

THE INTERPLAY BETWEEN RUMINATION, DEPRESSED MOOD AND METACOGNITIVE BELIEFS IN EVERYDAY LIFE

Word count: 13.171

Dagmar De Blancq
Student number: 01908688

Promotor: Dr. Gerly Tamm
Co-promotor: Prof. Dr. Kristof Hoorelbeke

Master's thesis submitted to Ghent University in partial fulfilment of the requirements for the degree of Master Clinical Psychology

Academic year: 2023 – 2024

Abstract

Introduction. Rumination is an important risk factor for the development and maintenance of different forms of psychopathology and has shown to exacerbate and prolong depressed mood in daily life. Yet, there is no consensus on the underlying mechanism behind rumination. Recent studies applying network analysis to construct network models of rumination, depressed mood and dysfunctional metacognitions hold great promise in further elucidating rumination. However, not much is known about the temporal dynamics between these variables in everyday life.

Methods. Building upon a previous study by Tamm et al. (2024), a 21-day Experience Sampling Method (ESM) procedure was used to collect data on brooding and reflection components of rumination, depressed mood and dysfunctional metacognitions. Network analysis was applied to construct temporal and contemporaneous network models of rumination, which allowed exploration of both temporal and concurrent associations between the included variables.

Results. Both temporal and contemporaneous network models included multiple connections between the nodes, all were positive. All nodes in the temporal network showed positive autocorrelations and multiple bidirectional temporal effects were presented.

Discussion. Findings support a majority of the assumptions from the S-REF and the metacognitive model of rumination. The temporal network results partially support predictions generated by the directed acyclic graphs (DAG) published by Tamm et al. (2024). Some contradictory findings are addressed. This study is the first to construct a temporal network model including these variables of interest. Theoretical and clinical implications are provided and limitations and future directions for research are discussed.

Acknowledgements

I would like to express my deepest gratitude to everyone who has supported me throughout the past two years of working on this Master's thesis.

First and foremost, I am extremely grateful for the support and guidance of my promotor, Dr. Gerly Tamm. Her invaluable and constructive feedback, expertise, and knowledge on this research subject, as well as her availability and patience, have been immensely helpful. The past two years have been a significant learning experience, and without her, this work would not have been possible.

Furthermore, I would like to express my gratitude to my co-promotor, Prof. Dr. Kristof Hoorelbeke, for his guidance, assistance with data analysis, and instrumental advice throughout the trajectory of this Master's thesis.

I am also thankful to my fellow students, friends, and family for their support and continuous encouragement throughout the construction of this Master's thesis and my studies at UGhent. Their patience and understanding during difficult times, as well as the joyful moments we have experienced together over the past five years, have been invaluable. A special thanks to my sister, who proofread sections of this Master's thesis while studying for her own exams; her help is greatly appreciated.

Table of contents

Introduction	1
Rumination	2
Defining rumination and understanding its underlying mechanisms	2
Components of rumination: brooding and reflection	2
Rumination in daily life.....	3
Depressed Mood.....	4
Defining and conceptualizing depressed mood.....	4
Studying depressed mood in daily life to understand rumination	5
Metacognitive beliefs	6
The metacognitive model of rumination	6
Empirical support for the metacognitive model.....	7
Mechanisms behind rumination: network analysis approach.....	8
The current study	11
Methods.....	13
Sample and design	13
Equipment.....	14
Experience Sampling Method (ESM) items.....	15
Procedure.....	17
Statistical analyses	17
Assumption checks for temporal network models	18
Network analysis.....	18
Results.....	19
Descriptive statistics and assumption checks	19
Temporal network model	20
Contemporaneous network model	21
Discussion.....	23

Clinical implications	28
Limitations and future directions	29
Conclusions	32
References.....	33
Appendix A.....	42
Appendix B.....	43

Introduction

“Difficult thoughts that you can’t think your way out of even if you logically know this thinking isn’t helpful”, “Thinking about the same thing over and over, replaying situations in your mind” (Joubert et al., 2022, p.938). When people are asked to describe ruminative thinking, they often refer to its repetitive and perseverative nature: it feels like a never-ending cycle of negative, unhelpful thoughts (Joubert et al., 2022). With depression rates rising at an alarming rate (Goodwin et al., 2022), research on the topic of rumination is now more relevant than ever, as this unhelpful thinking style has shown to be key in the development, maintenance and exacerbation of depressive symptoms (Watkins & Roberts, 2020).

In fact, rumination has been an important topic in psychopathology literature for decades. Rumination has been classically defined according to the Response Styles Theory (RST) by Nolen-Hoeksema (1991) as “repetitively focusing on the fact that one is depressed; on one's symptoms of depression; and on the causes, meanings, and consequences of depressive symptoms” (Nolen-Hoeksema, 1991, p. 569). The RST is one of the most well-researched theories developed to explain rumination and its deleterious effects on mental health aspects, such as depressed mood (Watkins & Roberts, 2020). Recent research has expanded this theory, for example by proposing a distinction between two rumination components of brooding and reflection (Treyner et al., 2003).

Importantly, research indicates that a person’s ruminative response style is a rather stable and trait-like manner of responding to distress which cannot fully explain why people use rumination in daily life (LeMoult et al., 2013; Marchetti et al., 2018). In this regard, the clinical metacognitive model of rumination and depression has shown to be helpful. This model suggests that metacognitive beliefs (i.e. the beliefs people have about their own thoughts, and rumination in particular) can make a person prone to ruminate and get stuck in an endless cycle of rumination and psychopathological symptoms (Cano-López et al., 2022; Papageorgiou & Wells, 2003; Wells & Matthews, 1996). However, much remains to be discovered about the underlying mechanism behind rumination in daily life. Specifically, how metacognitive beliefs, depressive symptoms and ruminative components interact throughout the day. A recent study modelled the complex relations between these constructs using network-analysis, proposing potential causal pathways towards rumination (Tamm et al., 2024). Yet, these results are of cross-sectional nature do not allow any causal conclusions.

Therefore, the current Master’s thesis builds upon the previous results from Tamm et al. (2024) and aims to better understand the temporal dynamics between metacognition in relation to the components of rumination (brooding and reflection) and depressed mood.

Before I discuss the current study, I will first provide a comprehensive overview of the existing literature regarding rumination, depressed mood, metacognitive beliefs and the relations between these variables in daily life.

Rumination

Defining rumination and understanding its underlying mechanisms

Multiple conceptualizations of rumination and its mechanisms have been proposed (Nolen-Hoeksema, 1991; Strauman, 2017; Watkins & Nolen-Hoeksema, 2014; Wells & Matthews, 1996). However, no consensus has been achieved about its definition and the exact mechanisms through which rumination can result in psychopathological characteristics like depressive mood. In this Master's thesis, I will rely on the classical definition of depressive rumination from Nolen-Hoeksema (1991) which suggests that rumination is a response-style that people engage in when they are experiencing distress.

When using this response-style, people tend to focus on the causes and consequences of their depressive symptoms and distress in a repetitive fashion. Attention is directed to the individual's emotional state and any action that might distract from this, will be avoided. Thus, ruminating makes it more likely that a person's distressing mood will activate thoughts and memories with a corresponding negative load, all while effective problem solving and instrumental behaviour will decrease, possibly leading to a worsening of depressive symptoms (Nolen-Hoeksema, 1991).

The review article by Watkins and Roberts (2020) corroborates this classical view on rumination. It also confirms that rumination can exacerbate psychopathology through multiple different mechanisms, e.g. through its negative influence on sensitivity to changing contingencies and context, its interference in the use of adaptive responses, its influence on negative mood-and thinking, and more. Furthermore, it underlines the importance of studying rumination by illustrating how rumination is now considered a transdiagnostic risk factor for the onset and maintenance of different types of psychopathology (Watkins & Roberts, 2020).

