulation was selected were used in this model.

Hypothesis 1D: SZ would demonstrate a lower threshold for each strategy than CN, as indicated by selecting each strategy at a lower level of negative emotion. Hierarchical logistic regression with an uncorrelated covariance structure was used to evaluate the effects of Group, Strategy, negative emotion (as a continuous predictor), the Group X negative emotion interaction, and the Group X Strategy X negative emotion interaction on regulation endorsement. Data was nested within sample, day, and individual for random intercepts; random slopes were used for negative emotion. In the event of singular model fit, random slope and intercept terms were removed from most to least complex until model fit was no longer singular. A significant Group X negative emotion interaction was to be followed by post-hoc contrasts to determine the effect of negative emotion on selection endorsement in each group (simple slopes). A significant Strategy X negative emotion interaction was to be followed by post-hoc pairwise contrasts to determine differences in simple slopes between strategies. A significant Group X Strategy X negative emotion interaction was to be followed by post-hoc contrasts to determine between-group and within-group conditional effects of negative emotion on selection endorsement.

Aim 2: To determine how strategy implementation is impaired in schizophrenia.

Hypothesis 2A: Interpersonal and distraction would be less effective at regulating emotion than reappraisal, suppression, and distraction; all strategies would be less effective in SZ compared to CN as evidenced by significant effects of Group (SZ, CN) X strategy (none, reappraisal, interpersonal, distraction, avoidance, suppression) on change in emotion between t *and* t *+ 1 in a multilevel model*. The model used the best fitting covariance structure and random intercepts by individual and day. Significant effects were to be followed by post-hoc pairwise contrasts and a significant interaction were to be followed by post-hoc pairwise contrasts within and between groups. Emotion change scores were calculated such that positive values indicate an increase in emotion (higher positive and higher negative emotion).

Hypothesis 2B: The implementation of reappraisal, interpersonal, and suppression on regulating positive and negative emotion at t *+ 1 would be moderated by negative emotion at* t*, while distraction would not be moderated*. Multilevel models were used to evaluate the effects of Group X Strategy X negative emotion at t on positive and negative emotion at $t + 1$. Models used the best fitting covariance structure and random intercepts for individual and day; random slopes were not included if they resulted in singular fit. The model of effectiveness on positive emotion at $t + 1$ included a term for positive emotion at t as a covariate. Significant interactions were to be followed by post-hoc contrasts to evaluate the how the effect of negative emotion at t moderated the effectiveness of specific strategies on emotion at $t + 1$ by group, as appropriate.

Aim 3: To determine the adaptiveness of strategy selection in schizophrenia.

Hypothesis 3A: Adaptive strategies (reappraisal and interpersonal) would evidence a greater reduction in delusions and negative symptoms from t *to* t *+ 1 compared to maladaptive strategies (distraction, avoidance, suppression) in multilevel models.* These models (one for delusions, one for negative symptoms) evaluated the Group X Strategy (none, distraction, reappraisal, suppression, interpersonal, avoidance) effect on change in delusions and negative symptoms from *t* to *t* + 1. Change in delusions and negative symptoms were calculated such that positive values indicated an increase in that symptom over time. Post-hoc pairwise contrasts were planned to examine between and within group differences in the adaptiveness of each strategy. Models used the best fitting covariance structure and random intercepts for individual and day; random slopes were included if they did not result in singular fit.

Hypothesis 3B: Adaptive strategies would be most adaptive (i.e., most associated with lower delusional and negative symptom severity) at higher levels of negative emotion as evidenced by a significant Strategy X Negative emotion interaction in multilevel models. Models examined Group X Strategy X Negative emotion interactions on delusions and negative symptoms at *t* + 1 with an autoregressive term for delusions or hallucinations at *t* as a covariate. Models used the best fitting covariance structure and random intercepts for individual and day; random slopes were included if they did not result in singular fit. Significant interactions were to be followed by post-hoc contrasts to evaluate the how the effect of negative emotion at *t* moderated the adaptiveness of specific strategies on symptoms at *t* + 1 by group, as appropriate.

Sensitivity Analysis

Sensitivity analyses were conducted to evaluate the minimum detectable effect with 80% power for each model. These were conducted via simulation due to the use of multilevel models. Data was simulated 100 times per effect size and assumed *n* = 50 in both groups, normal distributions for all continuous variables, and 25% missing EMA data. As Strategy is a multicategorical variable, minimum detectable effect was considered the minimum β value which produces a significant difference between any two strategies with adequate power. Simulations were built one effect at a time with each additional effect assuming the previous effects are also significant (i.e., if minimum β for the Group effect is 1.25, subsequent simulations for that hypothesis will include that effect). For models with a dichotomous outcome (hypotheses 1A and 1D), there is adequate power to detect the following minimum effects: Group β = 1.2; Strategy β = 0.45; negative emotion β = 0.3; Group X Strategy β = 0.45; Group X negative emotion β = 0.4; Strategy X negative emotion β = 0.5; Group X Strategy X negative emotion β = 0.6. For models with a continuous outcome (hypotheses 1B, 1C, 2A & B, and 3A & B), minimum detectable effects are as follows: Group β = 1.15; Strategy β = 0.1; negative emotion β = 0.17; Group X Strategy β = 0.15; Group X negative emotion β = 0.25; Strategy X negative emotion β = 0.29; Group X Strategy X negative emotion β = 0.39. These effect sizes are comparable to those observed in prior research (Ludwig et al., 2020; Visser et al., 2018). Multiple comparisons were minimized by only conducting post-hoc analyses in the presence of significant main effects.

CHAPTER 3

RESULTS

Overall, emotion regulation was initiated in 281 out of 3085 samples (9.11%). Reappraisal was selected 151 times (4.89%), interpersonal 129 times (4.18%), distraction 154 times (4.99%), avoidance 105 times (3.4%), and suppression was selected 46 times (1.49%) across both groups.

Aim 1: To determine the nature of abnormalities at the selection stage in schizophrenia.

Hypothesis 1A: SZ would endorse selecting strategies at a higher rate than CN. There were significant main effects of Group ($\chi^2[1] = 5.6$, $p = .017$) and Strategy ($\chi^2[4] = 27.68$, $p < .001$), whereas the Group X Strategy interaction was nonsignificant ($\chi^2[4] = 5.39$, $p = .249$). The effect of Group was such that CN were less likely to choose to regulate than SZ (OR = 0.39; reported in Raugh & Strauss, 2021). The effect of Strategy was such that expressive suppression was the least used strategy followed by avoidance with similar rates across reappraisal, interpersonal, and distraction, see Figure 2A. The absence of a significant interaction suggests that while SZ are more likely to regulate across strategies (as previously reported), their pattern of strategy selection (i.e., which strategies are most or leased used) is similar to that of CN.

Hypothesis 1B: SZ would report more emotion regulation effort than CN for all six strategies evaluated. While the effect of Group was nonsignificant ($F[1, 77] = 0.49$, $p = .487$), the Strategy ($F[4, 1219] = 22.25$, $p < .001$) and Group X Strategy ($F[4, 1219] = 3.78$, $p = .004$) effects were significant. The effect of Strategy was such that both CN and SZ exerted more effort towards reappraisal, interpersonal, and distraction compared to avoidance or expressive suppression. However, this main effect is qualified by the Group X Strategy interaction displayed in Figure 2B. SZ exerted more effort than CN for interpersonal regulation; otherwise, both groups generally exerted more effort for reappraisal, interpersonal, and distraction compared to avoidance and suppression. It appears that both groups exerted similar effort to strategies with the exception of interpersonal emotion regulation, which was more effortful in the SZ group.

