Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

How We Cope Shapes How We Think: Coping Strategies Differentially Predict Constrained and Freely Moving Thoughts

Cecilia L. Liu

cecilia.liu1@ucalgary.ca

University of Calgary

Mason Li

University of Calgary

Julia W.Y. Kam

University of Calgary

Research Article

Keywords: Coping, Automatic constraints, Deliberate constraints, Freely moving thought, Dynamic Framework of Thought, Experience sampling, Heart-rate variability

Posted Date: May 31st, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9583398/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

In times of stress, the strategies we use to cope can impact how we feel. However, the underlying pathways by which coping strategies influence emotional wellbeing remain underexplored. One potential mechanism is through our thoughts, as stress can alter thoughts and thoughts are intertwined with mood and wellbeing. Thus, understanding how coping strategies relate to thoughts after a stressor provides insight into acute changes in affect. The present study examined the relationship between coping strategy usage and automatically constrained, deliberately constrained, and freely moving thoughts (as characterized by the Dynamic Framework of Thought), along with affective outcomes of these relationships.

Methods

Participants completed the Brief COPE to assess their frequency of problem-focused, emotion-focused, and avoidant coping strategy usage in daily life, and reported on their thoughts after an in-lab stress task. Affective outcomes included subjective stress and affect, and physiological stress, quantified as heart rate variability recorded using electrocardiography.

Results

Emotion-focused coping predicted less automatically constrained thoughts, and avoidant coping predicted less deliberately constrained thoughts. Problem-focused coping predicted more automatically constrained and less freely moving thoughts, but these relationships did not survive correction. Subsequently, participants who used more problem-focused strategies experienced worse mood if they reported less automatically constrained and more deliberately constrained thoughts. Finally, individuals did not differ in physiological stress based on their thoughts.

Conclusions

Our findings suggest that coping strategy usage is associated with individual differences in thought constraints and short-term changes in affect, which may explain how long-term affective outcomes of coping strategies manifest through altered thought patterns. This understanding provides insight into the mechanisms underlying how coping strategies impact long term wellbeing and highlight a potential target for interventions to aid in more effective stress coping.

1. Introduction

From getting stuck in traffic to having a disagreement with a family member, encountering stressful situations is common in everyday life. How we choose to deal with these stressors, also known as coping strategies, can impact emotional wellbeing long after the stressful moment has passed. Indeed, these coping strategies are associated with depression and anxiety symptoms (1, 2) as well as psychological distress (3). Whereas a substantial amount of literature has focused on these long term psychological health outcomes such as depression and anxiety symptoms (4, 5), more research into how coping strategy usage is related to state-level differences in mental processes is needed to understand the pathways by which coping strategies relate to long-term wellbeing. In particular, the relationship between coping strategies and cognition is an important area of consideration given the strong connection between how we think and how we feel (6). Thus, the present study aims to investigate how coping strategy usage predicts our thoughts after a stressor and the affective correlates of this relationship.

1.2 Coping Strategies and Wellbeing

According to Lazarus and Folkman's Transactional Theory of Stress and Coping, coping refers to an individual's attempt to deal with or manage a situational challenge that exceeds their resources (7). Lazarus and Folkman proposed two different types of ways that people cope with stress: problem-focused and emotion-focused coping. Problem-focused strategies address the root cause of the stressful situation, such as taking action to fix the problem or making a plan to deal with the issue. Emotion-focused coping instead aims to ameliorate the negative emotions surrounding the stressor, such as by seeking emotional support from a friend or venting about the situation. A third type of strategies involve disengaging from the stressor such as distraction or denial; this has been historically categorized under emotion-focused coping (7) but have recently been classified separately as avoidant coping strategies (8). Understanding different coping strategies provides insight into why individuals might experience differences in the resolution of the stressor and long-term emotional wellbeing (9).

An important aspect of any coping strategy is whether it ultimately helps or harms the individual using it. Previous literature has placed an emphasis on categorizing strategies as adaptive or maladaptive based on the nature of the strategy or its impacts on mental wellbeing, which has been referred to as the "fallacy of uniform efficacy" (10). For example, problem-focused coping is typically characterised as adaptive, as it is associated with more effective coping (11) and better mental health outcomes such as decreased risk of depression (12) and more positive mood (13). The findings on emotion-focused coping are more mixed (14, 15), as emotion-focused coping may increase risk of rumination (11) but is also associated with better physical and mental health (16). Finally, avoidant coping is consistently labelled as maladaptive due to worse outcomes regarding mental and physical health (5, 12, 17). However, real life situations are not that simple; strategies that are effective in one circumstance may not be helpful in another (18, 19). For example, taking action to fix the stressor may be helpful if you have a flat tire, but not so much if you're dealing with the loss of a loved one. Additionally, a strategy might not be intrinsically maladaptive but can lead to negative outcomes when overreliance occurs (20). Rather than decisively labelling strategies as adaptive or maladaptive, examining how they work on a more acute scale may be useful for understanding the contexts in which a given strategy might lead to positive or negative outcomes.

1.3 Stress Alters Thoughts that are Linked to Wellbeing

Stress has a major impact on our thoughts, as the circumstances of our daily lives can dictate how we think. In particular, stress is related to changes in task-unrelated thoughts, which have implications for task performance and sustained attention (21). In daily life, higher stress level predicts more frequent task-unrelated thoughts (22). Priming personal concerns relevant to the participant during a laboratory task also leads to a slight increase in the frequency of task-unrelated thought (23). Finally, experimentally manipulating the anticipation of a stressful event causes participants to shift to task-unrelated thoughts more often compared to controls, although this effect was dependent on participants being in a negative mood before the experiment began (24).

Although these findings provide valuable insight into the effects of stress on task-unrelated thoughts, knowing that participants were not thinking about the ongoing task does not inform how those thoughts unfold over time. To that end, the Dynamic Framework of Thought proposed that our thoughts can be characterized by their constraints, or lack thereof (25). Automatic constraints occur in the absence of cognitive control, typically in response to external or internal events with affective salience, where individuals feel stuck on a certain topic and cannot stop thinking about it even if they tried to, such as ruminating about a recent negative event (e.g., argument with a partner or a manuscript rejection). Deliberate constraints, on the other hand, reflect processes involving cognitive control and result in goal-directed thoughts, such as planning for the future or thinking about how to solve a problem. Finally, freely moving thoughts occur when both automatic and deliberate constraints are weak, such that thoughts can dynamically jump from one topic to another with no constraints on the direction of thoughts. For example, you may shift from thinking about the weather to your dinner plans to a funny video you watched earlier.

Importantly, these thought dimensions characterized using the Dynamic Framework of Thought are intertwined with emotional wellbeing. Rumination, a classic example of automatically constrained thoughts, is strongly linked to negative affect and can exacerbate negative mood (26–28). Deliberate constraints may be related to increased positive affect, given

that diminished cognitive control is associated with distress (6). Finally, freely moving thoughts are associated with increased concurrent positive affect (29). Induction of freely moving thoughts increases both positive affect (30) and positively valenced thought content (31).

These thought dimensions may also be related to physiological indicators of stress. One widely used measure is heart rate variability, which quantifies the variation in the length of successive heart beats (32, 33). Reduced heart rate variability is generally interpreted as heightened stress level, as it reflects impaired parasympathetic nervous system function (34). The root mean square of successive differences (RMSSD) is an index of heart rate variability that is a reliable measure of stress (35, 36).

Based on previous literature, automatically constrained thoughts may be especially linked to differences in heart rate variability. Lower resting heart rate variability is associated with more frequent rumination and greater depressive symptoms (37), and periods of state-level rumination were accompanied by lower heart rate variability (38). Conversely, higher resting heart rate variability is associated with better control over unwanted thoughts, measured by individuals' success at suppressing thoughts (39). While the link between subjectively experienced stress and thoughts has been studied in the past, there is less work examining how physiological stress measures are related to thoughts, especially through the lens of the Dynamic Framework of Thought (25). This is an important area of investigation as subjective and physiological stress measures do not always align (40). Given these links between stress, thoughts, and affect, the relationships between coping strategies, thoughts, and mood are an important area of investigation for understanding how thoughts may contribute to coping outcomes with the goal of helping people improve their responses to stress.

1.4 The Present Study

There are several gaps in the literature that have yet to be addressed. First, no research to date that has examined the relationship between coping strategies and automatically constrained, deliberately constrained, and freely moving thoughts. Second, examining how coping and thoughts relate to affect shed light on their impact on wellbeing. Finally, although previous work has established links between stress and task-unrelated thought, the relationship between stress and the thought types defined in the Dynamic Framework of Thought is unknown. Understanding how these relationships operate on a short-term scale offer insight into potential mechanisms through which coping behaviors result in long-term differences in emotional wellbeing.

To address these gaps, we examined how coping strategy usage relates to automatically constrained, deliberately constrained, and freely moving thoughts after a stressor. Coping strategy usage was assessed using the Brief COPE (41), measuring how often participants use problem-focused, emotion-focused and avoidant coping strategies in everyday life. In the lab, participants completed a writing task designed to induce stress (42). Participants then completed an attention task during which they were occasionally asked to report on the extent to which they were experiencing the three categories of thoughts. Subjective stress and affect were measured at baseline, post-stress induction, and post-attention task. Physiological stress, indexed using heart rate variability, was measured at the same three timepoints using electroencephalography (ECG).

We predicted that usage of problem-focused, emotion-focused, and avoidant coping strategies would be differentially associated with automatically constrained, deliberately constrained, and freely moving thoughts. Given the limited research examining these thought dimensions, we did not have directional hypotheses regarding the relationship between coping and thoughts. On an exploratory basis, we examined whether coping strategies interact with thoughts in predicting later affect and the relationship between each thought dimension and RMSSD as a physiological measure of stress.