Components of rumination: brooding and reflection

Interestingly, literature reveals that there are two conceptually different components of rumination that don't appear to have the same adverse effects. When Treynor, Gonzalez and Nolen-Hoeksema (2003) constructed their version of the Ruminative Response Scale (RRS) based on the original from Nolen-Hoeksema and Morrow (1991), their findings suggested that rumination consists of a brooding-component, described as "a passive comparison of one's current situation with some unachieved standard", and a reflection-component which measures "a purposeful turning inward to engage in cognitive problem solving to alleviate one's depressive symptoms" (Treynor et al., 2003, p. 256). While brooding implies dwelling on one's negative feelings and thoughts, reflection refers to the act of intentionally analysing one's feelings and possible causes in order to solve problems. Both components show

concurrent associations with depression but only brooding is longitudinally associated with depression, suggesting that brooding is more maladaptive (Treyner et al., 2003).

The RRS (Nolen-Hoeksema & Morrow, 1991; Treyner et al., 2003) is now a widely employed measure of rumination, and studies applying factor analysis on variants of the RRS have confirmed the existence of these two components across cultures (Arana & Rice, 2017; Lee & Kim, 2014; Parola et al., 2017; Schoofs et al., 2010). Literature also confirms that brooding has more adverse effects than reflection. For example, brooding has shown to increase the effect of perceived stress on suicidal ideation (Cole et al., 2015) and to mediate the associations between particular variables and negative outcomes, like between perceived discrimination and depressive symptoms (Miranda et al., 2013) or perceived stress and decreased life satisfaction (Kim & Kang, 2022). In contrast, studies have suggested that reflection is not as maladaptive. While some studies do find a connection between reflection and depressive symptoms, other studies do not (Nolen-Hoeksema et al., 2008). Some studies even suggest that reflection might have a positive influence on people's functioning, perhaps because it can result in resolving problems (Kim & Kang, 2022; Treyner et al., 2003).

However, some results have highlighted the need for a more nuanced approach. There are indications that the strong or prolonged use of reflection can give rise to brooding. For example, Bernstein et al. (2019) detected strong bridge nodes inside a community of reflection-items of their partial correlation network of rumination items, suggesting that the prolonged or strong use of reflection has the potential to activate more maladaptive brooding-like processes. Results from Kim & Kang (2022) suggest that the use of reflection in response to stress can lead to the use of brooding and therefore result in less life satisfaction, even despite the fact that reflection itself appeared to have a positive association with life satisfaction. Moreover, the suggestion has also been made that reflection can increase the risk for depressive symptoms when it is combined with high levels of brooding, e.g. in participants exposed to high stress (Junkins & Haeffel, 2017). Therefore, it is important to take the dynamics between both components into account when trying to better understand the mechanisms through which rumination can lead to symptoms of depression.

Rumination in daily life

The definition of rumination from the RST (Nolen-Hoeksema, 1991) alludes to a person's general, rather stable and trait-like style of responding to distress. However, a distinction can be made between this *trait-rumination* and a form of *state-rumination*, with the latter comprising a person's momentary use of rumination in response to an acute stressor.

These constructs are indeed quite similar, with studies suggesting that people who score high on trait rumination also tend to exhibit more state rumination in daily life (Shi et al., 2024) and findings displaying moderate positive correlations between measures of trait and

state rumination (e.g. Marchetti et al., 2018). However, literature has clearly demonstrated the added value of studying the momentary use of rumination. In a study from LeMoult et al. (2013) for example, state rumination appeared to be positively correlated with maladaptive outcomes, even when controlling for a person's amount of trait rumination. Consequently, there has been a rise in studies looking into the use and fluctuations of rumination in daily life (e.g. Fang et al., 2019; Hoebeke et al., 2023).

ESM is ideal to study these fluctuations, as it is used to collect self-report data on mental processes by using a device that prompts to fill in questions on numerous moments throughout the day (Csikszentmihalyi & Larson, 1987). This allows researchers to study the daily dynamics of psychological constructs, like rumination. ESM measures can aid in validating proposed theories in daily life (Kircanski et al., 2015). ESM research on rumination indeed shows that a person's use of rumination varies throughout the day and does not solely depend on their trait-like tendency to ruminate. Daily rumination also interacts dynamically with other constructs like stress (Connolly & Alloy, 2017) and mood (Hjartarson et al., 2021, Shi et al., 2024). Some studies suggest that these dynamics are predictive of future trait-rumination (Fang et al., 2019).

These findings highlight the relevance of using daily ESM measures to better understand rumination and its underlying mechanisms that might lead to exacerbation of psychopathological symptoms. However, many of the interactions between rumination and other variables remain unexplored. For example, authors have emphasized the need for prospective ESM-research on the relations between rumination and metacognitive beliefs about rumination in daily life, as this presents a current gap in the literature (Tamm et al., 2024).

Depressed Mood

Defining and conceptualizing depressed mood

Depressed mood is the core characteristic of a depressive episode, in which people experience feelings of sadness, emptiness, anhedonia, hopelessness and irritability (World Health Organization, 2023). However, despite being an important diagnostic characteristic of depressive disorders, depressed mood ranges from low to high, and does not exclusively occur in psychopathology. Some measures of mood states even include a subscale of depressed-dejected mood (e.g. Curran et al., 1995), and many research papers study negative affect and negative or depressed mood in non-clinical individuals as well (Hjartarson, 2021; Kircanski et al., 2018).

Here, it is important to note that depressed mood refers to an emotional state that does not necessarily have a trigger (Lane & Terry, 2000). In many studies, terms like negative

affect, depressed mood and negative or low mood are used interchangeably (Lane et al., 2004). While emotions are typically evoked by a stimulus or situation and will not last very long, moods can be described as affective or emotional states that are more diffuse and are not necessarily elicited by a specific (appraisal of) a stimulus or situation (Lane & Terry, 2000). Moods are also not as intense as emotions and will last longer - from hours up to multiple days. They function as an affective background in the daily lives of individuals. They can impact experiences, behaviours and cognitions in a subtle manner, even while people are not always consciously aware of it (Lane & Terry, 2000; Wilhelm & Schoebi, 2007). However, for the sake of clarity, here depressed mood is conceptualised as a diffuse negative affective state with depressive characteristics like hopelessness, sadness, emptiness, anhedonia or irritability.

Another characteristic of mood states is their dynamic nature, which is also the case for depressed mood: it fluctuates in daily life (Ebner-Priemer & Trull, 2009; Wilhelm & Schoebi, 2007). Due to mood's central role in mood disorders and symptomatology, much psychopathology research is centred around the interactions between depressed or negative mood and psychological process variables, like rumination, in daily life (Crowe et al., 2019; Wenze & Miller, 2010).

Studying depressed mood in daily life to understand rumination

In previous sections, evidence has been discussed supporting the theoretical assumption that rumination exacerbates psychopathology by affecting depressive or negative mood (e.g. see: Watkins & Roberts, 2020). Furthermore, Tamm et al. (2024) showed in a Bayesian network model that rumination predicted negative beliefs about uncontrollability and harm of rumination which in turn was positively associated with depression. However, this finding was based on cross-sectional data. In order to better understand the daily dynamics of rumination, it would be relevant and naturalistic to look at the evidence for such associations in daily life.