Hypothesis 1C: SZ would engage in greater polyregulation than CN. The effect of Group on polyregulation was nonsignficicant (F[1,77] = 0.39, p = .534). CN selected 1.95 strategies on average when regulating (SD = 0.91), while SZ selected 2.16 strategies (SD = 1.16). SZ participants do not appear to engage in greater polyregulation than CN; both groups applied a mean of approximately two strategies when they initiated regulation.

Hypothesis 1D: SZ would demonstrate a lower threshold for each strategy than CN. In this model, the main effect of Group observed in Hypothesis 1A became nonsignificant (χ^2[1] = 1.77, p = .183), while the effect of Strategy was retained (χ^2[4] = 32.76, p < .001) and the Group X Strategy effect became significant (χ^2[4] = 8.96, p = .021). Negative emotion demonstrated a significant main effect on selection probability (χ^2[1] = 34.28, p < .001), significant interaction with Group (χ^2[1] = 8.97, p = .003; as observed in Raugh & Strauss, 2020), a nonsignificant interaction with Strategy (χ^2[4] = 2.93, p = .57), and a nonsignificant three-way interaction with Group and Strategy (χ^2[4] = 8.22, p = .084). The previously observed effect of Strategy is here qualified by a Group X Strategy interaction displayed in Figure 2C. SZ were more likely than CN to select interpersonal and avoidance as emotion regulation strategies. Within CN, reappraisal and distraction were the most selected strategies followed by interpersonal then avoidance and expressive suppression, whereas in SZ strategies were generally selected with similar frequency to each other except for expressive suppression. This model includes an additional term (negative emotion) not included in the model for Hypothesis 1A. The inclusion of this term significantly improves the model fit ($\chi^2[14] = 199.91$, $p < .001$) and suggests that group differences observed in Hypothesis 1A are due to group differences in negative emotion rather than regulatory behavior. The present results suggest that SZ demonstrate a lower threshold for emotion regulation across strategies. They also indicate that SZ are more likely than CN to select certain strategies (i.e., interpersonal and avoidance).

Aim 2: To determine how strategy implementation is impaired in schizophrenia.

Hypothesis 2A: Interpersonal and distraction would be less effective at regulating emotion than reappraisal, suppression, and distraction; all strategies would be less effective in SZ compared to CN. There was a significant main effect of Strategy on change in negative emotion; the effect of Group and Group X Strategy interaction were nonsignificant, see Table 3. The effect of Strategy was such that every strategy demonstrated a greater decrease in negative emotion from t to $t + 1$ compared to no strategy; however, no contrasts between strategies were significant (see Figure 3A). This indicates that all of the assessed strategies are similarly effective in both groups.

There were significant Group ($F[1, 101] = 18.74$, $p < .001$), Strategy ($F[5, 2091] = 7.17$, $p < .001$), and Group X Strategy ($F[5, 2091] = 4.69$, $p < .001$) effects on change in positive emotion from t to $t + 1$. The effect of Strategy was such that change in positive emotion was highest (i.e., increased the most) when no strategy was applied. This counterintuitive finding may be due to the role of negative emotion in motivating emotion regulation. Specifically, participants are more likely to regulate as negative emotion increases (as observed in Hypothesis 1D). As such, an exploratory analysis was conducted which included negative emotion at t as a covariate. This model demonstrated superior fit (L ratio = 1196.38, $p < .001$). In this exploratory model, negative emotion had a significant main effect ($F[1, 2090] = 1677.61$, $p < .001$); the other terms became nonsignificant, see Table 3. It appears that emotion regulation in response to negative emotion does not have a significant effect on subsequent change in positive emotion.

Hypothesis 2B: The implementation of reappraisal, interpersonal, and suppression on regulating positive and negative emotion at t *+ 1 would be moderated by negative emotion at* t*, while distraction would not be moderated*. Results regarding the moderation of strategy effectiveness on positive and negative emotion are presented in Table 3. The only significant effect observed for negative emotion was Group, suggesting that negative emotion at $t + 1$ was not significantly influenced by emotion regulation at t. However, there was a significant Strategy X Negative emotion interaction on positive emotion at $t + 1$ such that reappraisal ($\beta = 0.14$, 95% CI [0, 0.29], $t = 2.41$, $p = .016$), interpersonal ($\beta = 0.18$, 95% CI [0.3, 0.32], $t = 2.84$, $p = .005$), and distraction ($\beta = 0.18$, 95% CI [0.02, 0.33], $t = 2.74$, $p = .006$) were more effective at increasing positive emotion at $t + 1$ at higher levels of negative emotion at t relative to no strategy ($\beta = -0.03$, 95% CI [-0.1, 0.04]). While evidence does not indicate that the use of emotion regulation moderates the autoregression of negative emotion , strategies do moderate the relationship of negative emotion on subsequent positive emotion such that application of certain strategies (i.e., reappraisal, interpersonal, distraction) had a greater effect on positive emotion when negative emotion was elevated.

Aim 3: To determine the adaptiveness of strategy selection in schizophrenia.

Hypothesis 3A: Adaptive strategies (reappraisal and interpersonal) would evidence a greater reduction in delusions and negative symptoms from t *to* t *+ 1 compared to maladaptive strategies (distraction, avoidance, suppression).* There was a significant effect of Strategy on change in negative symptoms, see Table 3. This effect was such that all strategies except reappraisal evidenced a significant decrease in negative symptoms relative to no regulation (see Figure 3B). Further, expressive suppression was significantly more effective than reappraisal (t = 2.17, p = .03, d = 0.15); no other contrasts between strategies were significant.

There was a significant Group X Strategy interaction on change in delusions, see Table 3. This interaction was such that in CN, expressive suppression resulted in a greater decrease in delusions relative to no strategy, whereas reappraisal, interpersonal, and distraction resulted in greater decreases in delusions in SZ (see Figure 3C). Within CN, expressive suppression also resulted in significantly greater decreases in delusions relative to reappraisal (t = 2.85, p = .004, d = 0.12), interpersonal (t = 2.71, p = .007, d = 0.12), and distraction (t = 3.01, p = .003, d = 0.13). In SZ, no contrasts between strategies were significant. Between groups, distraction resulted in a greater decrease in delusions in SZ relative to CN (t = 2.5, p = .014, d = 0.5).

The results indicate that different strategies may be adaptive for different symptoms in different groups. Specifically, negative symptoms may be reduced by application of most strategies; however, reappraisal may be less adaptive than other options for negative symptoms. For delusions, CN appear to reduce delusions through use of suppression; however, SZ may find cognitive strategies (i.e., reappraisal, distraction) and interpersonal emotion regulation to be more adaptive.

Hypothesis 3B: Adaptive strategies would be most adaptive (i.e., most associated with lower delusional and negative symptom severity) at higher levels of negative emotion. There were no significant effects of Strategy or interactions with Strategy on negative symptoms or delusions at $t + 1$, see Table 3. The significant effects that are observed are reported elsewhere (see Raugh & Strauss, 2021). Models demonstrate significant autoregression and do not support significant effects of emotion regulation strategies on subsequent symptoms.