2. Methods

2.1 Participants

A total of 125 individuals met the inclusion criteria (outlined below) and participated in the study. Seven individuals were excluded from analyses due to incomplete study components (e.g., missing questionnaires or did not finish the attention task), resulting in a final sample of N = 118 for the main analyses (gender: 74% women, 21% men, 5% non-binary; age: *M* = 21.6 years, *SD* = 4.2 years; education: *M* = 14.3 years, *SD* = 2.5 years). Participants were mostly White (39%) and South Asian (19%); other common ethnicities reported were East Asian (9%), Hispanic (8%), Black (7%) and other/mixed ancestry (18%). Eighteen participants were excluded from analyses involving heart rate variability due to noisy or unusable ECG recordings but were kept in the main analyses.

Participants were recruited from the University of Calgary undergraduate Research Participation System and from the general community in Calgary, Alberta through advertisements posted on social media and physical flyers. The target sample size of N = 120 was based on recommendations for cluster analysis, as described below under Data Analysis (43). Individuals were eligible to participate if they were between the ages of 18–35, fluent in English, and had normal or corrected-to-normal vision. Participants received an honorarium for their participation in the form of course credits or a gift card. The study was approved by the University of Calgary's Conjoint Faculties Research Ethics Board (REB24-1265) and was conducted in accordance with the Declaration of Helsinki. All participants provided informed consent to participate.

2.2 Measures

Coping Strategies

Participants completed the Brief COPE scale (41), which contains 14 two-item subscales assessing how often they employ certain coping strategies when dealing with hardships in their life. Subscales include active coping, use of informational support, planning, positive reframing, venting, emotional support, humour, acceptance, self-blame, religion, self-distraction, denial, substance use, and behavioural disengagement. Participants responded to each question on a Likert scale of 1 ("Not at all") to 4 ("A lot").

These subscales were further aggregated as problem-focused, emotion-focused, and avoidant strategies (44–46). Problem-focused strategies include active coping, use of informational support, planning, and positive reframing. Emotion-focused strategies include venting, emotional support, humour, acceptance, self-blame, and religion. Avoidant strategies include self-distraction, denial, substance use, and behavioural disengagement. Scores for each category were calculated by averaging the scores from each component subscale. Cronbach's alpha was 0.76 for problem-focused coping, 0.52 for emotion-focused coping, and 0.66 for avoidant coping. Although these values are slightly lower than what has been reported in previous literature (45, 47), they nevertheless indicate moderate reliability (48).

Stress-Induction Writing Task

Participants completed a writing task, which has been used in prior research to successfully induce stress (42). In the task, participants were instructed to select a "negative life event that is currently troubling [them]" and rate how stressful the event was, how much control they had over it, and how large of an impact it had on their daily life on a Likert scale of 1 ("Not at all") to 7 ("Extremely"). Afterwards, they were given 8 minutes to write about their thoughts and feelings about the negative event.

Attention Task and Thought Probes

Participants completed the Sustained Attention to Response Task (SART) (49), which is the most commonly used paradigm to elicit episodes of task-unrelated thought (50) due to its simple and repetitive nature. During the SART, participants were asked to fixate their gaze at the center of a desktop monitor, where they were presented with either single digit numbers considered as non-target stimuli (i.e., 0–9) or a letter "X" considered as the target stimuli. Participants responded by pressing a button when the non-target digit was shown and withheld their response when the target letter "X" was shown. Target stimuli were shown infrequently (10% of all stimuli) to facilitate the automaticity of response and reduce cognitive demands of the task. In each trial, target and non-target stimuli were presented for 500 ms, followed by an interstimulus interval that randomly varied between 900 and 1100 ms, with each trial lasting approximately 1500 ms. Each block of trials

consisted of 15–45 stimuli, lasting on average 45 s (range: 22.5–67.5 s). In total, participants completed 30 blocks, which took around 40–50 minutes.

At the end of each block, participants were presented with a thought probe that asked them to report on their thoughts in the 10–15 seconds immediately prior to the probe. As there were 30 blocks, participants responded to 30 probes throughout the SART. Participants responded on a Likert scale of 1 (“Not at all”) to 7 (“Completely”) to indicate the extent to which their thoughts were 1) automatically constrained, 2) deliberately constrained, 3) freely moving, 4) focused on the attention task, and 5) focused on the content of the writing task. We provided definitions and real-life examples of all thought types to the participants before the task began, offered opportunities to clarify, and ensured they understood these questions before proceeding.

Measurement of Stress Response and Affect

Stress level was measured using self-report and physiological indicators. These measures were taken at three separate time points: at the beginning of the study session (as baseline), after the writing task (as immediate post-stress induction), and at the end of the attention task before debriefing (as delayed post-stress induction). Although our study primarily focused on the self-reported measures, we also collected physiological indicators as a complementary measure.

Subjective stress. Momentary stress level was assessed with the question “How stressed do you feel at this moment?” Participants answered on a Likert scale of 1 (“Not at all”) to 7 (“Extremely”).

Affect. Momentary affect was assessed with the question “How positive or negative do you feel at this moment?” Participants answered on a Likert scale of 1 (“Completely negative”) to 7 (“Completely positive”).

Heart rate variability as a measure of physiological stress. Participants’ heart rate was recorded continuously using electrocardiography (ECG) during the study session, as a physiological measure of stress. To ensure accurate heart rate measurements, participants were asked not to perform strenuous exercise within an hour of their participation in the experiment. Heart rate variability is a physiological measure of stress response, with smaller heart rate variability indexing higher levels of stress (34, 35). This measure captures the fluctuation in the length of time between two ECG heartbeat peaks (i.e., RR intervals). Specifically, it was quantified as the root mean square of successive differences (RMSSD), which is derived by calculating the difference in length between two consecutive RR intervals, squaring the values, averaging across an epoch of time, and then computing the square root (51). This is a widely utilized index of heart rate variability that reflects vagally mediated changes to heart rate, such as that caused by stress (35, 36), and is less affected by respiration compared to other indices of heart rate variability.

Resting RMSSD was calculated from three 60 second epochs (baseline, post-stress induction, and post-attention task) where the participant was instructed to sit still and simply focus on the center of the computer screen in front of them.

Covariates

At baseline, participants reported their age, gender, and years of education. Furthermore, they completed questionnaires to assess chronic stress level, depression symptoms, anxiety symptoms, and ADHD symptoms to control for the relationships between these factors and automatically constrained, deliberately constrained, and freely moving thoughts (25, 52, 53).

Perceived Stress Scale (PSS) (54). Chronic stress was assessed using the PSS, a 10-item measure of an individual’s experiences and feelings of stress over the past month (e.g. “How often have you been upset because of something that happened unexpectedly?”). Participants responded on a Likert scale of 0 (“Never”) to 4 (“Very Often”), for a total sum score range of 0–40 where higher scores indicate higher perceived stress. Cronbach's alpha was 0.83.

Patient-Reported Outcomes Measurement Information System (PROMIS) short forms (8a) for depression and anxiety (55). Depression and anxiety symptoms were assessed using the PROMIS Depression 8a and PROMIS Anxiety 8a scales.

Participants rated the frequency that they experienced depression symptoms (e.g. “I felt worthless”) and anxiety symptoms (e.g. “I felt fearful”) over the past 7 days on a Likert scale of 1 (“Never”) to 5 (“Always”). Raw scores for each scale were summed and converted to T-scores using conversion tables (56). Cronbach’s alpha was 0.91 and 0.90 for depression and anxiety, respectively.

Adult ADHD Self-Report Scale (ASRS) (57) ADHD symptoms were assessed using the ASRS, a 18-item scale measuring inattentive symptoms (e.g. “how often do you have problems remembering appointments or obligations?”) and hyperactive symptoms (e.g. “How often do you feel restless or fidgety?”) of ADHD within the past 6 months. Participants responded on a 5-point Likert scale of 1 (“Never”) to 5 (“Always”), resulting in a score range of 18–90. Since ADHD symptomology was not a main variable of interest, scores for the inattentive and hyperactive subscales were aggregated into one overall score. Cronbach’s alpha was 0.91.

2.3 Procedure

Participants first gave informed consent and completed a baseline questionnaire where they reported demographic information and responded to questionnaires (Brief COPE, PSS, PROMIS Depression and Anxiety, and ASRS). After arriving at the lab, participants’ baseline stress (subjective stress and heart rate variability) and affect measures were recorded. Next, participants went through a brief information session to familiarize them with the terminology used in the thought probes and included practice trials of the attention task. Participants then completed the stress induction writing task. Post-stress induction subjective and physiological stress were recorded, after which participants completed the attention task, responding to intermittent probes about their thoughts. Finally, subjective and physiological stress levels were recorded once again before participants were debriefed.

2.4 Electrocardiogram (ECG) Acquisition and Processing

ECG data was continuously recorded using three Ag/AgCl sintered ring electrodes connected to the BrainVision BIPAUX adapter and actiCHamp amplifier. The electrodes were attached to the participant according to the lead II positioning of the Einthoven triangle (58), with one lead on the right arm, one lead on the left ankle, and a ground electrode on the left arm, which provided the cleanest signal during pilot testing. Data was sampled at 500 Hz and recorded in the BrainVision Recorder.

Preprocessing was performed using the Fieldtrip Toolbox in MATLAB R2024a (The MathWorks Inc., Natick, Massachusetts). Line noise (60 Hz) was removed, and data were filtered using the Pan Tomkins Algorithm (59), which includes a bandpass filter for 5–15 Hz to increase the signal-to-noise ratio, a 5-point first order derivative filter, and a moving median filter on the squared signal to enhance the heartbeat peaks.