ESM studies suggest that both increases in negative mood and decreases in positive mood, predict rumination (Fang et al., 2019; Selby et al., 2016). Multiple studies indicate that this also works the other way around, as momentary levels of rumination predict subsequent mood (Faelens et al., 2021; Moberly and Watkins, 2008; Selby et al., 2016). Yet, as Hoebeke et al. (2022) have pointed out, this finding has not always been corroborated (see for example: Hjartarson et al., 2021).

The dynamics between negative mood and rumination could be important in the prediction of depressive symptoms. For example, Koster et al. (2015) have found that these dynamics, as measured by entropy, are predictive of future depressive symptoms after six months. Notably, this predictive effect was only found in the group of remitted depressed

patients, but not in a group of healthy controls. Fang et al. (2019) showed that dynamics between affect and rumination (also measured by entropy) were predictive of trait rumination at a 6-week follow-up and of depressive symptoms at trend-level. Yet, the significant predictive effect of entropy on depressive symptoms seemed to disappear when momentary measurements were also added as predictors. As these findings don't fully corroborate the conclusions of Koster et al. (2015), it is still unclear what exactly the predictive effects are of these dynamics on depressive symptoms.

Research on these daily dynamics is still quite young and more research is required before conclusions can be drawn. The current study will therefore take the temporal dynamics between depressed mood and rumination into account. However, when trying to uncover the reason why or how a shift in depressed mood can sometimes lead to rumination, literature suggests that metacognitive beliefs of a person play an important role (Papageorgiou & Wells, 2003). These beliefs will be discussed in the next section.

Metacognitive beliefs

Metacognitive beliefs can be described as a person's relatively stable ideas about their own thoughts and thinking processes (Papageorgiou & Wells, 2003). Moreover, these beliefs are able to influence the individual's thinking processes and can explain why some people end up in an endless cycle of rumination and depressed mood (Papageorgiou & Wells, 2003; Wells & Matthews, 1994, 1996). The theoretical foundations of the metacognitive beliefs will be presented in the following paragraphs, including the Metacognitive Model of Rumination and Depression (Papageorgiou & Wells, 2003), as well as its predecessor the Self-Regulatory Executive Function model (Wells & Matthews, 1996).

The metacognitive model of rumination

The metacognitive model stems from the broader Self-Regulatory Executive Function model (S-REF), which provides a rationale for understanding the dysfunctional information processing that is typically present in emotional disorders (Wells & Matthews, 1996). The S-REF delineates a cognitive architecture and the processing configurations that operate within it, including one specific processing style that is central in the maintenance of psychopathology, called the "Cognitive Attentional Syndrome" (CAS).

The CAS consists of negative repetitive thinking, like ruminating or worrying about negative events or feelings, as well as excessive threat-monitoring and unhelpful coping strategies. All of these have detrimental effects on a person's functioning and lead to perseveration of negative information that is relevant for the self. The S-REF proposes that a person's metacognitive knowledge, consisting of positive and negative metacognitive beliefs,

can bias a person into persistently using unhelpful-self regulation strategies from the CAS (Wells, 2019; Wells & Matthews, 1994, 1996).

Metacognition alludes to ‘the structures, content, and processes involved in the monitoring, appraisal, and control of cognition’ (Wells, 2019, p. 2). Research expanding the S-REF has concluded that five domains of dysfunctional metacognition can be distinguished: (1) positive beliefs about thoughts, e.g. about the use of worry or rumination; (2) negative beliefs about the uncontrollability and dangers of thoughts like worry or rumination; (3) low self-perceived cognitive confidence, regarding how much confidence one has in their own attention and memory; (4) a persistent need to control and regulate one’s thoughts- and lastly (5) cognitive self-awareness, indicating high awareness and self-monitoring of one’s thinking (Cartwright-Hatton & Wells, 1997; Wells, 2019; Wells & Cartwright-Hatton, 2004). The existence of these five domains has been corroborated across different cultures (Fergus & Bardeen, 2019; Khattak, 2023; Nordahl et al., 2022; Zhang et al., 2020) and studies show that such dysfunctional metacognitive beliefs are more prevalent in people who suffer from psychopathology (Sun et al., 2017, as cited in Anyan et al., 2023).

The S-REF has inspired research to examine the role of such metacognitive beliefs in the use of negative repetitive thinking styles characteristic of psychopathology. This has resulted in more specific theories like the metacognitive model of rumination and depression (Papageorgiou & Wells, 2003). This model predicts that people who hold positive beliefs about rumination (e.g. “Ruminating helps me to cope”) will be more inclined to use a ruminative thinking strategy when experiencing depressed mood. However, rumination will intensify and prolong the negative feelings, which can lead to activation of a person’s negative metacognitive beliefs about rumination. These beliefs reflect negative appraisals about the uncontrollability and (social) dangers of ruminative thinking. In turn, the individual will be prone to think or feel in a negative fashion, which can cause or amplify depressive symptoms (Wells & Matthews, 1996). This way, a person can end up in an endless cycle of rumination and depressive mood.

A more recent article which expanded on the S-REF model (Wells, 2019) has instigated a new line of research examining the relations between the different metacognitive variables (Nordahl et al., 2022) as well as their role within a network of metacognitive variables and CAS-strategies (Anyan et al., 2023). In the next paragraphs, I will discuss important empirical findings concerning the metacognitive models.

Empirical support for the metacognitive model

A meta-analytic review-paper based on 47 studies that compared psychiatric patients with healthy control participants showed that dysfunctional metacognitions can be viewed as a common feature of different forms of psychopathology (Sun et al., 2017, as cited in Anyan et

al., 2023). Moreover, Cano-López et al. (2022) recently conducted a systematic review and meta-analysis of the empirical evidence concerning the clinical metacognitive model of rumination and depression. 41 studies (N = 10,607) were used, including both clinical and nonclinical samples. Moderate, positive associations were found between positive beliefs about rumination and rumination, as well as for negative beliefs about rumination and rumination. The positive beliefs about ruminations showed only a low positive association with depression, while negative beliefs were moderately associated with depression. A Two-Stage Structural Equation Modelling approach (TSSEM) using 16 studies (N=4477) resulted in a good fit of the model. Thus, this study provides good evidence for the metacognitive model of rumination and depression and its predictions, both in clinical and in non-clinical samples.

However, a majority of this research pertains to cross-sectional data or longitudinal study designs with a timespan of months. The same goes for effectiveness- and intervention studies on metacognitive therapy (MCT; Wells, 2009). MCT is a form of therapy which is based on the principles of the S-REF and the metacognitive model of rumination. While studies provide evidence for its effectiveness in the reduction of both dysfunctional metacognitions and psychopathological symptoms (Norman & Morina, 2018) and suggest that changes in metacognitive beliefs are related to a decrease in symptomatology of different disorders over the course of the therapy (Jelinek et al., 2017; Johnson et al., 2018; Nordahl et al., 2017; Solem et al., 2009; Sunde et al., 2021), it is still unclear how these processes can unfold in a person's natural context on a moment-to-moment basis.

Studies on the metacognitive model in daily life are scarce. However, some of the rare existing ESM-studies on the topic are promising. For example, the study from Kubiak et al. (2014) demonstrated significant positive associations between baseline positive beliefs about rumination and momentary rumination, as well as evidence for momentary rumination's mediating role between baseline positive beliefs about rumination and mood in daily life. Furthermore, research shows that different types of metacognitive beliefs can be successfully assessed in daily life as a state-like variable (Aadahl et al., 2021; Temple et al., 2024; Thielsch et al., 2015). Multiple authors have pointed to the lack of studies investigating the temporal dynamics between different metacognitive beliefs, rumination and depressive mood in daily life and suggest that this line of research should be further explored via a network-analytical approach (Anyan et al., 2023; Nordahl et al., 2022; Tamm et al., 2024).