Exploratory analyses

Several exploratory analyses were conducted to contextualize the primary findings. Due to the recruitment of cognitive control in emotion regulation, an exploratory analysis was conducted to evaluate the effects of neurocognitive ability on selection probability. A multilevel model examined the effects of Group, Strategy, negative emotion, and neurocognition (as MCCB overall *t* score) on selection probability and this model was compared to the model used for Hypothesis H1D. The inclusion of neurocognition improved model fit ($\chi^2[20] = 47.54$, $p < .001$). There were significant effects of Group ($\chi^2[1] = 5.08$, $p = .024$), Strategy ($\chi^2[4] = 21.54$, $p < .001$), negative emotion ($\chi^2[1] = 20.14$, $p < .001$, $\beta = 1.17$), neurocognition ($\chi^2[1] = 8.53$, $p < .001$, $\beta = 1.06$), Group X neurocognition ($\chi^2[1] = 3.94$, $p = .047$), and negative emotion X neurocognition ($\chi^2[1] = 6.35$, $p = .012$). All other effects were nonsignificant, including the Group X Strategy interaction previously observed ($\chi^2[4] = 2.85$, $p = .583$). The Group X neurocognition interaction was such that the slope of neurocognition on selection probability was greater in CN ($\beta = 0.83$, 95% CI [0.24, 1.42]) than SZ ($\beta = 0.14$, 95% CI [-0.28, 0.56]). The negative emotion X neurocognition interaction was such that the effect of negative emotion was greater in those with higher neurocognitive ability ($\beta = 0.79$, SE = 0.32). These results suggest that neurocognitive ability is important for the *identification* of emotion regulation rather than the *selection* due to the lack of interactions with Strategy. In particular, it appears that greater neurocognitive ability results in a greater effect of negative emotion on the probability of regulation and that it plays a greater role in identification in CN relative to SZ. The Group X

Strategy interaction became nonsignificant in this model, possibly suggesting that differences in selection between groups may be due to neurocognition.

The second exploratory analysis was to replicate and understand the relationship between emotion regulation and positive symptoms identified by Kimhy et al. (2020). While an omnibus test of the effect of Strategy on concurrent delusions was nonsignificant ($F[5, 1308] = 1.52$, $p = .178$), inspection of the β values for each strategy relative to none (0.11 to 0.2) indicated comparable effect sizes to those found by Kimhy et al. (2020). This may reflect that emotion regulation is more likely to be initiated when negative emotion is high and negative emotion is elevated in the presence of positive symptoms. To explore this possibility, concurrent negative emotion was entered into the model as a covariate. The resulting model demonstrated better fit (L ratio = 225.87, $p < .001$) and the observed β values for each strategy were reduced (0 to 0.1) as negative emotion was the only significant predictor of concurrent delusion severity ($F[1, 1307] = 278.3$, $p < .001$, $\beta = .42$). These results support that positive symptoms are elevated when emotion regulation is identified; however, they do not support that positive symptoms are elevated at those instances due to emotion regulation. Instead, results indicate that negative emotion accounts for the relationship between positive symptoms and emotion regulation. This interpretation is particularly probable given the observed effects of regulation strategies on delusional intensity over time (i.e., no effect or a reduction of delusions).

Finally, exploratory analyses were conducted to follow the null effects observed in Hypotheses 2B and 3B. Specifically, models were conducted to examine the moderated autoregression of positive emotion, negative symptoms, and delusions. These models were conducted similarly to their original counterparts with negative emotion at *t* as a covariate and examining the effects of Group, Strategy, and the autoregression (positive emotion, negative symptoms, or delusions at *t*) on the outcome at *t* + 1. Results are presented in Table 4. Models generally do not demonstrate that the autoregressive effect is moderated by strategy, indicating that strategies do not moderate positive emotion or negative symptoms across time. However, several notable effects emerged regarding delusions. Significant effects were observed for Group, the delusion autoregression, Group X delusion, and Strategy X delusion. The Group and autoregression effects were expected; the SZ group demonstrates elevated delusional severity relative to CN and greater delusions at *t* are associated with greater delusions at *t* + 1. The Group X delusion effect indicates that the autoregressive effect differs by group. Specifically, the autoregressive slope of delusions is greater in SZ ($\beta = 0.26$, 95% CI [0.18, 0.34]) than CN ($\beta = -0.1$, 95% CI [-0.24, 0.03]. The Strategy X delusion effect was such that the autoregressive effect of delusion varied based on the application of emotion regulation strategies, see Figure 4. Specifically, reappraisal, avoidance, and expressive suppression significantly reduced the autoregressive effect while interpersonal and distraction did not. This supports that emotion regulation strategies can reduce delusional intensity, particularly reappraisal, avoidance, and expressive suppression.

CHAPTER 4

DISCUSSION

The current study had three primary aims: 1) Determine the nature of abnormalities in emotion regulation strategy selection in SZ; 2) To evaluate the effectiveness of emotion regulation strategy implementation in SZ; and 3) To evaluate the adaptiveness of emotion regulation strategy implementation in SZ. Several notable findings emerged, discussed below separately in relation to strategy selection, effectiveness, and adaptiveness.

Strategy Selection

There are several means by which individuals with different forms of psychopathology can evidence abnormalities at the selection stage (Sheppes et al., 2015). For example, individuals may represent too many possible strategies, an inadequate range of strategies, or represent maladaptive strategies over adaptive strategies. Failure to generate strategies (i.e., reduced repertoire) would represent a bottleneck which would disrupt later stages of selection. Regardless of which strategies are represented, valuation of such strategies may be abnormal. Specifically, maladaptive strategies may be overvalued (or evaluated positively) while adaptive strategies are undervalued (or evaluated negatively) or valuation may be contextually insensitive (i.e., improperly evaluating the use of a given strategy in a given situation). Finally, cognitive deficits may prevent an individual from acting on the strategies that have been represented and valued as appropriate.

Consistent with hypotheses and previous research, SZ were more likely to initiate emotion regulation (main effect of Group on emotion regulation rate; abnormalities at the identification stage, see Raugh & Strauss, 2021). Further, they demonstrated a different pattern of strategy selection compared to CN (abnormalities at the selection stage). Both groups were more likely to select and exert greater effort towards reappraisal, interpersonal, and distraction strategies relative to avoidance and expressive suppression. However, the SZ group was more likely to engage in interpersonal and avoidance strategies and exerted more effort towards interpersonal regulation compared to CN. The greater probability of reappraisal, interpersonal, and distraction strategies and the greater effort exerted with them is notable due to the elevated cognitive demands of these strategies (Sheppes & Levin, 2013).

The greater use of interpersonal emotion regulation in SZ is a surprising finding given the prevalence of asociality (i.e., reduced engagement in and desire for social activity) in SZ (Bobes et al., 2010; Mäkinen et al., 2008). Several factors may contribute to the greater use and effort for interpersonal emotion regulation. SZ participants often exhibit deficits in social skills and social cognition (i.e., perspective-taking, reading social cues, social knowledge, empathy) that may make it more difficult to engage in social interactions that serve a regulatory function (Halford & Hayes, 1995; Le et al., 2018; Mueser et al., 1991; Randall et al., 2003). Further, they may have reduced frequency and quality of social interactions (i.e., greater interpersonal distance, poor rapport, social isolation) maintained by asociality and defeatist beliefs about social interactions that increase the difficulty of regulating emotions through interpersonal interaction (Durand et al., 2021; Granholm et al., 2018; Granholm, Ben-Zeev, et al., 2013; Granholm, Holden, et al., 2013; Mote & Fulford, 2020). Difficulties with understanding and describing emotional experience (i.e., poor emotional intelligence, alexithymia) may also complicate the communication of emotional experience and needs to another person (Kee et al., 2009; Kimhy et al., 2012, 2014). Finally, positive symptoms such as paranoia and auditory hallucinations may make it difficult to engage with an interaction partner (Fett et al., 2012; Randall et al., 2003; Wang et al., 2019).