After filtering, each 60 second epoch of interest (baseline, post-stress induction, and post-attention task) was cleaned using visual inspection in MATLAB to remove noisy segments, which were mostly due to movement artifacts. Outliers in the resulting RR intervals were defined as any value outside the normal range of 280 ms to 1500 ms based on previous literature (60, 61) and were discarded. Ectopic beats were identified as RR intervals that deviated more than 20% from the previous interval and were also discarded (61–63). All discarded RR intervals were replaced with interpolated intervals using linear interpolation (64, 65). Given that RMSSD can be reliably calculated from ultra-short heart rate recordings of as little as 30 seconds of data (66), and interpolation provides more accurate RMSSD for up to 50% of missing beats compared to deletion (67), segments were only removed from the dataset if there was less than 30 seconds of useable data. Eighteen participants were removed from analyses involving heart rate variability due to technical errors in recording the ECG (N = 3) or noise segments spanning more than 50% of the recording (N = 15).

2.5 Data Analysis

Analyses were preregistered on OSF (https://osf.io/a8pd5). All initial analyses covaried for age, gender, education attainment, PSS score, PROMIS depression and anxiety scores, ASRS score, stressful event controllability, and stressful

event impact. If a covariate was not significant in any of the confirmatory analyses, we implemented the same analyses without this covariate for brevity.

Cluster Analysis and Pre-determined Categories of Coping Strategies

Previous literature has demonstrated the utility of evaluating coping using a person-centered approach. For example, some studies have used cluster analysis to group individuals into different coping "profiles" based on their pattern of coping strategy usage (1, 2, 17, 68), as the strategies used by individuals may change depending on the context of the stressor. In our initial preregistration, we planned to use a two-step cluster analysis in a similar manner and create data-driven groupings. Given that past literature has generally reported 3–4 clusters in the Brief COPE (1, 2, 17) and recommendations for cluster analysis suggest that N = 20–30 participants per expected subgroup would be sufficient (43), we aimed for a sample size of N = 120.

Scores for each question in the Brief COPE were transformed into standardized z-scores (mean = 0, standard deviation = 1). As recommended by Henry et al. (69), a two-step approach was used to identify clusters of coping strategy use from the standardized scores. First, hierarchical cluster analysis was used to identify clusters in the data without a pre-existing hypothesis of the number of clusters. Clustering was conducted using Ward's method (which minimizes the error sum of squares) (70) and Euclidian distance was used as the distancing metric. Euclidian distance is calculated as the square root of the sum of the squared differences between cases on each variable (69). The number of clusters that maximized the gap statistic was selected for the second step. Next, to confirm these results, a k-means cluster analysis was conducted with *k* set to the number of clusters identified in the hierarchical cluster analysis. Cluster validity was evaluated using Silhouette scores.

Both hierarchical cluster analysis and k-means cluster analysis did not support the presence of clusters in the data. For hierarchical clustering, the gap statistic did not substantially increase beyond $k = 1$, indicating a lack of evidence for more than one cluster in the data (71). In *k*-means clustering, our largest silhouette score was 0.12; values close to 0 indicate overlapping or ambiguous clusters (72). This was further supported by the Hopkins statistic (0.59), in which values close to 0.5 indicate low clustering tendency (73). We discuss potential explanations for this in the Supplementary Materials. Thus, we replaced initial preregistered analyses that were dependent on coping strategy clusters based on participants' data with pre-determined categories of coping strategies (i.e., problem-focused, emotion-focused, and avoidant) commonly utilized in previous research (45, 46). Although the person-centered approach of clustering has its benefits, our decision was to use a variable-centered approach given the absence of reliable clusters in our data, which has been proposed to be better suited for investigating psychological processes underlying coping (74).

Coping Strategy Predicting Thoughts

We first assessed our primary question concerning the relationship between coping strategy and thoughts. Participants' scores for problem-focused, emotion-focused, and avoidant coping were used as predictors in a set of three linear regression models predicting their mean rating of automatically constrained, deliberately constrained, and freely moving thoughts throughout the attention task. Bonferroni correction was applied to account for multiple comparisons, such that the threshold for significance was $\alpha < .05/3$ or $\alpha < .017$.

To compare results to existing literature on task-unrelated thoughts and thought content, coping strategies were used to predict participants' mean rating of task-unrelated thoughts (which were reverse coded from their responses to the question of how focused they were on the attention task) and stressor-related thoughts (based on scores calculated from responses to the question of how focused they were on the content of the writing stress induction task).

Coping Strategies and Thoughts Predicting Later Affect

To examine the impact of thoughts and coping strategies on later affect, we implemented a linear regression model to test the interactions between each coping strategy and thought type in predicting post-attention task affect. Post-stress

induction affect was included as a covariate to control for the impact of earlier mood.

Thoughts Predicting Heart Rate Variability

To assess whether automatically constrained, deliberately constrained, and freely moving thoughts were associated with differences in physiological stress level, participants' mean rating of each thought dimension during the attention task was used to predict their post-stress induction RMSSD (recorded immediately after completing the stress-induction writing task) as an index of heart rate variability using linear regression. Post-stress induction heart rate was included as a covariate in the model to control for the impact of heart rate on RMSSD (75).

3. Results

3.1 Descriptive Statistics

Mean scores (on a scale from 1–4) for problem-focused coping (M = 2.73, SD = 0.56), emotion-focused coping (M = 2.45, SD = 0.43), and avoidant coping (M = 1.83, SD = 0.43) were comparable to samples in past research (44, 45). Participants' mean ratings of thoughts (on a scale from 1–7) were 3.48 (SD = 1.26) for automatically constrained thoughts, 4.34 (SD = 1.05) for deliberately constrained thoughts, and 4.57 (SD = 1.06) for freely moving thoughts, aligning with previous work (29, 76). Mean RMSSD values (M = 45.15 ms, SD = 17.12 ms) were also consistent with previous research (68, 77, 78). Descriptive statistics and bivariate Pearson correlations for main study variables are presented in Table 1.

Table 1
Bivariate Pearson correlations among study variables and total descriptive statistics (N = 118).

Variable	Mean (SD)	Range (of mean)	1	2	3	4	5	6	7	8	9
1. Problem-focused coping[a]	2.73 (0.56)	1.50–4.00	-								
2. Emotion-focused coping[a]	2.45 (0.43)	1.25–3.67	0.46***	-							
3. Avoidant coping[a]	1.83 (0.43)	1.00–3.12	-0.11	0.24**	-						
4. Automatically constrained thoughts[b]	3.48 (1.26)	1.17–6.44	0.03	-0.13	0.10	-					
5. Deliberately constrained thoughts[b]	4.34 (1.05)	1.64–7.00	0.17	-0.04	-0.25**	-0.10	-				
6. Freely moving thoughts[b]	4.57 (1.06)	1.05–6.80	-0.16	0.06	0.17	0.16	-0.55***	-			
7. Task-unrelated thoughts[b]	3.59 (1.15)	1.03–6.27	-0.18	-0.04	0.19*	0.15	-0.77***	0.60***	-		
8. Stressor-related thoughts[b]	4.51 (1.14)	1.00–6.96	0.11	0.07	0.16	0.10	-0.002	-0.17	0.06	-	
9. Affect[c]	4.25 (1.12)	1.57–7.00	-0.01	-0.17	-0.25**	-0.10	0.26**	-0.23*	0.11	-0.22*	-
10. RMSSD[d]	45.15 ms (17.12 ms)	10.27–98.89 ms	-0.04	-0.17	-0.04	0.20	0.08	-0.11	-0.02	-0.15	0.00

[a]Coping strategy scores have a possible range of 1 to 4.

[b]Thought ratings have a possible range of 1 to 7.

[c]Affect calculated after the attention task, has a possible range of 1 (“Completely negative”) to 7 (“Completely positive”).

[d]RMSSD calculated immediately after the stress induction. N = 100 due to noisy or unusable ECG data.

*p < .05. **p < .01. ***p < .001.

3.2 Stress Induction Control Analysis

To check whether the stress induction writing task altered participants’ subjective and physiological stress level, we conducted a set of paired t-tests comparing post-stress induction stress level to baseline stress level. Subjective stress

significantly increased from baseline (*M* = 3.90, *SD* = 1.33) to post-stress induction (*M* = 4.51, *SD* = 1.14, *t*(117) = -5.05, *p* < .001). However, physiological stress, assessed using RMSSD, did not differ between baseline (*M* = 45.27 ms, *SD* = 18.40 ms) and post-stress induction (*M* = 45.15 ms, *SD* = 17.12 ms, *t*(99) = 0.10, *p* = .92).

3.3 Primary Analysis: Coping Strategies Predicting Thoughts

Three linear regression models, reported in Table 2, were implemented to determine whether coping strategy usage (i.e., problem-focused, emotion-focused, and avoidant coping) predicted thoughts. Separate models were implemented for automatically constrained, deliberately constrained, and freely moving thoughts. Main results of these analyses are plotted in Fig. 1.

Table 2
Linear regression models of coping strategies predicting mean thought ratings.

	Automatically Constrained Thoughts			**Deliberately Constrained Thoughts**			**Freely Moving Thoughts**		
	β (SE)	**95% CI**	**p**	**β (SE)**	**95% CI**	**p**	**β (SE)**	**95% CI**	**p**
Main effects									
Problem-Focused	0.29 (0.13)	[0.03, 0.55]	.032[a]	0.12 (0.11)	[-0.09, 0.34]	.252	-0.22 (0.11)	[-0.43, -0.003]	.047[a]
Emotion-Focused	-0.37 (0.13)	[-0.64, -0.11]	.006	-0.11 (0.11)	[-0.32, 0.11]	.318	0.16 (0.11)	[-0.06, 0.38]	.158
Avoidant	0.03 (0.14)	[-0.24, 0.30]	.827	-0.24 (0.10)	[-0.43, -0.05]	.014	0.01 (0.10)	[-0.11, 0.28]	.403
Covariates[b]									
Depression	0.39 (0.14)	[0.12, 0.67]	.004	-			-		
Age	-			0.30 (0.09)	[0.11, 0.49]	.002	-		
Gender[c]	-			-			-0.81 (0.22)	[-1.26, -0.36]	.001
R^2	0.12			0.16			0.16		
F Statistic	3.89			5.50			4.26		

Note. β = standardized coefficients, SE = standard error, 95% CI = 95% confidence interval.