Mechanisms behind rumination: network analysis approach

In the past decades, the network approach of psychopathology has gained popularity and has instigated a new line of research, generating network models of psychological disorders and constructs (Contreras et al., 2019; Robinaugh et al., 2020). The network approach forms an alternative to the latent-variable approach of psychopathology. Medical

terminology (like “disorder”, “symptoms”) is often used to describe people's struggles with their mental health, implying that an underlying disease causes psychopathological symptoms. However, such a latent-variable approach has shown to be less suitable to explain the aetiology of mental disorders when compared to the recently introduced network approach of psychopathology (Borsboom, 2008).

The network approach posits that symptoms (presented as nodes) are related to each other (as presented by edges), possibly through feedback loops and within complex causal networks. This can result in the presentation of psychological disorders. With the development of statistical network analysis methods, it has become possible to generate network models of psychopathology in a data-driven manner (Borsboom, 2008; Borsboom & Cramer, 2013).

This network analysis approach allows to model complex and dynamic relations between different psychological variables (e.g. Bernstein et al., 2019; Bringmann et al., 2016; Hoorelbeke et al., 2019). Therefore, it holds great promise in explaining the mechanisms behind rumination. For example, the earlier mentioned study of Bernstein et al. (2019) examined the network structure of different trait rumination items. This revealed clusters corresponding to subcomponents of rumination as well as novel insight in how specific items or thoughts can be of great influence in the rumination network or activate other clusters -thus explaining how adaptive rumination might turn into brooding. Multiple network studies have also explored the relations between rumination and other constructs like depressive symptoms and mood (for example, see: Hoorelbeke et al., 2019).

Importantly, a recent publication regarding the Metacognitive Control System of the S-REF (Wells, 2019) has also resulted in researchers applying network analysis to understand the dynamic relations between metacognitive beliefs (Anyan et al., 2023; Nordahl et al., 2022). This has extended to networks including metacognition, CAS-strategies and symptoms of anxiety and depression (Anyan et al., 2023; Tamm et al., 2024). In the next paragraphs, relevant findings will be discussed.

Results from network studies concerning the metacognitive items and domains of the Metacognitions Questionnaire-30 (MCQ-30) confirmed positive associations and high mutual influence among the five metacognitive domains (Anyan et al., 2023; Nordahl et al., 2022). This suggests that a person who strongly holds onto one domain of dysfunctional metacognitions will probably score higher on the other metacognitive domains as well. Beliefs from metacognitive domains seem to mutually strengthen each other. In accordance with the metacognitive theory of rumination and depression from Papageorgiou and Wells (2003), both Nordahl et al. (2022) and Anyan et al. (2023) suggest differentiation between two subcomponents of negative metacognitive beliefs that are strongly related but not the same: beliefs about uncontrollability of worrying and beliefs about dangers of worrying.

Furthermore, positive metacognitive beliefs and beliefs about (lack of) cognitive confidence appeared to not be very influential nor to be easily influenced through (changes in) the other metacognitive beliefs in the network (Nordahl et al., 2022). However, both Anyan et al. (2023) and Nordahl et al. (2022) report that the domain “beliefs about the need to control thoughts” forms the most central domain/cluster in their metacognitive network models. Interestingly, this is also the case in the broader network model from Anyan et al. (2023) that includes dysfunctional metacognitions, CAS strategies like worry and rumination and symptoms of anxiety and depression. Together, these results could indicate that the belief domain “need to control thoughts” has the strongest influence on the entire network - however, further investigation and replication is needed.

Additionally, the broad model from Anyan et al. (2023) indicates that connections differ depending on the particular CAS-strategies and symptoms that are involved. The authors report that the need for control is the metacognitive domain that connects most with depression symptoms, while cognitive self-awareness would be linked most with rumination. The role of cognitive self-awareness in the onset of rumination is also supported by results from a cross-sectional network analysis study by Tamm, Hoorelbeke, and Koster (2024).

Tamm, Hoorelbeke, and Koster (2024) published an integrated network model of rumination that includes self-regulatory and metacognitive constructs. These authors used DAGs (directed acyclic graphs) to uncover potential causal pathways towards rumination. These graphs suggested that rumination might be caused by three of the study's variables: positive beliefs about rumination, cognitive self-awareness and effortful control. Specifically, the study provided hypotheses for two sets of causal pathways. The first set aligns with the metacognitive view, as it stems from positive beliefs about rumination and includes both a direct and indirect pathway (a pathway from positive beliefs about rumination directly to rumination, or indirectly through cognitive self-awareness). The second set aligns more with a self-regulatory view (e.g. Strauman, 2017), as it includes a pathway that starts from the metacognition of cognitive confidence (i.e. estimations and evaluations about one's cognitive abilities) and leads to rumination indirectly through effortful control. Furthermore, the DAGs suggest that rumination can result in depressive symptoms through the activation of a person's negative beliefs about the uncontrollability of their thinking.

Altogether, the results from the discussed network models are in line with the previously discussed theories and evidence regarding dysfunctional metacognitions, rumination and depressive symptomatology. They also add novel and clinically interesting knowledge through uncovering the potential causal pathways towards rumination and depression. However, these conclusions are limited due to the cross-sectional nature (Bos et al., 2017). In order to enable causal interpretations, a prospective study could be combined with network analysis to model temporal dynamics between timepoints (Epskamp et al., 2018).

The current study

This Master's thesis is part of a larger research project and builds upon results from a previous study in which a data-driven integrated metacognitive and self-regulatory model for rumination has been proposed (Tamm et al., 2024). Specifically, this thesis aims to explore the temporal dynamics between dysfunctional metacognition in relation to the components of rumination (brooding and reflection) and depressed mood. For this purpose, network models will be constructed and explored.

The discussed literature suggests multiple variables that would be relevant to include in such network models of rumination. For one, it would be valuable to study both reflective and brooding rumination and how they interact in producing symptoms (Treynor et al., 2003). Second, depressed mood has shown to be pivotal in understanding the mechanism underlying rumination, as it can instigate and maintain or even exacerbate rumination – and vice versa (Faelens et al., 2021). Third, the metacognitive beliefs that people hold about their thinking, help explain why people tend to ruminate and why it leads to depressive symptoms in some people and not in others (Papageorgiou & Wells, 2003; Wells & Matthews, 1996).

Currently, the amount of network models that have been constructed including all of these variables of interest are scarce, and none of them include a distinction between brooding and reflection components of rumination (e.g. Anyan et al., 2023; Tamm et al., 2024). Furthermore, the previously discussed study by Tamm et al. (2024) is the first to suggest possible causal metacognitive pathways towards rumination by means of constructed DAGs. However, due to its cross-sectional nature, no conclusions could be drawn about the temporal order in which these variables relate and influence each other in daily life. The proposed pathways remain to be tested via prospective research.

These limitations point to a clear gap in the literature, as replication of such network models, as well as the construction of temporal network models, would hugely benefit the research on mechanisms behind rumination and could be valuable for treatment practice (Tamm et al., 2024). Therefore, this Master's thesis will extend on the previous research from Tamm et al. (2024) and try to address all of these limitations. Specifically, the study aims to answer the following research questions: (1) How do brooding, reflection, depressed mood and metacognitive beliefs about rumination temporally relate to each other? (2) How are depressed mood and metacognitive beliefs about rumination related with the reflection and brooding components of rumination, concurrently?