The greater use of situation modification in the form of avoidance may contribute to long-term negative symptoms in SZ. Avoidance is implicated in etiological models of several psychiatric diagnoses (e.g., depression, posttraumatic stress disorder, agoraphobia, social anxiety disorder) and could contribute to secondary negative symptoms. Specifically, successful application of avoidance may motivate a person to avoid other situations in which they anticipate negative emotion and reduce hedonic, goal-directed, and social behavior. A person who experiences paranoid ideation in crowded spaces (i.e., "they are going to hurt me" when in a busy store) may modify their situation by leaving (avoidance) and experience a reduction in negative emotion. As a result, they may be more likely to modify similar situations or engage in situation selection of avoiding even going to a store in the future. This would lead to a functional impairment and elevated negative symptoms in the long-term, as reflected in fewer social and goal-directed activities.

However, the present results also suggest that people with SZ do not exclusively use these strategies. They select reappraisal, distraction, and expressive suppression at similar rates to CN. This is in contrast to trait findings which indicate a greater use of maladaptive strategies (specifically expressive suppression) and reduced use of adaptive strategies (reappraisal) relative to CN (Chapman et al., 2020; Henry et al., 2008; Kimhy et al., 2012; O'Driscoll et al., 2014; van der Meer et al., 2009). Several plausible explanations exist for this discrepancy. As discussed previously, trait measures involve elements of several stages including regulatory goals from the identification stage, strategy selection, and how effectively strategies are implemented. Low correspondence is to be expected given the wider range of components of emotion regulation represented in trait measures compared to the more specific state measures employed in the present study. Due to the general timeframe evaluated, trait measures rely on general beliefs about emotion regulation (Robinson & Clore, 2002). Beliefs around emotion regulation may be inaccurate in SZ due to memory impairments (i.e., difficulty encoding and recalling emotion regulation efforts) which lead them to endorse different habits of emotion regulation than they exhibit in daily life (Aleman et al., 1999); similar discrepancies between trait and state emotion regulation have been observed in nonpsychiatric samples (McMahon & Naragon-Gainey, 2020) and other SZ samples (Kimhy et al., 2020; Ludwig et al., 2020). The results of the present study also directly address which strategies were effective.

Effectiveness

The present study operationalized effectiveness as how the application of a given strategy resulted in decreases in negative emotion or increases in positive emotion over time. Findings regarding effectiveness in the present study are mixed and appear to differ based on the framework used to evaluate effectiveness (i.e., change score from t to $t + 1$ or time-lagged regression). When evaluating change scores, models supported the effectiveness of emotion regulation strategies at downregulating negative emotion but not upregulating positive emotion. Contrary to hypotheses, strategy effectiveness did not differ between groups and between-strategy contrasts were generally nonsignificant. The present results suggest that engaging in any form of emotion regulation results in a greater decrease in negative emotion across time relative to no strategy, supporting the effectiveness of emotion regulation strategies in both groups.

However, results from the time-lagged regression approach show effects on positive emotion but not negative emotion. Specifically, the application of reappraisal, interpersonal, and distraction strategies were more effective at increasing positive emotion at *t* + 1 at higher levels of negative emotion at *t*. This effect was not observed for negative emotion.

The lack of time-lagged effects for negative emotion raises the question of why effects were observed for change scores but not the time-lagged regression. The two models have different advantages and limitations. A change-score model is more intuitive to calculate and interpret while still representing change in a value over time. However, it is agnostic to the absolute intensity of either score (i.e., a change from 70 to 65 and from 15 to 10 are both a change score of -5). As such, it can miss effects due to the absolute level of the variable at *t*. A time-lagged regression model is able to represent the effects of strategy at varying levels of negative emotion (alternatively, how strategy moderates the effect of negative emotion over time). However, such models are more complex and require more samples in order to be adequately powered. The change-score models used for the analyses in Hypotheses 2A and 3A involve a two-way interaction (Group X Strategy), whereas the time-lagged regression models involve up to a three-way interaction (Group X Strategy X Negative emotion) which requires more observations to have similar power to the change score model. Due to the differential strengths and limitations of each modeling approach, a finding which is produced by only one of the two approaches should be interpreted cautiously until replicated in future studies using both approaches.

Adaptiveness

The present study operationalized adaptiveness as how the application of a given strategy resulted in decreased delusions or negative symptoms over time. It was hypothesized that adaptive strategies (reappraisal, interpersonal) would evidence greater reductions in negative symptoms and delusions over time compared to maladaptive strategies (distraction, avoidance, suppression); however, results from change-score models indicate that most strategies resulted in decreases in negative symptoms and delusions over time. Specifically, almost every strategy resulted in significant decreases in negative symptoms relative to no strategy. Reappraisal was the only strategy that did not show a significant effect in post-hoc contrasts to no strategy and resulted in significantly less negative symptom change than suppression, contrary to hypotheses. These results did not hold for time-lagged regression where there was not a significant effect involving strategy.

However, compelling evidence emerged regarding the effects of emotion regulation strategies on delusional intensity. The change-score model demonstrated an interaction such that suppression was the only strategy in CN which resulted in significant decreases in delusions. In SZ, reappraisal, interpersonal, and distraction emerged as decreasing delusions over time. While time-lagged regression of negative emotion did not support this effect, exploratory moderated autoregression analysis produced similar findings. Across both groups, reappraisal, avoidance, and suppression attenuated the autoregressive effect of delusions. Evidence from both modeling approaches suggests that reappraisal, avoidance, and suppression are adaptive in that their application results in decreased delusions relative to no strategy. This is counter to results described by Kimhy et al. (2020) where reappraisal and suppression were positively associated with concurrent (i.e., same time sample) positive symptoms. However, exploratory analyses in the present study clarify this relationship. Positive symptoms are associated with concurrent negative emotion; emotion regulation is more likely when negative emotion is elevated. The relationship between concurrent positive symptoms and emotion regulation becomes nonsignificant when controlling for negative emotion.

These findings have implications for cognitive therapy for psychosis. Specifically, the use of cognitive reappraisal appears to reduce delusional intensity and make delusional intensity less stable over time. The present results do not indicate if this is due to shifting delusional conviction; however, that is a plausible explanation which warrants further investigation. Further, it appears that avoidance and suppression also effectively reduce delusion intensity. These alternative strategies may be used by individuals for a range of reasons but may have secondary harms which are not associated with reappraisal. How situation selection and modification in the form of avoidance may contribute to secondary negative symptoms is outlined above. The results regarding expressive suppression warrant further exploration. Specifically, suppression may effectively manage delusional ideation in CN who may have paranoid or referential thoughts but do not demonstrate conviction in those thoughts. In the absence of conviction, suppression may be adaptive for reducing attenuated positive symptoms. However, this strategy also appeared to be adaptive in SZ. It is unclear from the present results if habitual suppression attenuates delusional severity or if the attenuation is short-lived.

Limitations

Several limitations should be considered when interpreting the current findings. Statistical power for some models is limited due to the infrequency of strategy endorsement (i.e., less than 10% of samples). Further, time-lagged regression interactions often had standard errors which exceeded observed effect sizes. This would likely be remedied by having more samples of each strategy. Future studies may benefit from an “un-gated” approach similar to that of Visser et al. (2018) and Ludwig et al. (2020) to maximize samples of each strategy. Similarly, individuals may engage in behaviors that serve a regulatory function without recognizing that function (i.e., automatic emotion regulation) (Braunstein et al., 2017). As such, future studies should consider eliciting strategies independent of explicit regulatory goals.