[a]This effect did not survive Bonferroni correction.

[b]Only significant covariates were kept in each model for brevity.

[c]Dummy coded variable, reference = women.

Both problem-focused coping and emotion-focused coping significantly predicted automatically constrained thoughts, such that individuals who used more problem-focused coping strategies reported more automatically constrained thoughts during the attention task (*p* = .032) and individuals who used more emotion-focused coping reported less automatically constrained thoughts (*p* = .006). The association between problem-focused coping and automatically constrained thoughts did not survive Bonferroni correction and should be interpreted with caution. Depression was a significant covariate, as participants with higher levels of depression symptoms reported more automatically constrained thoughts (*p* = .005).

Individuals who used more avoidant coping strategies reported less deliberately constrained thoughts during the attention task (p = .014). Age was a significant covariate in this model, such that older participants reported more deliberately constrained thoughts than younger participants (p = .002).

Finally, problem-focused coping negatively predicted freely moving thoughts, such that individuals who used more problem focused coping strategies reported less freely moving thoughts during the attention task (p = .047); however, this relationship did not survive Bonferroni correction. Gender was a significant covariate, such that men reported less freely moving thoughts compared to women (p < .001). Our sample size of non-binary participants (N = 5) was not sufficient to make comparisons between groups.

To compare our results to past literature examining task-unrelated thoughts and thought content, we also implemented linear regression models to determine if coping strategy usage was related to task-unrelated thoughts and stressor-related thoughts. These results are reported in detail in Supplementary Table S1.

Avoidant coping positively predicted task-unrelated thoughts such that individuals who used more avoidant coping strategies reported more task-unrelated thoughts during the attention task (p = .042). Age was a significant covariate, such that older participants reported less task-unrelated thoughts compared to younger participants (p = .001).

Furthermore, avoidant coping also positively predicted stressor-related thoughts such that participants who used more avoidant coping strategies reported more stressor-related thoughts during the attention task (p = .033). Age was again a significant covariate, such that older participants reported less stressor-related thoughts compared to younger participants (p = .005).

3.4 Secondary Analysis: Coping Strategy x Thoughts Predicting Later Affect

We then tested whether interactions between coping strategy and thoughts were associated with subjective affect at the end of the study session (post-attention task) using a linear regression model. Post-stress induction affect was included in the model to account for the influence of previous affect. These results are reported in detail in Supplementary Table S2. Although there were no significant main effects, the interactions between problem-focused coping with deliberately constrained thought (p = .032) and problem-focused coping with automatically constrained thought (p = .017) were significant.

We followed up on these significant interactions *post hoc* using simple slopes and Johnson-Neyman intervals. We probed the simple slopes of problem-focused coping predicting later affect at low (− 1 SD) and high (+ 1 SD) levels of automatically constrained and deliberately constrained thoughts and calculated the range of automatically constrained and deliberately constrained thoughts that resulted in significant associations between problem-focused coping and affect.

The relationship between problem-focused coping and affect was not significant at both high (1 SD above the mean, p = .10) and low (1 SD below the mean, p = .08) values of automatically constrained thoughts. To follow up on the range of values at which automatically constrained thoughts moderate the relationship between problem-focused coping and affect, a Johnson-Neyman analysis indicated that more problem-focused coping usage predicted worse mood when automatically constrained thoughts were above 5.16 (i.e., 1.33 SD above the mean) but better mood when automatically constrained thoughts were below 1.66 (i.e., 1.44 SD below the mean). Thus, participants who reported higher levels of problem-focused coping reported worse mood later on if they had more automatically constrained thoughts but better mood if they had less automatically constrained thoughts, which is visualized in Fig. 2A.

The negative relationship between problem-focused coping and affect was not significant for people who reported more deliberately constrained thoughts than average (1 SD above the mean, p > .05), but significant for people who reported less than average (1 SD below the mean, p < .05). A Johnson–Neyman analysis indicated that the relationship between problem-focused coping and affect was significant when deliberate constraints were less than 3.32, which was 0.97 SD below the

mean. Thus, reporting more problem-focused coping was associated with worse mood later on, but only for participants who reported less deliberately constrained thoughts than the average participant in our sample, which is visualized in Fig. 2B.

3.5 Secondary Analysis: Thoughts Predicting Heart Rate Variability

Next, a linear regression was implemented to determine the relationship between thoughts and heart rate variability, which is reported in Supplementary Table 3. Automatically constrained thoughts were positively associated with RMSSD, such that individuals who reported more automatically constrained thoughts had higher RMSSD (β = 3.13, p = .029). Post-stress induction heart rate was included as a covariate and was significantly predictive of RMSSD (β = -9.61, p < .001). However, when baseline RMSSD was included in the model, automatically constrained thoughts were no longer significantly predictive of post-stress induction RMSSD (β = 1.32, p = .213).

4. Discussion

This study aimed to investigate the relationship between coping strategy usage and thoughts as defined by the Dynamic Framework of Thought (25). Our primary results indicated that coping strategies differentially predicted automatically constrained, deliberately constrained, and freely moving thoughts. Specifically, problem-focused coping predicted more automatically constrained and less freely moving, emotion-focused coping predicted less automatically constrained thoughts, and avoidant coping predicted less deliberately constrained thoughts. Our secondary analyses revealed that thoughts moderated the relationship between coping strategies and later affect, such that problem-focused coping predicted worse mood for participants who reported more automatic constraints and less deliberate constraints, but problem-focused coping predicted better mood for participants who reported fewer automatic constraints. Furthermore, individuals who reported more automatically constrained thoughts had larger RMSSD (as an index of heart rate variability) after the stress induction task, but this effect went away after controlling for baseline RMSSD. Taken together, these results indicate that coping strategies are predictive of thoughts after a stressful event and that these thoughts can alter the affective outcomes of coping, suggesting that the types of thoughts people experience are an important factor when considering long term benefits or consequences of different coping strategies.

4.1 Differential Relationships between Coping Strategies and Thoughts

Individuals who used more problem-focused coping in everyday life reported more automatically constrained and less freely moving thoughts during the attention task. Previous literature has proposed that automatic constraints can be driven by affective salience, such that topics that are emotionally relevant to an individual are more likely to capture their attention even if they are not intentionally thinking about that topic (25, 79, 80). Given that participants were asked to write about a negative event that they were still currently worried about, the stressor was likely at least partially unresolved. This may mean that problem-focused strategy usage can increase affective salience of the stressor when it is not yet resolved. For example, applying the strategy of planning what to do about the stressor would conceivably make you more likely to think about your plans rather than your task-at-hand. Furthermore, the association with decreased freely moving thoughts may suggest that the thoughts of individuals who use problem-focused strategies were automatically drawn to certain topics and continuously stayed on the same topic, rather than being able to switch freely between topics. However, these results should be interpreted with caution since they did not survive Bonferroni correction, and future work with larger sample sizes should be implemented to confirm these relationships.

We also found that individuals with a higher tendency to use emotion-focused coping in everyday life reported less automatically constrained thoughts. This suggests that emotion-focused coping may decrease affective salience, resulting in less automatic constraints. Importantly, participants were asked to write about the circumstances and emotions associated with their self-selected negative event in the stress-induction task. Individuals who typically use strategies that address their emotions towards stressful events may have been less affected by the stress induction method because they

had already processed their emotions towards the stressor. This interpretation contrasts with previous literature which posits that those with high emotional processing ability are at risk of becoming hypervigilant and ruminating when asked to further reflect on their emotions (11). However, in our study, emotion-focused coping was not associated with differences in stressor-related thoughts during the task. One possible explanation for this discrepancy is that this style of coping may heighten affective salience of the stressor in the moment or immediately after (11), but over time, the stressor becomes less salient as they have already been emotionally processed (as in our study). Taken together, emotion-focused coping might be associated with lower reactivity to emotionally salient cues or thoughts, manifesting as lower automatically constrained thoughts. An important avenue for future investigation is determining the timeline of the impact of emotion-focused coping on a stressor on thought dynamics and affective wellbeing.

Our results also revealed that those who used more avoidant coping in everyday life reported less deliberately constrained thoughts. Deliberate constraints require the use of cognitive control to intentionally direct the flow of thoughts (25), so this result could be a reflection of the association between avoidant coping and dysregulated executive functioning. For example, older adults who used more avoidant strategies had worse executive function and working memory (81, 82). In patients recovering from a stroke, avoidant coping strategy usage was predictive of worse executive functioning, measured using cognitive tasks involving inhibition, set-shifting, and working memory (83). Accordingly, given that avoidant coping and deliberate constrained thoughts are both related to executive function, our findings of avoidant coping being predictive of less deliberate constraints on thoughts may reflect different manifestations of the same underlying disruption in cognitive control.

Furthermore, more frequent use of avoidant strategies was associated with more task-unrelated thoughts, which have been linked to dysregulated executive function and cognitive control failures (84, 85). Since avoidant coping is proposed to be associated with decreased cognitive control as well (81–83), this may explain the relationship between avoidant coping and task-unrelated thoughts as well. Avoidant coping was also associated with stressor-related thoughts in our study, suggesting an increased risk of rumination and worrying (86). Notably, previous work found that individuals who frequently used avoidant coping strategies and had low cognitive flexibility and inhibition reported more depressive symptoms (87). Taken together, these relationships between coping, thoughts, and executive function could be a potential mechanism through which avoidant coping strategies lead to negative mental health outcomes, such as increased perceived stress (17), symptoms of depression and anxiety (45, 46), and suicidal ideation (45).