In order to answer these research questions, an approach will be applied that is similar to the design from Faelens et. al (2021) and Hoorelbeke et al. (2019). Specifically, the ESM-method (Csikszentmihalyi & Larson, 1987) will be used to gather momentary data on the various constructs of interest over a period of 21 days. These ESM data pertain to daily self-

report measurements of rumination (including both reflection and brooding), depressed mood, and five metacognitive belief domains. Subsequently, network analysis will be applied. I will specifically focus on construction of temporal and contemporaneous network models.

An advantage of temporal network models is their visualization of how strongly nodes at a time-point ($t-1$) are associated with each other at a next time-point (t), as these demonstrate directed effects that might imply causality (Epskamp et al., 2018). Thus, construction of the temporal network model will allow to answer the first research question by modelling how fluctuations in reflection, brooding, depressed mood and metacognitive beliefs can predict one another through time. Due to the lack of existing prospective network models of rumination, metacognition and depressed mood, this research question is of exploratory nature. However, based on the findings from Tamm et al. (2024), I hypothesize that positive beliefs about rumination will significantly predict one or both of the rumination components directly, as well as indirectly through higher cognitive self-awareness. The DAG's from their study also lead to the hypothesis that rumination (brooding and/or reflection) will significantly predict the activation of negative beliefs about the uncontrollability of thinking, and that these negative beliefs will predict significantly higher depressed mood.

However, as Faelens et al. (2021) have pointed out in their article, quite some time passes between time-points in ESM-studies (e.g. multiple hours) and therefore the temporal network models might not always be able to adequately model real-life dynamic psychological processes that can take place in a matter of seconds to minutes. Some researchers suggest that contemporaneous network models might be more informative in this regard, as these model co-occurring activity of nodes within a single-time-period (Epskamp et al., 2018; Faelens et al., 2021). Contemporaneous network models do not allow to draw conclusions about causality, but together with the temporal network models they can allow for a more comprehensive understanding of the variables of interest, how they relate to one another and how they might interact dynamically.

Regarding the second research question, I therefore aim to plot a contemporaneous network model using the same variables. Again, due to a scarcity of existing network models that include all of these variables, the second research question is rather exploratory. Based on results of the undirected cross-sectional network model by Tamm et al. (2024) that included many of the current study's variables of interest and more, it can be hypothesized that at least one or both of the rumination components will be directly and positively associated with depressive mood, negative beliefs about uncontrollability of thinking, positive beliefs about rumination, as well as with cognitive self-awareness and (lack of) cognitive confidence. However, the results from this thesis might differ from the publication by Tamm et al. (2024), since the latter is based on cross-sectional data from questionnaires and the current thesis will measure metacognitive variables on a daily basis via ESM.

Methods

This Master's thesis is part of a bigger research project on self-regulatory and metacognitive theories about repetitive negative thinking, which has been pre-registered on Open Science Framework (<https://osf.io/x49tf>). The aim of this project is to extend previous research findings (Tamm et al., 2024) by modelling temporal dynamics between multiple variables of interest, by identifying targets for intervention and by performing exploratory analyses (e.g. between different baseline-measures and time-series data).

The current Master's thesis uses only a part of the project's dataset. Therefore I will not describe all the measures that were carried out, only the measures that fall within the scope of this Master's thesis. A part of the dataset from the research project will also be used by Linde Van der Beken in her Master's thesis.

Sample and design

The design of this study consists of a mixed prospective design. The ESM data were measured over a period of 21 days where participants received a notification to fill in the same questionnaire 6 times per day.

The final sample included 79 adult participants from the United Kingdom (UK). All participants were recruited via Prolific Academic (www.prolific.com), where they voluntarily signed up for the study. All participants were informed beforehand about the expectations, research goals, participant rights, and data processing. They were informed that they would receive a monetary compensation for their time spent. The research project has been approved by the FPPW Ethics Committee.

The aim was to recruit 150 participants in Academic Prolific. This number was determined after inspection of studies where similar estimation procedures were applied (e.g. Faelens et al., 2021). In combination with the specified number of observations per participant, this sample size should facilitate reliable computation of idiographic and group level network models (for more details on sample size determination, see preregistration). Data collection was stopped when 150 participants had started the baseline study. However, not all of these participants had completed all tasks. 140 participants were confirmed as having completed the baseline measures (as indicated by completion codes). 129 of these participants continued with the ESM procedure. The most prominent reasons (feedback from the participants) for not continuing or completing the study were technical issues related to the participant's computer (e.g., Mac is not compatible with E-Prime Go) and the intensive longitudinal nature of the ESM design.

All included participants (N = 79) reported experiencing depression on a pre-selection item. Participants' age ranged from 21 up to 65 years. For sample characteristics, see Table 1.

Table 1

Sample Characteristics (N = 79)

Mean age (<i>SD</i>)	38 years (<i>SD</i> = 10 years)
Gender (<i>n</i>)	Male (38), Female (40), Prefer not to respond (1)
Ethnicity (<i>n</i>)	White (65), Asian (7), Black (3), Mixed (3), Other (1)
Education (<i>n</i>)	Graduate (19), Undergraduate (31), Secondary year 12 or 12-13 (12), Secondary year 7-11 (7), Additional vocational or other further education (9), Primary (1)
Employment (<i>n</i>)	Employed, self-employed, or contractor (59); On leave (13), Student (6), Prefer not to respond (1)

In order to participate, the following inclusion criteria had to be met: (1) age 18-85, (2) self-reported experiencing of depression (as measured via Prolific Academic through a self-reported pre-selection item: "Do you experience depression?"), and (3) proficiency in English. Participants were excluded if: (1) they were unable to perform the study tasks (e.g. because of uncorrected visual impairments, motor disabilities, etc.), (2) they had already participated in previous studies within the current research project (e.g. Tamm et al., 2024), (3) they did not have access to the necessary software and equipment in order to complete the measurements. Similar to the procedure in Tamm et al. (2024), indices to check and evaluate the quality of the data were also included in the baseline questionnaires and these could also be used as an argument to exclude certain participants.

Data points were only included when participants responded within 30 minutes of receiving the notification. After ESM data collection, participants with a low total response rate (< 50%) were excluded from the dataset (n = 34). This resulted in a sample of 95 participants with a sufficient response rate ($\geq 50\%$). Descriptive analyses of the data of the remaining 95 participants demonstrated low variation (*SD* = 0) in 16 participants regarding on one or more of the ESM variables included into this study. Since ESM data with a lack of within-person variability are not suited for multilevel analyses (Gabriel et al., 2018), these participants were excluded from the dataset. This resulted in a final sample of 79 participants.

Materials

Equipment

At baseline, the participants had to use their own laptop or computer to complete questionnaires via LimeSurvey (www.limesurvey.org) and behavioral tasks for cognitive

functioning (n-back, Stroop, Simon, Flanker) via E-Prime Go (<https://pstnet.com/eprime-go>). These baseline measures fall outside the scope of this study. For the ESM measures, participants registered themselves on Samply (<https://samply.uni-konstanz.de>). Through Samply, they received links to LimeSurvey in order to complete surveys on their own devices (smartphone, tablet).

Experience Sampling Method (ESM) items

ESM measures were used during a period of 21 days. The applied notification schedule was based on the one used in Hoorelbeke et al. (2019). Using Samply, a notification with a link to a LimeSurvey questionnaire appeared in a text message on the smartphone of the participants 6 times a day between 9 a.m. and 9 p.m. These notifications appeared according to a time-stratified schedule: every notification was sent out at random during an interval of 120 minutes throughout the day. When the participants received a notification, they were required to complete the questionnaire within 30 minutes. A reminder was sent when the participants had not finished the questionnaire after 15 minutes of receiving the notification and after 30 minutes the notification would disappear.