A limited set of strategies were probed in the present study. Strategies were selected based on their role in the Extended Process Model (Gross, 2015a, 2015b; Sheppes et al., 2015); however, they still represent a limited set of possible emotion regulation strategies (Heiy & Cheavens, 2014; Medland et al., 2020; Naragon-Gainey et al., 2017). Relatedly, only responses to the probed strategies were elicited; participants could not input a self-generated option. Future studies should consider other strategies and may benefit from a wider conceptualization which could represent participant repertoire. The reasons for emotion regulation were not assessed. It is unclear at each instance if emotion regulation was initiated due to an interpersonal stressor, symptoms (i.e., delusions), or other reasons. While this would increase the complexity of the design, strategy selection is likely to be influenced by features of the affective stimulus (Sheppes & Levin, 2013; Suri et al., 2018; Tang & Huang, 2019; Vishkin et al., 2020; Young & Suri, 2020).

The present study was able to employ examination of relatively brief temporal relationships (i.e., across hours) in daily life due to the resolution available through EMA designs. However, laboratory studies of emotion regulation show that the effects of emotion regulation can be observed in milli-seconds (Hajcak et al., 2010). EMA is ill-suited for such a narrow time-frame; however, previous EMA studies of emotional episode duration have suggested up to hour-long timeframes (Verduyn et al., 2009, 2011). Further, the present study does not lend itself to investigation of habitual effects. For example, while avoidance and suppression may reduce delusions in the moment, they may have deleterious long-term effects which cannot be investigated here. Future studies should evaluate the same questions at multiple levels of resolution from seconds to years to help understand the nuanced and unfolding effects of emotion regulation choices. As in previous publications on this same dataset (Raugh & Strauss, 2021), emotion, symptoms, and regulation were collected concurrently. While using analyses that include effects across time helps overcome this limitation, the effects of regulation may have unfolded prior to survey initiation based on the timing of negative emotion and regulation efforts. This is a common limitation in EMA studies where effects are either assumed to be present within a sample (proximal/concurrent effects with unclear directionality) or across samples (distal/time-lagged effects with presumed directionality). Future studies may be able to overcome this limitation with event-contingent surveys initiated by participants or triggered by devices which measure physiological arousal; however, the technology for physiologically triggered surveys is still in early stages and presents numerous implementation difficulties (Raugh et al., 2019).

The present study did not employ a momentary measure of cognitive control or cognitive ability on the cell phone. As such, analysis of the role of cognitive control in strategy selection is limited to trait neurocognitive performance. Future studies may incorporate ecological tests of cognitive control. Finally, the sample used for this study included stable outpatients with chronic psychotic disorders. As such, the results may not generalize to more severe presentations (i.e., inpatient populations) or at earlier stages of the illness (i.e., clinical high-risk or first episode). Furthermore, it is unclear if the observed effects are specific to individuals with psychotic disorders or if similar selection patterns, effectiveness, and adaptiveness would be observed in other psychiatric diagnoses. Future studies would benefit from transphasic (i.e., across illness stage) and transdiagnostic inquiry.

Conclusions and Future Directions

Despite these limitations, the present study has notable implications and furthers understanding of emotion regulation in SZ. Previous research has investigated identification (Raugh & Strauss, 2021; Visser et al., 2018) and implementation (Bartolomeo et al., 2020; Horan et al., 2013; Kimhy et al., 2020; Ludwig et al., 2020; Raugh & Strauss, 2021; Strauss et al., 2013, 2015, 2019; Sullivan & Strauss, 2017; van der Meer et al., 2014; Visser et al., 2018) while generally relying on trait self-report measures to evaluate selection (Chapman et al., 2020; Kimhy et al., 2012; Ludwig et al., 2019; O'Driscoll et al., 2014; Perry et al., 2011; van der Meer et al., 2009). Prior research has suggested that the identification stage of emotion regulation in SZ is best characterized by inefficient regulation choices of regulating more and with greater effort than CN (Raugh & Strauss, 2021; Visser et al., 2018). This body of literature also suggests that the implementation stage of emotion regulation in SZ is characterized by less effective or ineffective emotion regulation relative to CN (Bartolomeo et al., 2020; Horan et al., 2013; Kimhy et al., 2020; Ludwig et al., 2020; Raugh & Strauss, 2021; Strauss et al., 2013, 2015, 2019; Sullivan & Strauss, 2017; van der Meer et al., 2014; Visser et al., 2018).

However, the selection stage in SZ appears to be normal; SZ select effective and adaptive strategies associated with reductions in negative emotion and symptoms. While they regulate more often and at lower levels of negative emotion, SZ select strategies which are effective at managing their distress and adaptive in their short-term effects on symptoms. They are more likely to select interpersonal emotion regulation (a putatively adaptive strategy) and avoidance (a putatively maladaptive strategy), both of which show effectiveness at reducing negative emotion and adaptiveness in reducing delusional severity. Collectively, the present findings support that people with SZ choose to regulate their emotions in ways indicated by the short-term effects of strategies on emotion and symptoms.

These findings contrast those from trait self-report of strategy selection (Chapman et al., 2020; Kimhy et al., 2012; Ludwig et al., 2019; O'Driscoll et al., 2014; Perry et al., 2011; van der Meer et al., 2009) and laboratory study of strategy implementation (Bartolomeo et al., 2020; Horan et al., 2013; Kim et al., 2020; Strauss et al., 2013, 2015). While plausible reasons for discrepancies with trait self-report measures are discussed above (i.e., greater specificity and ecological validity of state assessment) and consistent with other EMA studies of emotion regulation in SZ (Ludwig et al., 2020), discrepancies with laboratory findings warrant additional consideration. Specifically, laboratory findings consistently demonstrate reduced effectiveness of emotion regulation compared to CN, predominantly indexed via greater LPP amplitude during regulation conditions compared to CN. It is notable that the LPP ERP component is evident from approximately 300 milliseconds following stimulus onset through approximately 5000 milliseconds (Hajcak et al., 2010). While this component is considered sustained in terms of ERP components, the duration is nonetheless brief considering the duration of emotional episodes in ecological settings (Verduyn et al., 2009, 2011). Further, these studies typically rely on IAPS images which may lack personal relevance and sustained impact on emotional states that can be evoked from ecological stimuli (Raugh et al., 2019; Schatten et al., 2020; Wilhelm & Grossman, 2010). Laboratory studies are vital to identifying implementation in controlled settings and the rapid unfolding of early emotional responses; however, ecological designs may more accurately represent real-world forces that motivate emotion regulation strategy selection and the subjective experience of strategy implementation.

The present findings also stand in the context of previous EMA study of emotion regulation in SZ (Kimhy et al., 2020; Ludwig et al., 2020; Strauss et al., 2019; Visser et al., 2018). Specifically, they contrast with findings of Visser and colleagues (2018) who found greater polyregulation and greater use of reappraisal, distraction, suppression, and avoidance in SZ compared to CN. They also observed greater effectiveness of emotion regulation in CN compared to SZ for decreasing negative emotion. Ludwig and colleagues (2020) also observed greater endorsement of reappraisal, suppression, and distraction in SZ relative to CN. These findings were not replicated in the present study. The reasons for this are unclear but may be due to the assessment procedures. Specifically, both studies evaluated strategy selection using a continuous scale (reflecting *how much* a strategy was applied), whereas the present study employed a dichotomous endorsement (reflecting *if* a strategy was applied). The prior studies (Ludwig et al., 2020; Visser et al., 2018) thus may have more variability in their outcome measure while the present study may be a more specific assessment of selection (i.e., without confounding with implementation). The available literature does not indicate which approach may be more appropriate; further study is warranted. However, results of the present study do replicate findings from Ludwig and colleagues (2020) suggesting that emotion regulation is generally effective in SZ.