4.2 Coping Strategies and Thoughts Predict Later Affect

We found that deliberate and automatic constraints moderated the relationship between problem-focused coping and later affect. Previous literature has generally documented positive outcomes associated with problem-focused coping including better mood and quality of life (13) and physical health (5). Our results suggest a more nuanced relationship that is modulated by thoughts. In particular, individuals who had high problem-focused coping usage, but experienced higher-than-average levels of automatic constraints and lower-than-average levels of deliberate constraints experienced worse mood afterwards. Conversely, individuals who had high problem-focused coping usage, but low levels of automatic constraints, reported better mood later on. Since automatically constrained thoughts were not correlated with stressor-related thoughts in our data, we posit that it was not the stressor-related content of thoughts that moderated the relationship to affect but specifically the automaticity of the constraints (i.e., how difficult it is to control thoughts, resulting in thoughts being stuck on a certain topic). These findings provide support for the idea that a lack of control over thoughts can lead to negative affect (6), and that interactions between coping strategies and thoughts are an important factor in the affective outcomes after dealing with stress. This is in line with the notion that coping strategies are likely not inherently adaptive or maladaptive, but that outcomes can depend on contextual factors (10). Together, this suggests that interventions to reduce automatic constraints on thought, such as increasing cognitive control to counter affective salience, are an important area of exploration to help improve coping outcomes.

4.3 Thoughts and Heart Rate Variability

Participants who reported more automatically constrained thoughts had higher heart rate variability (as indexed by RMSSD) measured after the stress induction writing task, but this relationship was no longer significant after controlling for baseline RMSSD. It is important to note that RMSSD did not significantly differ from baseline to the post-stress induction measurement. Given the absence of physiological changes as indexed by RMSSD following a stress induction task, we refrain from potentially overinterpreting results involving RMSSD and instead conclude that there is insufficient evidence in our data to support the idea that physiological stress is associated with differences in thoughts after a stressor. This contrasts with previous literature that has reported decreased heart rate variability associated with rumination (37, 38). However, since automatically constrained thoughts were not associated with stressor-related thoughts in our study, this provides evidence that the category of automatically constrained thoughts cannot be solely represented by a subset, such as rumination. Thus, future investigations are warranted to explore differences between various types of automatically constrained thoughts, such as obsessive thoughts or automatic constraints that are driven by factors other than affective salience, such as sensory salience (25) or habits (79).

4.4 Stress Induction Efficacy

Our control analyses showed that subjective stress after the stress induction writing task was significantly higher than baseline, but no difference in physiological stress (indexed by RMSSD) was observed. Notably, subjective stress level does not always correspond to physiological stress indicators (40). We interpret these results to highlight that the stress induction writing task worked to increase subjective stress but may not have been salient enough to induce physiological indicators of stress since participants were asked to recall a recent stressor. While other stress induction paradigms such as the Trier Social Stress Task (88) have been consistently shown to increase physiological stress indicators such as cortisol and heart rate indices (89, 90), utilizing the writing task has the benefit of inducing subjective stress and thoughts related to a personally relevant event for participants that is critical to addressing our research aims.

4.5 Limitations and Future Directions

There are limitations to our study that necessitate caution when interpreting and applying the results. Our sample consisted of mostly young, educated participants who had the time and means to come into the lab to participate. Thus, our results may not be generalizable to older adults, who may experience different types of stressors in their daily life (91) and different frequency of certain types of thoughts (92, 93) when compared to younger samples. The in-person nature of the study may have also limited the severity of stressors reported during the writing task (i.e. an individual undergoing significant life stress might be less likely to participate due to time and energy), resulting in smaller effects of the stress induction task. Examining relationships between coping, stress, and thoughts in the context of a larger range of stress experiences in a naturalistic environment is an important avenue of investigation; thus, future work should consider online or remote participation methods such as daily diary or ecological momentary assessment.

Our study measured coping strategies at the trait level, as we asked participants to report how often they used certain strategies when dealing with stress in their daily life, whereas our measures of thoughts, stress, and affect were taken in a laboratory setting and reflected experiences in the moment. One limitation of this is that we are unable to make causal links between coping strategies and other variables. For example, even if a participant indicated that they frequently use problem-focused strategies, they may have used a different strategy when dealing with the specific stressful event they wrote about. Since our results provide evidence that there is indeed a link between coping strategies and thoughts on a between-person level, future work should utilize within-person associations and causal study designs to further inform interventions to improve coping efficacy through targeting cognitive and attentional processes.

5. Conclusion

The present study reports novel findings regarding the differential relationship between coping strategies and thoughts. Emotion-focused coping was linked to decreased automatically constrained thoughts whereas avoidant coping predicted decreased deliberately constrained thoughts. Problem-focused coping was associated with worse mood for participants

who reported more automatic constraints and less deliberate constraints, highlighting that thought constraints moderate coping outcomes. These acute relationships between coping and thoughts inform our understanding of how coping strategies lead to long term benefits or harms to emotional wellbeing, making them an important area of exploration with the goal of informing how individuals can better cope with stress.

Abbreviations

Brief COPE: Coping Orientation to Problems Experienced Inventory

ECG: Electrocardiography

RMSSD: Root Mean Square of Successive Differences

SART: Sustained Attention to Response Task

PSS: Perceived Stress Scale

PROMIS: Patient-Reported Outcomes Measurement Information System

ADHD: Attention Deficit Hyperactive Disorder

ASRS: Adult ADHD Self-Report Scale

N: Sample size

SD: Standard Deviation

M: Mean

p value: Probability value

df: Degrees of Freedom

SE: Standard Error

β: Standardized regression coefficients

95% CI: 95% Confidence Interval

Declarations

Human Ethics and Consent to Participate

The study procedure was approved by the University of Calgary's Conjoint Faculties Research Ethics Board (REB24-1265) and was conducted in accordance with the Declaration of Helsinki, and all participants provided informed consent to participate.

Clinical trial number

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare no competing interests,

Funding

This research was supported by funding from the Natural Sciences and Engineering Research Council of Canada (CLL and JWYK) and the Hotchkiss Brain Institute at the University of Calgary (CLL).

Authors' Contributions

CLL: Conceptualization, Data collection and curation, Formal analysis, Writing - original draft, review & editing. **ML:** Data collection. **JWYK:** Conceptualization, Writing - review & editing. All authors read and approved the final manuscript.

Authors' Affiliations

Department of Psychology, University of Calgary, Calgary, Alberta, Canada

Cecilia Liu, Mason Li, & Julia Kam

Hotchkiss Brain Institute, University of Calgary, Calgary, Alberta, Canada

Cecilia Liu & Julia Kam

References

1. Doron J, Thomas-Ollivier V, Vachon H, Fortes-Bourbousson M. Relationships between cognitive coping, self-esteem, anxiety and depression: A cluster-analysis approach. Personal Individ Differ. 2013;55(5):515–20. 10.1016/j.paid.2013.04.017.
2. Tokumitsu K, Sugawara N, Okayasu H, Kawamata Y, Shinozaki M, Sato Y, et al. The relationship of stress coping styles on substance use, depressive symptoms, and personality traits of nurses in higher education institution. Neuropsychopharmacol Rep. 2023;43(4):482–95. 10.1002/npr2. 12324 PubMed PMID: 36871953; PubMed Central PMCID: PMC10739130.
3. Nielsen MB, Knardahl S. Coping strategies: a prospective study of patterns, stability, and relationships with psychological distress. Scand J Psychol. 2014;55(2):142–50. 10.1111/sjop.12103 . PubMed PMID: 24697686.
4. Labrague LJ. Psychological resilience, coping behaviours and social support among health care workers during the COVID-19 pandemic: A systematic review of quantitative studies. J Nurs Manag. 2021;29(7):1893–905. 10.1111/jonm.13336 . PubMed PMID: 33843087; PubMed Central PMCID: PMC8250179.
5. Penley JA, Tomaka J, Wiebe JS. The Association of Coping to Physical and Psychological Health Outcomes: A Meta-Analytic Review. J Behav Med. 2002;25(6):551–603. 10.1023/A:1020641400589.
6. Kam JWY, Wong AY, Thiemann RF, Hasan F, Andrews-Hanna JR, Mills C. On the relationship between unprompted thought and affective well-being: A systematic review and meta-analysis. Psychol Bull. 2024;150(5):621–41. 10.1037/bul0000428.