ESM items were selected based on the same established questionnaires that were used in the study from Tamm et al. (2024). The items were slightly modified for the current study based on their suitability for momentary assessment. In order to prevent participant overload, almost every variable was measured using a single ESM item. The selected ESM items were piloted in a sample of 500 participants via Prolific Academic across multiple days. Participants were able to give feedback if items or instructions seemed unclear. In order to validate the ESM items, correlates were checked with corresponding standardized questionnaires of the measured variables. Correlations between the piloted items were also inspected. Results from the pilot study suggested that the selected ESM items worked well as proxies for the measured variables.

The final ESM survey consisted of 17 items that participants had to rate on a Likert scale from 1 (“not at all”) to 100 (“very much”), according to how much the item was reflected in participants’ experience since their last response. A full list of the ESM items and instructions can be found in the appendix (see Appendix A). The current thesis only discusses eight of these ESM items. The instructions, relevant items and correlates with respective original questionnaires and subscales can be found in Table 2. All correlations were statistically significant ($p < .05$).

Table 2*ESM items*

Items	Construct	<i>r</i>
<i>Instruction:</i> Think about the feelings and thoughts that you have experienced since the last responded signal. Rate each item to what extent did you feel or think this way on a scale from 0 to 100. 0 – not at all, 100 – almost all the time/very much. Insert a number from 0 to 100 into the text field.		
Depressed	Depressed mood	.81
I focused on my negative feelings	Reflection	.52
I focused on my problems	Brooding	.63
I expected that rumination will help me solve problems.	Positive belief about rumination	.42
I expected that rumination will result in uncontrollable thinking	Negative belief about rumination	.56
I was constantly aware of my thinking	Cognitive self-awareness	.64
I thought that I should be in control of my thoughts	Need to control thoughts	.41
I had little confidence in my memory	(lack of) Cognitive confidence	.76

Note. Correlation coefficients (*r*) of the ESM items with their respective original questionnaires and subscales:

DASS-21 Depression subscale, RRS Reflection subscale, RRS Brooding subscale, PBRS, NBR1

Uncontrollability subscale, MCQ-30 Cognitive Self-Consciousness subscale, MCQ-30 Need to Control Thoughts subscale, MCQ-30 Cognitive Confidence subscale.

All correlations were statistically significant ($p < .05$). Degrees of freedom for the correlations were calculated as $df = 498$ ($N = 500$).

A total of five metacognitive items were included in the ESM survey in order to measure fluctuations in metacognitive beliefs (see Table 2). These five items each correspond to a subscale of the MCQ-30 questionnaire (Cartwright-Hatton & Wells, 1997; Wells & Cartwright-Hatton, 2004).

A single ESM item was used to assess fluctuations in (lack of) cognitive confidence (see Table 2). Cognitive confidence refers to the amount of confidence a person has in their attention and memory. The item was adapted from the cognitive confidence subscale of the MCQ-30 (Wells & Cartwright-Hatton, 2004). Another item was derived from the MCQ-30 (Wells & Cartwright-Hatton, 2004) to assess daily fluctuations in the belief that one needs to be in control of their thoughts. Additionally, cognitive self-awareness was measured using an item adapted from the cognitive self-consciousness subscale of the MCQ-30 (Wells & Cartwright-Hatton, 2004). Cognitive self-awareness reflects how much a person monitors their thoughts and how aware a person is of their thinking.

Momentary activation of positive metacognitive beliefs about rumination was measured with a single ESM item which was derived from the Positive Beliefs about Rumination Scale (PBRS; Papageorgiou & Wells, 2001a). Similarly, an ESM item was derived from the first subscale (NBR1) of the Negative Beliefs about Rumination Scale (NBR1; Papageorgiou &

Wells, 2001b) in order to measure activation of metacognitive negative beliefs about the uncontrollability of rumination. Based on the DAG's from Tamm et al. (2024) where the NBRS2 subscale appeared to only function as a by-product of interactions between other variables, the decision was made to only include an ESM item regarding the negative metacognitive beliefs about uncontrollability of rumination (NBRS1).

Momentary brooding rumination and reflection were each assessed with single ESM items derived respectively from the brooding and reflection subscales of the Ruminative Response Scale (RRS; Nolen-Hoeksema & Morrow, 1991; Treynor et al., 2003), which is a measure of depressive rumination. Brooding refers to “a passive comparison of one’s current situation with some unachieved standard” and reflection is defined as “purposeful turning inward to engage in cognitive problem solving to alleviate one’s depressive symptoms” (Treynor et al., 2003, p. 256). The item for depressed mood (see Table 2) was derived from the self-report questionnaire Depression Anxiety Stress Scale-21 (DASS21; Henry & Crawford, 2005; Lovibond & Lovibond, 1995).

Procedure

The participants received an invitation to take part in the present study online through Prolific Academic. After answering positively on a pre-selection, participants were allowed to continue participation in the study and were asked to sign informed consent. The participants were then directed to E-Prime Go to complete a set of cognitive tasks, after which they were asked to complete a set of baseline questionnaires via LimeSurvey.

After completion of the baseline measures, participants received a request to register themselves on Samply for the ESM part of the study. This phase started the day following participant’s registration. During this phase, participants received a signal to fill in the ESM survey 6 times a day (for specifics: see the section on ESM measures) for 21 consecutive days. The ESM items were presented in fixed blocks (e.g. the mood block was always presented first) in order to avoid unwanted interference like the induction of mood by asking about negative thoughts. Within every block, ESM items were randomized. After data collection, the participants received feedback and debriefing and their time spent in this study was compensated for.

Statistical analyses

The data analyses were conducted in R Studio (version 4.3.3) with R version 4.3.3. Data from signals that were Not Applicable (NA), like non-responses, were not included in the dataset. No imputation of data was carried out. This resulted in a dataset with a total of 9853 unique datapoints. 16 out of the 95 participants showed no variation ($SD = 0$) in one or more

items, and were therefore excluded from the data analysis, resulting in a final dataset of 79 participants with a total of 8157 datapoints and an average of 103 (out of 126) responses (average of time lags) per participant.

Outliers were checked and descriptive statistics (mean, standard deviation, first and third quartile) were first computed for every participant on a within-person level, regarding all eight variables of interest separately. Subsequently, using the computed within-person descriptive statistics, a mean and standard deviation were calculated for each variable.

All descriptive statistics and intraclass correlations are reported in Table 3.

Assumption checks for temporal network models

Applying a similar procedure as Faelens et al. (2021) and Aalbers et al. (2019), Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Unit Root tests were computed to check for level stationarity of every variable per participant, and KPSS were also computed to check for trend stationarity (Kwiatkowski et al., 1992). In order to correct for multiple testing, Bonferroni corrections ($ps < .05$) were applied during these assumption checks. Normality was assumed (Epskamp et al., 2018).

Within versus between subject variability was checked for each of the ESM items by computation of the intraclass correlations (ICC's) using `lmer()` models via the `lme4` package (version 1.1-35.3; Bates et al., 2024) and the `performance:icc()` function from the `sjstats` package (version 0.18.2; Lüdtke, 2022) in R. Lower ICC's are considered to be preferable in ESM analysis (Boelger & Laurenceau, 2013). Low ICC's for ESM items indicate a sufficient within-person variability (in relation to between-person variability), which indicates that the ESM items are expected to vary through time.