People with SZ experience chronic elevated distress (Cho et al., 2017; Cohen & Minor, 2010; Sanchez et al., 2014) which is associated with reduced quality of life (Best et al., 2020). Understanding what emotion regulation strategies are effective and adaptive in the short and long-term may help people with SZ to manage this distress and improve their quality of life. People with SZ engage in a variety of strategies to manage their emotions and which have differential consequences for emotional experience and symptoms. In particular, cognitive emotion regulation techniques appear to be effective for reduction of negative emotion and adaptive for reductions in delusional severity. However, people with SZ may come into treatment for these symptoms relying on strategies such as distraction, avoidance, or suppression which are adaptive in the short term but may contribute to dysfunction in the long-term. A vital element of cognitive treatments for psychosis is likely to involve acknowledging the utility of existing methods (i.e., avoidance, distraction) and building motivation and skills to employ different techniques (i.e., reappraisal) which are more likely to be adaptive in the long-term.

Table 1. Demographic Characteristics

Variable	CN (n = 53)	SZ (n = 50)	Test Statistic	p	Effect size
Age; M (SD)	39.3 (10.5)	38.42 (11.84)	$F = 0.16$	.69	$d = 0.08$
Female; n (%)	37 (69.8%)	32 (64%)	$\chi^2 = 0.39$	.53	OR = 1.3
Personal education; M (SD)	15.49 (2.83)	13.22 (2.31)	$F = 19.76$	< .001	$d = 0.88$
Parental education: M (SD)	13.54 (2.87)	13.89 (2.95)	$F = 0.35$	.56	$d = 0.12$
Race; n (%)			$\chi^2 = 7.58$	.18	
Black	15 (28.3%)	15 (30%)			
Asian-American	3 (5.7%)	0			
Biracial	3 (5.7%)	3 (6%)			
White	24 (45.3%)	30 (60%)			
LatinX	6 (11.3%)	2 (4%)			
Other	2 (3.8%)	0			
Survey adherence; M (SD)	69.26% (20.95%)	59.79% (25.1%)	$F = 4.34$	.04	$d = 0.41$

Note. Adherence is the percentage of surveys completed (out of eight per day) before removing days with inadequate adherence.

Table 2. Ecological Momentary Assessment items.

Construct	Scale	Item(s)
Positive emotion[1]	0 - 100	How _____ do you feel right now? ● Amused, fun-loving, silly ● Content, serene, peaceful ● Happy, joyful, glad ● Love, closeness, trust ● Proud, confident, self-assured
Negative emotion[1]	0 - 100	How _____ do you feel right now? ● Angry, irritated, annoyed ● Sad, downhearted, unhappy ● Scared, fearful, afraid ● Ashamed, humiliated, disgraced ● Anxious, nervous, pressured
Strategy[2]	1 = Yes, 0 = No	Which strategies were you using to DECREASE your NEGATIVE emotions? 1. Shifting attention (Turning attention away from situation) 2. Reappraising (Thinking about the situation differently) 3. Hiding expressions (Hiding how you are feeling) 4. Sharing (Talking to others about how you feel) 5. Avoiding (Removing yourself from the situation)
Effort[2]	0 - 100	(*If shifting attention was endorsed*) How much effort did you use to try to change your emotion(s) by shifting your attention? (*If reappraisal was endorsed*) How much effort did you use to try to change your emotion(s) by reappraising the situation? (*If hiding expressions was endorsed*) How much effort did you use to try to change your emotion(s) by hiding them? (*If sharing was endorsed*) How much effort did you use to try to change your emotion(s) by sharing with others? (*If avoiding was endorsed*) How much effort did you use to try to change your emotion(s) by avoiding the situation?
Success, self-perceived	0 - 100	How successful were you at changing your emotions?
Emotion regulation self-efficacy	0 - 100	How successful do you think you will be at changing your emotions the next time you are in this situation?
Anhedonia internal experience[1]	0 - 100[3]	How much are you enjoying the activity? How much do you think you will enjoy that activity the next time you do it? How much are you enjoying this social interaction? How much do you think you will enjoy interacting with them next time?
Anhedonia behavior	1 = Yes, 0 = No[3]	What are you doing right now? Recreation
Avolition internal experience	0 - 100[3]	How interested are you in the activity?
Avolition behavior	1 = Yes, 0 = No[3]	What are you doing right now?[4] Working/ Studying, Errands/ Housework, Exercising, Shopping, or Commuting/ Traveling
Asociality internal experience	0 - 100[3]	How interested are you in this social interaction?

Asociality behavior	1 = Yes, 0 = No[3]	Who are you interacting with?[4] Significant other, Family/ Roommates, or Friends
Negative symptoms[1]	0 - 200	Anhedonia internal experience * (1 + anhedonia behavior) Avolition internal experience * (1 + avolition behavior) Asociality internal experience * (1 + asociality behavior)
Delusions[1]	0 - 100	Please rate the following: ● How suspicious do you feel right now? ● How much is something or someone controlling your thoughts? ● How much is someone reading your mind or are you reading someone else's mind?

Note. [1] = Average of all responses. [2] = Each response is a separate variable. [3] = Reverse scored. [4] = If any endorsed, 1, otherwise, 0.

Table 3. Results of models investigating strategy effectiveness and adaptiveness.

	Change models (Hypotheses 2A & 2B)		
Outcome	Group	Strategy	Group X Strategy
Negative emotion	0.09	8.09***	1.45
Positive emotion[1]	3.85	0.22	1.63
Negative symptoms	1.08	3.58**	1.15
Delusions	1.19	3.01*	3.17**

	Moderated models (Hypotheses 2B and 3B)							
Outcome	Group	Strategy	NE	Group X Strategy	Group X NE	Strategy X NE	Group X Strategy X NE	Covariate
Negative emotion	26.28***	0.55	2.85	0.85	1.74	1.83	1.08	-
Positive emotion	2.54	0.42	0.2	0.67	0.02	2.23*	0.61	59.08***
Negative symptoms	0.82	0.69	4.24*	0.32	3.26	0.87	0.88	45.82***
Delusions	27.66***	0.4	0.26	1.71	7.23**	1.73	2.05	160.33***