7. Lazarus RS, Folkman S. Stress, Appraisal, and Coping. Springer Publishing Company; 1984. p. 460.
8. Solberg MA, Gridley MK, Peters RM. The Factor Structure of the Brief Cope: A Systematic Review. West J Nurs Res. 2022;44(6):612–27. 10.1177/01939459211012044.
9. Skinner EA, Edge K, Altman J, Sherwood H. Searching for the structure of coping: A review and critique of category systems for classifying ways of coping. Psychol Bull. 2003;129(2):216–69. 10.1037/0033-2909.129.2.216.
10. Bonanno GA, Burton CL. Regulatory Flexibility: An Individual Differences Perspective on Coping and Emotion Regulation. Perspect Psychol Sci. 2013;8(6):591–612. 10.1177/1745691613504116.
11. Baker JP, Berenbaum H. Emotional approach and problem-focused coping: A comparison of potentially adaptive strategies. Cogn Emot. 2007;21(1):95–118. 10.1080/02699930600562276.
12. Chang OD, Ward KP, Lee SJ. Examining Coping Strategies and Mental Health during the COVID-19 Pandemic: Evidence for the Protective Role of Problem-Focused Coping. Health Soc Work. 2024;49(3):175–84. 10.1093/hsw/hlae018.
13. Shermeyer L, Morrow MT, Mediate N. College students' daily coping, mood, and quality of life: Benefits of problem-focused engagement. Stress Health. 2019;35(2):211–6. 10.1002/smi.2847.
14. Austenfeld JL, Stanton AL. Coping through emotional approach: a new look at emotion, coping, and health-related outcomes. J Pers. 2004;72(6):1335–63. 10.1111/j.1467-6494.2004. 00299.x PubMed PMID: 15509285.
15. Stanton AL, Low CA. Expressing Emotions in Stressful Contexts. Curr Dir Psychol Sci. 2012;21(2):124–8. 10.1177/0963721411434978.
16. Hoyt MA, Llave K, Wang AWT, Darabos K, Diaz-Yanez KG, Hoch M, et al. The Utility of Coping Through Emotional Approach: A Meta-Analysis. Health Psychol Off J Div Health Psychol Am Psychol Assoc. 2024;43(6):397–417. 10.1037/hea0001364 . PubMed PMID: 38330307; PubMed Central PMCID: PMC11847609.
17. Doron J, Trouillet R, Maneveau A, Neveu D, Ninot G. Coping profiles, perceived stress and health-related behaviors: a cluster analysis approach. Health Promot Int. 2015;30(1):88–100. 10.1093/heapro/dau090.
18. Cheng C, Lau HPB, Chan MPS. Coping flexibility and psychological adjustment to stressful life changes: A meta-analytic review. Psychol Bull. 2014;140(6):1582–607. 10.1037/a0037913.
19. Leslie-Miller CJ, Joormann J, Quinn ME. Coping Flexibility: Match Between Coping Strategy and Perceived Stressor Controllability Predicts Depressed Mood. Affect Sci. 2024;6(1):94–103. 10.1007/s42761-024-00275-9 . PubMed PMID: 40094042; PubMed Central PMCID: PMC11903985.
20. Carver CS, Scheier MF, Weintraub JK. Assessing coping strategies: A theoretically based approach. J Pers Soc Psychol. 1989;56(2):267–83. 10.1037/0022-3514.56.2.267.
21. Smallwood J, Schooler JW. The restless mind. Psychol Bull. 2006;132(6):946–58. 10.1037/0033-2909.132.6.946.
22. McVay JC, Kane MJ, Kwapil TR. Tracking the train of thought from the laboratory into everyday life: An experience-sampling study of mind wandering across controlled and ecological contexts. Psychon Bull Rev. 2009;16(5):857–63. 10.3758/PBR.16.5.857 . PubMed PMID: 19815789; PubMed Central PMCID: PMC2760023.
23. McVay JC, Kane MJ. Dispatching the wandering mind? Toward a laboratory method for cuing spontaneous off-task thought. Front Psychol. 2013;4:570–570. 10.3389/fpsyg.2013.00570.
24. Stawarczyk D, Majerus S, D'Argembeau A. Concern-induced negative affect is associated with the occurrence and content of mind-wandering. Conscious Cogn. 2013;22(2):442–8. 10.1016/j.concog.2013.01.012.
25. Christoff K, Irving ZC, Fox KCR, Spreng RN, Andrews-Hanna JR. Mind-wandering as spontaneous thought: A dynamic framework. Nat Rev Neurosci. 2016;17(11):718–31. 10.1038/nrn.2016.113.
26. Kuehner C, Welz A, Reinhard I, Alpers GW. Lab meets real life: A laboratory assessment of spontaneous thought and its ecological validity. PLoS ONE. 2017;12(9):e0184488. 10.1371/journal.pone.0184488.
27. Moberly NJ, Watkins ER. Ruminative self-focus and negative affect: An experience sampling study. J Abnorm Psychol. 2008;117(2):314–23. 10.1037/0021-843X.117.2.314.

28. Watkins ER, Roberts H. Reflecting on rumination: Consequences, causes, mechanisms and treatment of rumination. Behav Res Ther. 2020;127:103573. 10.1016/j.brat.2020.103573.
29. Mills C, Porter AR, Andrews-Hanna JR, Christoff K, Colby A. How task-unrelated and freely moving thought relate to affect: Evidence for dissociable patterns in everyday life. Emotion. 2021;21(5):1029–40. 10.1037/emo0000849.
30. Sikka P, Valli K, Revonsuo A, Tuominen J. The dynamics of affect across the wake-sleep cycle: From waking mind-wandering to night-time dreaming. Conscious Cogn. 2021;94:103189. 10.1016/j.concog.2021.103189.
31. Li H, Hills T. Time, valence, and imagination: a comparative study of thoughts in restricted and unrestricted mind wandering. Psychol Res. 2024;88(5):1510–21. 10.1007/s00426-024-01969-2 . PubMed PMID: 38767718; PubMed Central PMCID: PMC11639231.
32. Immanuel S, Teferra MN, Baumert M, Bidargaddi N. Heart Rate Variability for Evaluating Psychological Stress Changes in Healthy Adults: A Scoping Review. Neuropsychobiology. 2023;82(4):187–202. doi:10.1159/000530376 PubMed PMID: 37290411; PubMed Central PMCID: PMC10614455.
33. McCraty R, Shaffer F. Heart Rate Variability: New Perspectives on Physiological Mechanisms, Assessment of Self-regulatory Capacity, and Health risk. Glob Adv Health Med. 2015;4(1):46–61. 10.7453/gahmj.2014.073 . PubMed PMID: 25694852; PubMed Central PMCID: PMC4311559.
34. Kim HG, Cheon EJ, Bai DS, Lee YH, Koo BH. Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature. Psychiatry Investig. 2018;15(3):235–45. 10.30773/pi.2017.08. .17 PubMed PMID: 29486547; PubMed Central PMCID: PMC5900369.
35. Attar ET, Balasubramanian V, Subasi E, Kaya M. Stress Analysis Based on Simultaneous Heart Rate Variability and EEG Monitoring. IEEE J Transl Eng Health Med. 2021;9:2700607. 10.1109. /JTEHM.2021.3106803 PubMed PMID: 34513342.
36. Rajendra Acharya U, Paul Joseph K, Kannathal N, Lim CM, Suri JS. Heart rate variability: a review. Med Biol Eng Comput. 2006;44(12):1031–51. 10.1007/s11517-006-0119-0.
37. Carnevali L, Thayer JF, Brosschot JF, Ottaviani C. Heart rate variability mediates the link between rumination and depressive symptoms: A longitudinal study. Int J Psychophysiol. 2018;The Psychophysiology of Stress and Adaptation: Models, Pathways, and Implications131:131–8. 10.1016/j.ijpsycho.2017.11.002
38. Kocsel N, Köteles F, Szemenyei E, Szabó E, Galambos A, Kökönyei G. The association between perseverative cognition and resting heart rate variability: A focus on state ruminative thoughts. Biol Psychol. 2019;145:124–33. 10.1016/j.biopsycho.2019.04.004.
39. Gillie BL, Vasey MW, Thayer JF. Individual differences in resting heart rate variability moderate thought suppression success. Psychophysiology. 2015;52(9):1149–60. 10.1111/psyp.12443.
40. Weber J, Angerer P, Apolinário-Hagen J. Physiological reactions to acute stressors and subjective stress during daily life: A systematic review on ecological momentary assessment (EMA) studies. PLoS ONE. 2022;17(7):e0271996. 10.1371/journal.pone.0271996.
41. Carver CS, Brief COPE. Inventory [Internet]. 1997 [cited 2025 Jun 12]. Available from: https://doi.apa.org/doi/10.1037/t04102-000 doi:10.1037/t04102-000.
42. Banks JB, Tartar JL, Tamayo BA. Examining factors involved in stress-related working memory impairments: Independent or conditional effects? Emotion. 2015;15(6):827–36. 10.1037/emo0000096.
43. Dalmaijer ES, Nord CL, Astle DE. Statistical power for cluster analysis. BMC Bioinformatics. 2022;23(1):205. 10.1186/s12859-022-04675-1.
44. Buchanan B. The Value of NovoPsych Data - New Norms for the Brief-COPE - NovoPsych. NovoPsych [Internet]. 2021 Jun 25 [cited 2026 Feb 12]. Available from: https://novopsych.com/news/the-value-of-novopsych-data-new-norms-for-the-brief-cope/
45. Clausen BK, Porro D, Zvolensky MJ, Capron DW, Buitron V, Albanese BJ. Unique relations of avoidant, emotion, and problem focused coping and suicidality in a sample of sexual and gender minorities. J Affect Disord. 2025;379:473–80. 10.1016/j.jad.2025.03.077.