Network analysis

In order to explore the temporal effects between all eight variables of interest (see Table 2), a two-step multilevel vector autoregressive (VAR) approach (Epskamp et al., 2018) was applied by using the *mVAR* package (version 0.5.2; Epskamp et al., 2024). This algorithm is especially suitable for hierarchical time-series data with 20 or more observations, as in the current study. Within-and between-person effects are separated and the two-step multi-level approach uses the time-series data to estimate that the associations between the variables. Time series data can be modelled as 1) *temporal networks* in which each arrow indicates the predicted effect from a previous timepoint (t-1) to the next timepoint (t), and 2) *contemporaneous networks* in which all associations from each timepoint are considered simultaneously and a more general averaged overview of the associations between the nodes

from the same timepoint is provided (Epskamp et al., 2018). Both approaches were applied here.

When using the mlVAR package (version 0.5.2, Epskamp et al. 2024), within-subject centering is applied to all the variables and then univariate multi-level regressions are executed. This means that performance of a variable (node) at a certain timepoint (t) is predicted by all of the variables (nodes) at a previous timepoint ($t-1$), and this is done for every single node. As a result, a temporal network model can be computed (Epskamp et al., 2018). In an additional step, multi-level regressions are performed again, but now using the residuals (given a *time t*) that were estimated from the first step as dependent variables that are predicted by all of the nodes at a *previous time (t-1)*. This will make it possible to compute a contemporaneous network model that includes all of the nodes (the five metacognitive components, ruminative brooding and reflection, as well as depressed mood) as to visualize their co-occurring activity patterns within a single time-period (Epskamp et al., 2018). The qgraph-package (version 1.9.8, Epskamp et al., 2012) aids in plotting the network models. Due to the exploratory nature of the study, the inclusion of edges in the contemporaneous network model was done by using the OR-rule. This approach guarantees that edges will be included in the model if they appear to be significant in at least one of the model iterations.

Thus, all of the eight variables of interest were included in the analyses and were presented as nodes in the network models. Connections between these variables were presented as edges (vertices) in the networks and when estimating the temporal networks, the edges also indicated the direction in which a node at $t-1$ predicted a node at t (visualized with arrows). The thickness of these edges visualized the strength of the associations and their colour and shape indicated the nature of the association as positive (blue, full) or negative (red, dashed). The Fruchterman-Reingold algorithm (Fruchterman & Reingold, 1991) was also applied, which uses connectivity patterns in order to determine a node's specific position in the model, thereby reflecting the centrality of a given node within the network.

Results

Descriptive statistics and assumption checks

For descriptive statistics of the data and ICC's, see Table 3.

Kwiatkowski-Phillips-Schmidt-Shin Unit Root tests indicated stationarity for all network variables of every included participant. Stationarity was not violated ($p > .05$).

Table 3

Descriptive statistics

Variable	<i>M</i>	<i>SD</i>	<i>Q1</i>	<i>Q3</i>	<i>ICC</i>
Depressed mood	23.09	13.42	14.54	28.37	0.67
Brooding	24.05	16.90	12.40	32.19	0.47
Reflection	26.06	17.33	14.42	34.89	0.46
Positive beliefs about ruminations	20.94	13.45	12.40	26.86	0.62
Negative beliefs about ruminations	28.90	14.42	19.75	35.68	0.68
Self-awareness	40.35	16.03	30.54	49.86	0.70
Need to control thoughts	40.47	16.27	31.44	48.33	0.69
Cognitive Confidence	20.56	9.70	14.80	23.58	0.83

Note: *M* and *SD* refer to within-subject *Ms/SDs*

Temporal network model

First, a temporal network model was computed (Figure 1). The model only included positive temporal associations between the nodes. All nodes showed positive autocorrelations, indicating that performance of a node at time $t-1$ was predictive of the same node's performance at time t . Depressed mood showed the strongest autocorrelation. Significant edge weights are included in the appendix (see Appendix B).

Cognitive self-awareness appeared to predict more use of both of the ruminative components (brooding and reflection) at a subsequent timepoint (t). The estimated temporal association between self-awareness and brooding was bidirectional, indicating that both nodes predicted each other's performance at a following timepoint. The association with reflection was unidirectional, indicating that cognitive self-awareness predicted subsequent reflection, but not the other way around. Additionally, the cognitive self-awareness node showed positive bidirectional temporal associations with the nodes of depressed mood and the need to control thoughts, as well as unidirectional positive predictive effects on the (lack of) cognitive confidence and the positive beliefs about ruminations nodes at a subsequent timepoint. Negative beliefs about ruminations appeared to be the only node in the temporal network that unidirectionally predicted subsequent cognitive self-awareness.

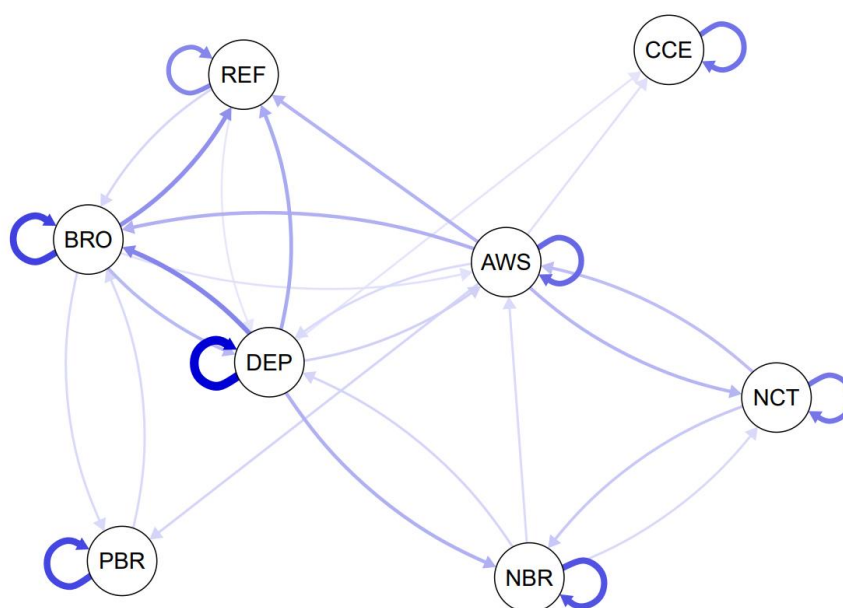
Results further suggested that the nodes of depressed mood, brooding and reflection were all positively and bidirectionally associated with each other in the temporal network model, indicating that these nodes predicted each other's performance at a subsequent

timepoint t . The nodes of brooding and positive beliefs about rumination also showed positive bidirectional temporal associations with one another, and a similar dynamic was suggested for the nodes of depressed mood and negative beliefs about rumination, as well as for the nodes of negative beliefs about rumination and need to control thoughts.

The (lack of) cognitive confidence node appeared to be temporally predicted by the nodes of depressed mood and cognitive self-awareness, but the (lack of) cognitive confidence node itself did not temporally predict any of the other nodes in the temporal network model.

Figure 1

Temporal network model of rumination, depressed mood and dysfunctional metacognitions



Note. DEP = Depressed Mood, BRO = Brooding, REF = Reflection, PBR = Positive Beliefs about Rumination, NBR = Negative Beliefs about Rumination, AWS = Cognitive Self-Awareness, NCT = Need to Control Thoughts, CCE = lack of Cognitive Confidence.

Contemporaneous network model

The contemporaneous network model is shown in Figure 2. The edge weights matrix is included in the appendix (see Appendix B). The model illustrated undirected associations between the variables of interest within the same timeframe. As has been pointed out by Epskamp et al. (2018), some interactions between variables are expected to happen in a fast-paced manner and as such these might be captured within contemporaneous network models. However, directions of effects cannot be deduced from contemporaneous network models due to their undirected nature.