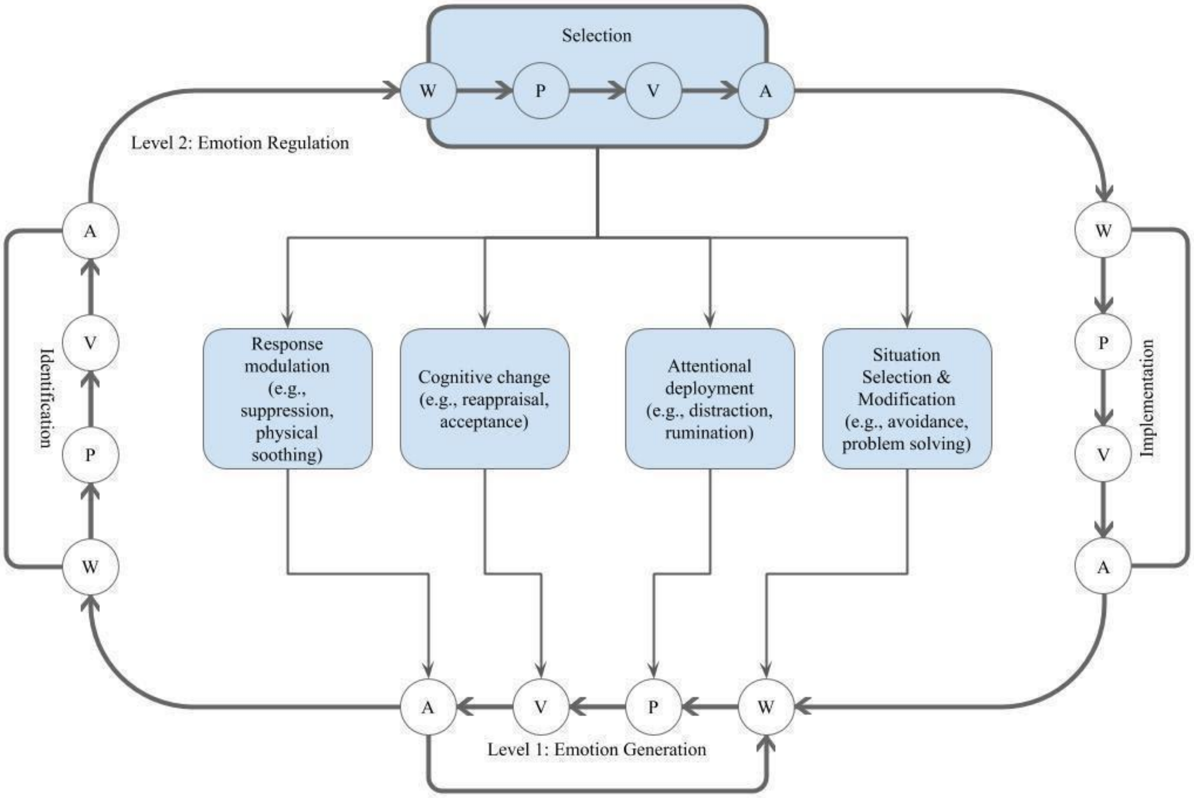
Note. NE = Negative emotion at t; [1] = Model with negative emotion at t as a covariate, see text. All values are F. Change models use a change score in the outcome variable (i.e., outcome at $t + 1$ – outcome at t), while moderated models use the outcome at $t + 1$ with the outcome at t entered as a covariate (see Data Analysis).
* = $p < .05$, ** = $p < .01$, *** = $p < .001$

Table 4. Exploratory moderated autoregression models

Outcome	Group	Strategy	AR	Group X Strategy	Group X AR	Strategy X AR	Group X Strategy X AR	Negative Emotion
Positive emotion	2.85	0.5	34.37***	1.32	0.07	0.99	0.26	0.05
Negative symptoms	2.53	0.71	62.16***	0.19	5.44*	0.35	0.41	0.6
Delusions	34.01***	0.63	9.68**	1.44	34.44***	6.81***	1.31	0.32

Note. AR = Autoregressive effect (effect of variable at t on itself at $t + 1$).
* = $p < .05$, ** = $p < .01$, *** = $p < .001$

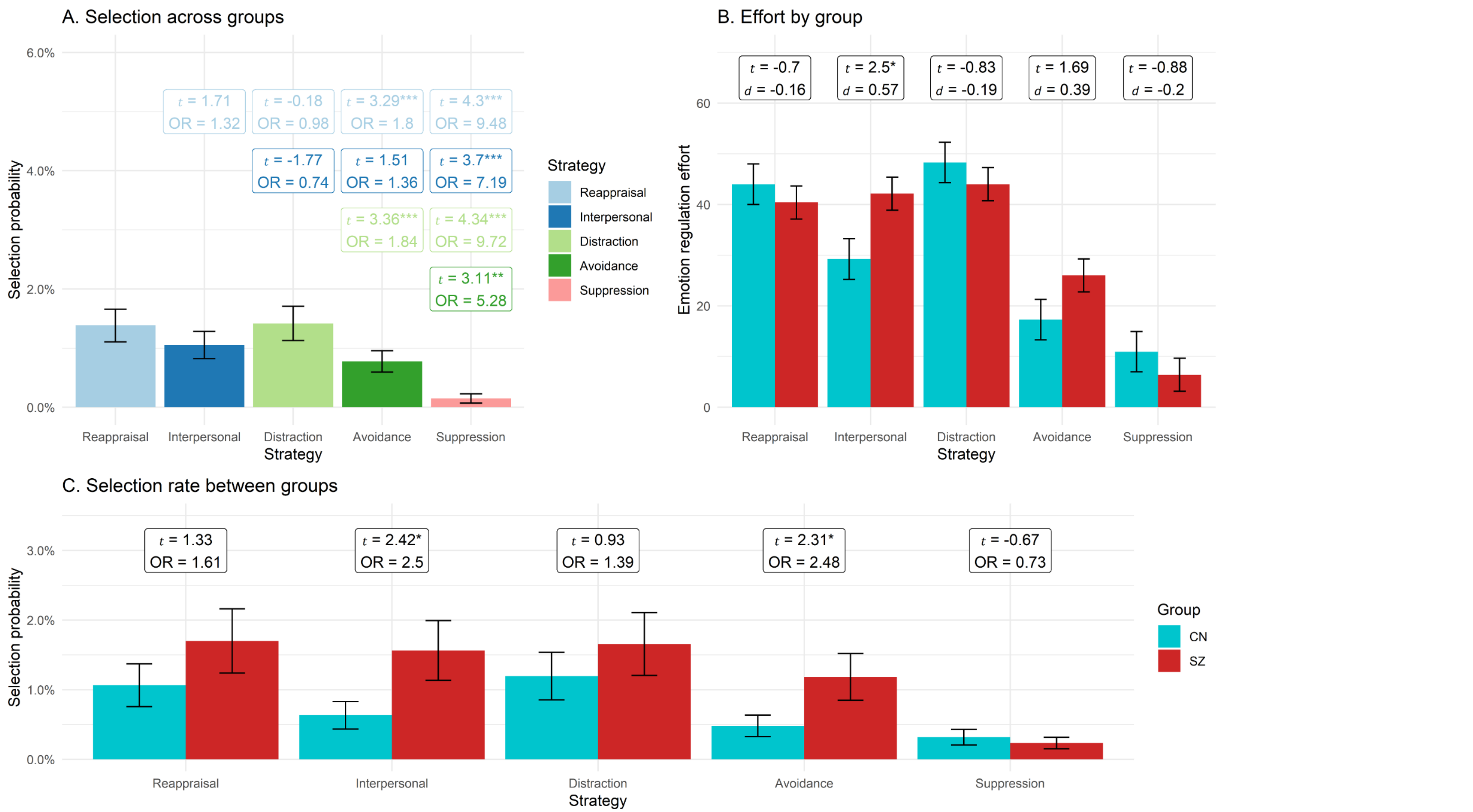
Figure 1
Extended Process Model of emotion regulation



Note. Adapted from McRae & Gross, 2020. W = World, P = Perception, V = Valuation, A = Action. Shaded areas reflect the selection of specific strategies and the components of emotion generation that they act upon.