46. Dias C, Cruz J, Fonseca A. The relationship between multidimensional competitive anxiety, cognitive threat appraisal, and coping strategies: A multi-sport study. Int J Sport Exerc Psychol. 2012;10(1):52–65. 10.1080/1612197X.2012.645131.
47. Stratta P, Capanna C, Carmassi C, Patriarca S, Di Emidio G, Riccardi I, et al. The adolescent emotional coping after an earthquake: A risk factor for suicidal ideation. J Adolesc. 2014;37(5):605–11. 10.1016/j.adolescence.2014.03.015.
48. Hinton PR, McMurray I, Brownlow C. SPSS Explained. 2nd Edition. Routledge; 2014.
49. Robertson IH, Manly T, Andrade J, Baddeley BT, Yiend J, `Oops!'. Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. Neuropsychologia. 1997;35(6):747–58. 10.1016/S0028-3932(97)00015-8.
50. Smallwood J, Davies JB, Heim D, Finnigan F, Sudberry M, O'Connor R, et al. Subjective experience and the attentional lapse: Task engagement and disengagement during sustained attention. Conscious Cogn. 2004;13(4):657–90. 10.1016/j.concog.2004.06.003.
51. Shaffer F, Ginsberg JP. An Overview of Heart Rate Variability Metrics and Norms. Front Public Health. 2017;5:258. 10.3389/fpubh. .2017.00258 PubMed PMID: 29034226; PubMed Central PMCID: PMC5624990.
52. Alperin BR, Christoff K, Mills C, Karalunas SL. More than off-task: Increased freely-moving thought in ADHD. Conscious Cogn. 2021;93:103156. 10.1016/j.concog.2021.103156 . PubMed PMID: 34119895; PubMed Central PMCID: PMC8442616.
53. Yang H, van Vugt M. Sticky thinking disrupts decision making for individuals with a tendency toward worry and depression. Emot Wash DC. 2025;25(4):997–1010. 10.1037/emo0001449 . PubMed PMID: 40402636.
54. Cohen S, Kamarck T, Mermelstein R. Perceived Stress Scale [Internet]. 1983 [cited 2025 Jan 9]. Available from: https://doi.apa.org/doi/10.1037/t02889-000 doi:10.1037/t02889-000.
55. Cella D, Riley W, Stone A, Rothrock N, Reeve B, Yount S, et al. Initial Adult Health Item Banks and First Wave Testing of the Patient-Reported Outcomes Measurement Information System (PROMIS™) Network: 2005–2008. J Clin Epidemiol. 2010;63(11):1179–94. .011 PubMed PMID: 20685078; PubMed Central PMCID: PMC2965562.
56. Cella D, Choi SW, Condon DM, Schalet B, Hays RD, Rothrock NE, et al. PROMIS® Adult Health Profiles: Efficient Short-Form Measures of Seven Health Domains. Value Health. 2019;22(5):537–44. 10.1016/j.jval.2019.02.004.
57. Kessler RC, Adler L, Ames M, Demler O, Faraone S, Hiripi E, et al. The World Health Organization Adult ADHD Self-Report Scale (ASRS): a short screening scale for use in the general population. Psychol Med. 2005;35(2):245–56. 10.1017/s0033291704002892 . PubMed PMID: 15841682.
58. Brody DA, Romans WE, Little RC. The Einthoven Triangle: An Observation Regarding the Validity of the Originally Proposed Triangular Representation of the Human Body. Science. 1952;116(3024):659–60. 10.1126/science.116.3024.659.
59. Pan J, Tompkins WJA, Real-Time QRS, Detection Algorithm. IEEE Trans Biomed Eng. 1985;BME–32(3):230–6. 10.1109/TBME.1985.325532.
60. Tanaka H, Monahan KD, Seals DR. Age-predicted maximal heart rate revisited. J Am Coll Cardiol. 2001;37(1):153–6. 10.1016/s0735-1097(. 00)01054-8 PubMed PMID: 11153730.
61. Tiwari A, Cassani R, Gagnon JF, Lafond D, Tremblay S, Falk TH. Annu Int Conf IEEE Eng Med Biol Soc IEEE Eng Med Biol Soc Annu Int Conf. 2020;2020:4530–3. 10.1109/EMBC44109. 2020.9175414 PubMed PMID: 33019001. Prediction of Stress and Mental Workload during Police Academy Training Using Ultra-Short-Term Heart Rate Variability and Breathing Analysis.
62. Clifford GD. ECG Statistics, Noise, Artifacts, and Missing Data.
63. Salo MA, Huikuri HV, Seppanen T. Ectopic Beats in Heart Rate Variability Analysis: Effects of Editing on Time and Frequency Domain Measures. Ann Noninvasive Electrocardiol. 2006;6(1):5–17. 10.1111/j.1542-474X.2001.tb00080. x PubMed PMID: 11174857; PubMed Central PMCID: PMC7027677.

64. Jiao Y, Sun Z, Fu L, Yu X, Jiang C, Zhang X, et al. Physiological responses and stress levels of high-speed rail train drivers under various operating conditions - a simulator study in China. Int J Rail Transp. 2023;11(4):449–64. 10.1080/23248378.2022.2086638.
65. Sun Z, Liu H, Jiao Y, Zhang C, Xu F, Jiang C, et al. Machine learning noise exposure detection of rail transit drivers using heart rate variability. Transp Saf Environ. 2024;6(2):tdad028. 10.1093/tse/tdad028.
66. Shaffer F, Meehan ZM, Zerr CL. A Critical Review of Ultra-Short-Term Heart Rate Variability Norms Research. Front Neurosci. 2020;14:594880. 10.3389/fnins. 2020.594880 PubMed PMID: 33328866; PubMed Central PMCID: PMC7710683.
67. Benchekroun M, Chevallier B, Zalc V, Istrate D, Lenne D, Vera N. The Impact of Missing Data on Heart Rate Variability Features: A Comparative Study of Interpolation Methods for Ambulatory Health Monitoring. IRBM. 2023;44(4):100776. 10.1016/j.irbm.2023.100776.
68. Machado AV, Pereira MG, Souza GGL, Xavier M, Aguiar C, de Oliveira L, et al. Association between distinct coping styles and heart rate variability changes to an acute psychosocial stress task. Sci Rep. 2021;11(1):24025. 10.1038/s41598-021-03386-6.
69. Henry DB, Tolan PH, Gorman-Smith D. Cluster analysis in family psychology research. J Fam Psychol JFP J Div Fam Psychol Am Psychol Assoc Div 43. 2005;19(1):121–32. 10.1037/0893-3200.19.1.121 PubMed PMID: 15796658.
70. Ward JH. Hierarchical Grouping to Optimize an Objective Function. J Am Stat Assoc. 1963;58(301):236–44. 10.1080/01621459.1963.10500845.
71. Tibshirani R, Walther G, Hastie T. Estimating the Number of Clusters in a Data Set Via the Gap Statistic. J R Stat Soc Ser B Stat Methodol. 2001;63(2):411–23. 10.1111/1467-9868.00293.
72. Rousseeuw PJ, Silhouettes. A graphical aid to the interpretation and validation of cluster analysis. J Comput Appl Math. 1987;20:53–65. 10.1016/0377-0427(87)90125-7.
73. Lawson RG, Jurs PC. New index for clustering tendency and its application to chemical problems. J Chem Inf Comput Sci. 1990;30(1):36–41. 10.1021/ci00065a010.
74. Helsper CA, Faiman HB, Finch WH, Cassady J. Nothing means anything if everything means something: exploring the issues of coping profiles and the person-centered approach. Anxiety Stress Coping. 2025;38(1):36–57. 10.1080/10615806.2024.2377380 . PubMed PMID: 38988052.
75. Sacha J. Why should one normalize heart rate variability with respect to average heart rate. Front Physiol. 2013;4. 10.3389/fphys.2013.00306.
76. Kam JWY, Irving ZC, Mills C, Patel S, Gopnik A, Knight RT. Distinct electrophysiological signatures of task-unrelated and dynamic thoughts. Proc Natl Acad Sci. 2021;118(4):e2011796118. 10.1073/pnas.2011796118.
77. Nunan D, Sandercock GRH, Brodie DA. A Quantitative Systematic Review of Normal Values for Short-Term Heart Rate Variability in Healthy Adults. Pacing Clin Electrophysiol. 2010;33(11):1407–17. 10.1111/j.1540-8159.2010.02841.x.
78. Umetani K, Singer DH, McCraty R, Atkinson M. Twenty-Four Hour Time Domain Heart Rate Variability and Heart Rate: Relations to Age and Gender Over Nine Decades. J Am Coll Cardiol. 1998;31(3):593–601. 10.1016/S0735-1097(97)00554-8.
79. Christoff Hadjiilieva K. Mindfulness as a Way of Reducing Automatic Constraints on Thought. Biol Psychiatry Cogn Neurosci Neuroimaging 2025;Cognitive Neurosci Mindfulness10(4):393–401. 10.1016/j.bpsc.2024.11.001
80. Markovic J, Anderson AK, Todd RM. Tuning to the significant: neural and genetic processes underlying affective enhancement of visual perception and memory. Behav Brain Res. 2014;259:229–41. PubMed PMID: 24269973.
81. MacAulay RK, Tallman M, Maynard TR, Timblin H. Coping patterns associations with cognitive function in older adults. J Int Neuropsychol Soc. 2024;30(8):738–45. 10.1017/S1355617724000377.
82. Nieto M, Romero D, Ros L, Zabala C, Martínez M, Ricarte JJ, et al. Differences in Coping Strategies Between Young and Older Adults: The Role of Executive Functions. Int J Aging Hum Dev. 2020;90(1):28–49. doi:10.1177/0091415018822040 PubMed PMID: 30612437.

83. Kegel J, Dux M, Macko R. Executive function and coping in stroke survivors. NeuroRehabilitation. 2014;34(1):55–63. 10.3233/NRE-131010.
84. Hawkins GE, Mittner M, Forstmann BU, Heathcote A. Self-reported mind wandering reflects executive control and selective attention. Psychon Bull Rev. 2022;29(6):2167–80. 10.3758/s13423-022-02110-3 . PubMed PMID: 35672655; PubMed Central PMCID: PMC9722835.
85. McVay JC, Kane MJ. Does mind wandering reflect executive function or executive failure? Comment on Smallwood and Schooler (, Watkins. (2008). Psychol Bull. 2010;136(2):188–97. 10.1037/a0018298
86. Tan X, An Y, Chen C. Avoidant coping as mediator of the relationship between rumination and mental health among family caregivers of Chinese breast cancer patients. Eur J Cancer Care (Engl). 2022;31(1):e13523. 10.1111/ecc.13523.
87. Morris MC, Evans LD, Rao U, Garber J. Executive Function Moderates the Relation between Coping and Depressive Symptoms. Anxiety Stress Coping. 2015;28(1):31–49. 10.1080/10615806.2014.925545 . PubMed PMID: 24866556; PubMed Central PMCID: PMC4236259.
88. Kirschbaum C, Pirke KM, Hellhammer DH. The 'Trier Social Stress Test' – A Tool for Investigating Psychobiological Stress Responses in a Laboratory Setting. Neuropsychobiology. 2008;28(1–2):76–81. 10.1159/000119004.
89. Goodman WK, Janson J, Wolf JM. Meta-analytical assessment of the effects of protocol variations on cortisol responses to the Trier Social Stress Test. Psychoneuroendocrinology. 2017;80:26–35. 10.1016/j.psyneuen.2017.02.030.
90. Helminen EC, Morton ML, Wang Q, Felver JC. Stress Reactivity to the Trier Social Stress Test in Traditional and Virtual Environments: A Meta-Analytic Comparison. Psychosom Med. 2021;83(3):200–11. 10. 1097/PSY.0000000000000918 PubMed PMID: 33534392.
91. Stefaniak AR, Blaxton JM, Bergeman CS. Age Differences in Types and Perceptions of Daily Stress. Int J Aging Hum Dev. 2022;94(2):215–33. 10.1177/00914150211001588.
92. Jordão M, Ferreira-Santos F, Pinho MS. St. Jacques PL. Meta-analysis of aging effects in mind wandering: Methodological and sociodemographic factors. Psychol Aging. 2019;34(4):531–44. 10.1037/pag0000356.
93. Welhaf MS, Banks JB, Bugg JM. Age-Related Differences in Mind Wandering: The Role of Emotional Valence. J Gerontol B Psychol Sci Soc Sci. 2023;79(1):gbad151. 10.1093/geronb/gbad151 . PubMed PMID: 37813376; PubMed Central PMCID: PMC10745276.

Figures

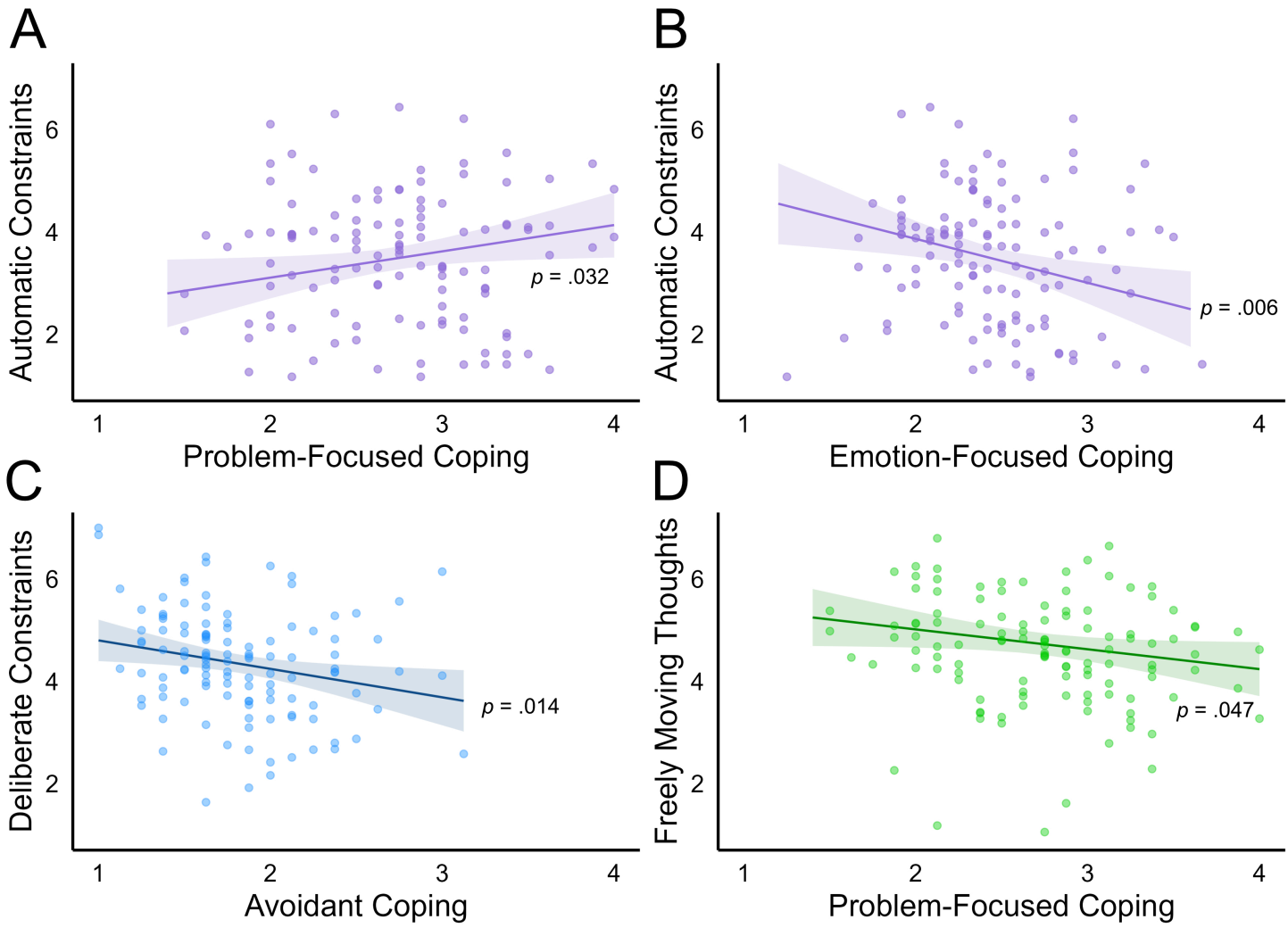


Figure 1

Coping strategies predict thoughts reported after a stress induction task.

Note. Significant relationships between coping strategy usage (scale of 1-4) and thoughts (scale of 1-7). Coloured bands around each line represent 95% CI. Unstandardized axes were used for visualization purposes. (A) Problem-focused coping predicted less automatically constrained thoughts. (B) Emotion-focused coping predicted less automatically constrained thoughts. (C) Avoidant coping predicted less deliberately constrained thoughts. (D) Problem-focused coping predicted less freely moving thoughts.

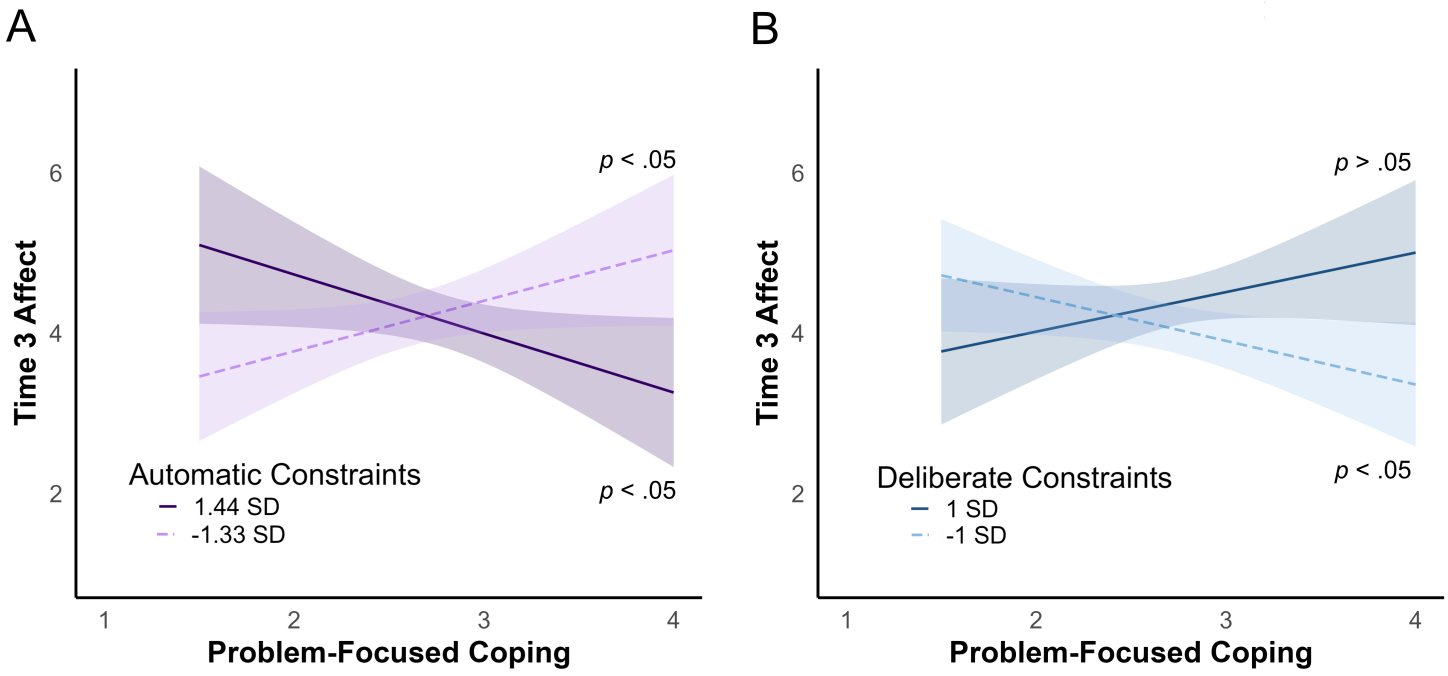


Figure 2

Thoughts moderate the relationship between problem-focused coping and later affect.

Note. (A) Greater problem-focused coping using predicted worse mood assessed after the attention task for participants who reported more automatically constrained thoughts (1.44 SD) and better mood for participants who reported less automatically constrained thoughts (-1.33 SD). (B) Greater problem-focused coping usage predicted worse mood after the attention task for participants who reported less deliberately constrained thoughts (-1 SD). Coloured bands around each line represent 95% CI. Unstandardized axes were used for visualization purposes.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- CopingandThoughtsSM04.30.2026.docx