Figure 2

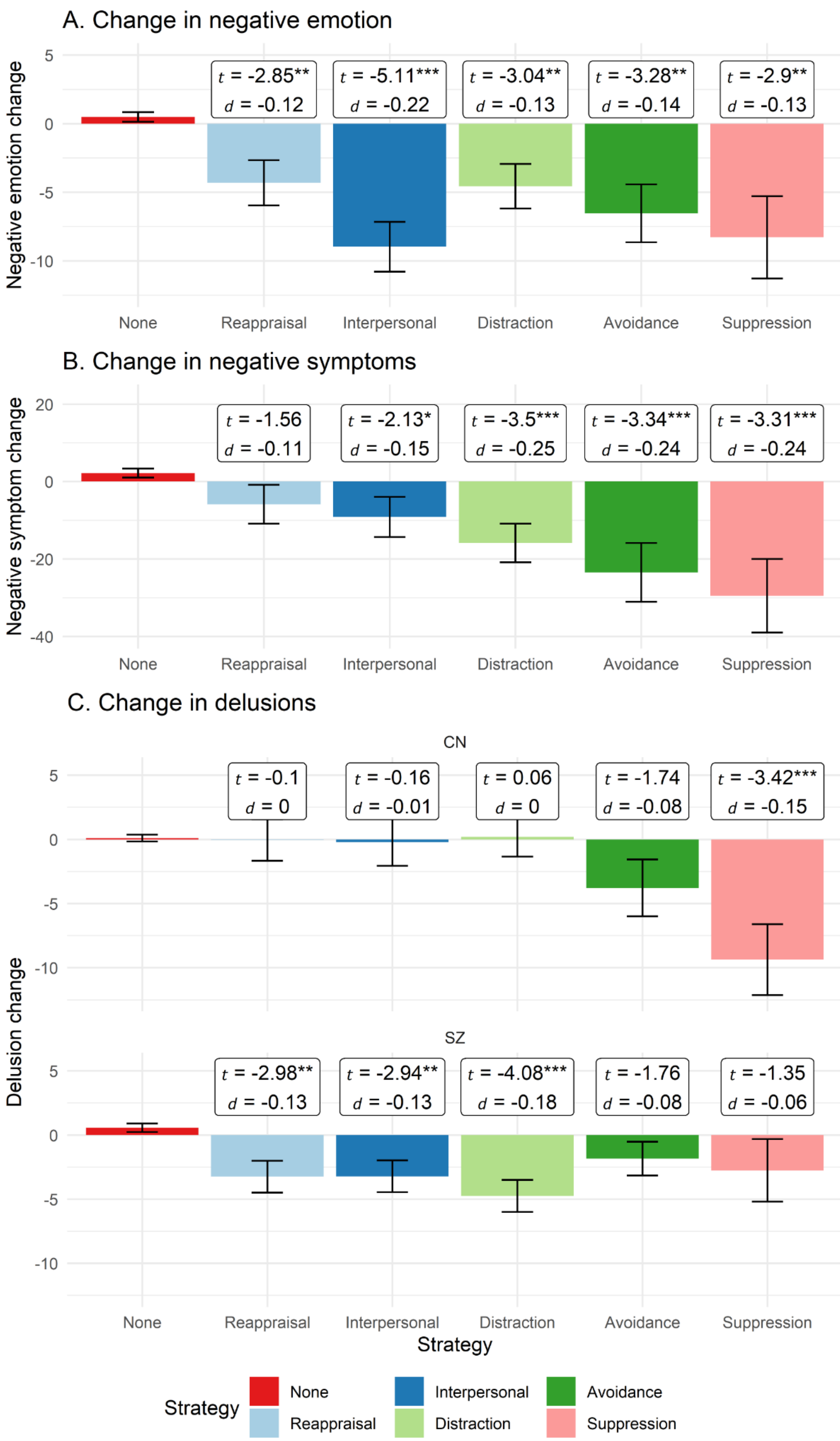
Strategy selection rate and effort.



Note. Panel A: Rate of strategy selection across both groups. Panel B: Emotion regulation effort by group and strategy. Panel C. Rate of strategy selection between groups. All values are estimated marginal probabilities (A and C) or means (B); all error bars reflect standard error. Colored labels represent contrasts relative to the corresponding-colored strategy. Black labels represent contrasts between groups for a specific strategy.
* = $p < .05$, ** = $p < .01$, *** = $p < .001$

Figure 3

Change in negative emotion, negative symptoms, and delusions over time by strategy.

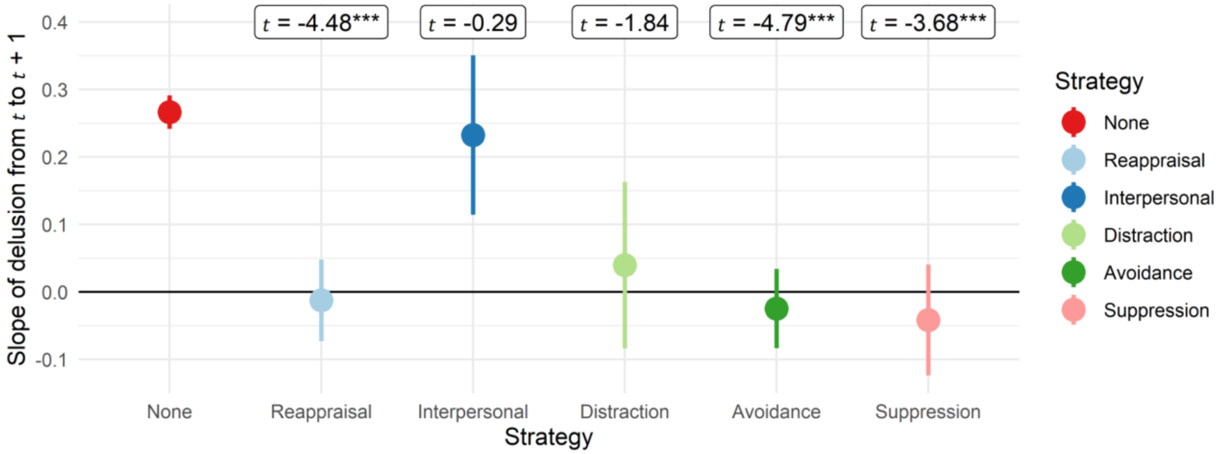


A. Change in negative emotion
Negative emotion change
5
0
-5
-10
t = -2.85**
d = -0.12
t = -5.11***
d = -0.22
t = -3.04**
d = -0.13
t = -3.28**
d = -0.14
t = -2.9**
d = -0.13
None
Reappraisal
Interpersonal
Distraction
Avoidance
Suppression
B. Change in negative symptoms
Negative symptom change
20
0
-20
-40
t = -1.56
d = -0.11
t = -2.13*
d = -0.15
t = -3.5***
d = -0.25
t = -3.34***
d = -0.24
t = -3.31***
d = -0.24
None
Reappraisal
Interpersonal
Distraction
Avoidance
Suppression
C. Change in delusions
CN
t = -0.1
d = 0
t = -0.16
d = -0.01
t = 0.06
d = 0
t = -1.74
d = -0.08
t = -3.42***
d = -0.15
SZ
t = -2.98**
d = -0.13
t = -2.94**
d = -0.13
t = -4.08***
d = -0.18
t = -1.76
d = -0.08
t = -1.35
d = -0.06
Delusion change
5
0
-5
-10
None
Reappraisal
Interpersonal
Distraction
Avoidance
Suppression
Strategy
Strategy
None
Reappraisal
Interpersonal
Distraction
Avoidance
Suppression

Note. Panel A = Change in negative emotion by strategy. Panel B = Change in negative symptoms by strategy. Panel C = Change in delusions by strategy and group. All values reflect estimated marginal means with standard error bars. All contrasts reflect effect of a given strategy relative to no strategy.
* = $p < .05$, ** = $p < .01$, *** = $p < .001$

Figure 4

Moderated autoregression of delusions over time by strategy.



Note. Points represent simple slope of delusions at t on delusions at $t + 1$ for each strategy, lines represent standard errors around each estimate. Labels reflect contrast of autoregressive slope for the given strategy relative to no strategy.

* = $p < .05$, ** = $p < .01$, *** = $p < .001$

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