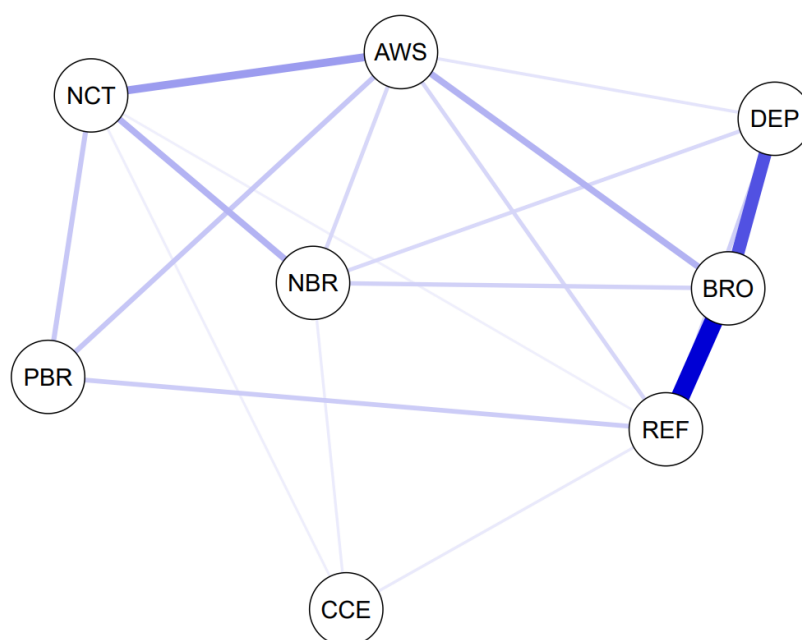
The model (fig. 2) showed that all variables were positively connected within the network. Both rumination components of brooding and reflection were strongly positively

associated. Brooding was positively associated with concurrent depressed mood, cognitive self-awareness and negative beliefs about rumination. Reflection also showed positive, but slightly smaller associations with concurrent depressed mood and cognitive self-awareness. Additionally, reflection was positively related to concurrent positive beliefs about rumination, need to control thoughts and (lack of) cognitive confidence. Aside from positive connections with the concurrent rumination nodes, depressed mood also appeared to be positively connected with negative beliefs about rumination and cognitive self-awareness.

Cognitive self-awareness formed a well-connected node within the model, as it showed positive concurrent associations with both rumination components of brooding and reflection, as well as with depressed mood and with the metacognitive nodes of both positive and negative beliefs about rumination and need to control thoughts. As for connectedness of the metacognitive variables, the model suggested that positive beliefs about rumination, need to control thoughts, cognitive self-awareness and reflection were all positively associated with each other within a single measurement period. The negative beliefs about rumination node showed similar concurrent associations, except not with positive beliefs about rumination. The model further suggested that (lack of) cognitive confidence shared some of the smaller positive connections in the contemporaneous network model with the need to control thoughts, negative beliefs about rumination and reflection.

Figure 2

Contemporaneous network model of rumination, depressed mood and dysfunctional metacognitions



Note. DEP = Depressed Mood, BRO = Brooding, REF = Reflection, PBR = Positive Beliefs about Rumination, NBR = Negative Beliefs about Rumination, AWS = Cognitive Self-Awareness, NCT = Need to Control Thoughts, CCE = lack of Cognitive Confidence.

Discussion

The aim of this study was to explore the temporal dynamics of the cognitive architecture underlying rumination within a metacognitive framework, while taking into account the core findings from Tamm et al. (2024). Hence, the interplay between metacognitive aspects, rumination, and depressed mood was explored within temporal and contemporaneous network models. Both of this thesis's constructed network models demonstrated multiple direct connections between the brooding and reflection components of rumination, depressed mood and dysfunctional metacognitive beliefs - all of which were positive. The current thesis's findings provide empirical support for metacognitive theories, specifically for the metacognitive model of rumination and depression by Papageorgiou and Wells (2003) and for the Self-Regulatory Executive Function (S-REF) model by Wells and Matthews (1996). Furthermore, the results contribute significantly to the literature by providing a novel data-driven model of the temporal dynamics between the rumination components, dysfunctional metacognitions and depressed mood. In the following paragraphs, I will discuss this study's results in more detail, starting with the temporal dynamics (research question 1) and subsequently discussing the concurrent associations (research question 2).

Starting with findings from the temporal network model (first research question), it is important to note that all variables were shown to predict their own subsequent performance (positive autocorrelations). I firstly hypothesized - in accordance with the predictions proposed in the previously published DAG by Tamm et al. (2024) - that positive beliefs about rumination within the temporal network model would significantly predict at least one of the rumination components directly, and indirectly through higher cognitive self-awareness. The results from the current thesis partially support these predictions. Momentary positive beliefs about rumination and brooding (but not reflection) did predict each other positively, and bidirectionally, in the temporal network model. These findings provide evidence for the direct pathway from positive beliefs to rumination, as proposed in the directed DAG by Tamm et al. (2024). Furthermore, these results align with the empirically supported prediction from the metacognitive model of rumination, suggesting that such positive beliefs can make a person prone to ruminate and can therefore lead to increased rumination (Cano-López et al., 2022; Papageorgiou & Wells, 2003). The observed bidirectionality in the temporal network model provides preliminary evidence for the possibility of a self-maintaining temporal loop between brooding and positive beliefs about rumination.

However, contrary to predictions from Tamm et al. (2024), the current study's findings did not support the prediction that positive beliefs about rumination could indirectly lead to more rumination through cognitive self-awareness over time. Results did show that cognitive self-awareness temporally predicted subsequent positive beliefs, both of the rumination components, and more; yet positive beliefs did not temporally predict cognitive self-awareness

nor any of the other nodes, aside from brooding. These results shed a new light on the direction of temporal influence between cognitive self-awareness and positive beliefs about rumination, and suggest the need for future research into these temporal dynamics.

Secondly, I hypothesized that at least one of the rumination components would directly predict subsequent negative beliefs about uncontrollability of rumination in the temporal network model. However, results from the temporal network model demonstrated no such direct associations. Thus, this finding diverges from the empirically supported metacognitive proposition which states that rumination eventually results in negative beliefs about uncontrollability of rumination (Cano-López et al., 2021; Cano-López et al., 2022; Papageorgiou & Wells, 2003), and from the prediction in the DAG by Tamm et al. (2024).

Nevertheless, results from the temporal network did corroborate previous research findings of rumination and negative or depressed mood mutually predicting one another (Faelens et al., 2021; Selby et al., 2016; Tamm et al., 2024), as the model showed bidirectional temporal associations between the rumination components and depressed mood on the one hand, and between depressed mood and negative beliefs about uncontrollability of rumination on the other hand. Additionally, these results expand on previous theory and findings by suggesting that activated negative beliefs about rumination do not lead directly to more subsequent rumination throughout the day, but perhaps indirectly through worsening depressed mood. The bidirectional connections also suggest the potential for people to become trapped in a endless cycle of rumination, depressed mood and negative thoughts about rumination. In line with theoretical metacognitive frameworks (Cano-López et al., 2022; Papageorgiou & Wells, 2003; Wells & Matthews, 1996), this thesis is one of the first to provide preliminary support for the existence these self-maintaining cycles in daily life.

Furthermore, visual inspection of the temporal network revealed some additional temporal dynamics between ruminative components, dysfunctional metacognitions and depressed mood. I will discuss these in the following paragraphs. For example, cognitive self-awareness appeared central in the model and shared temporal connections with all the other nodes. Specifically, being self-aware of one's own cognitive processes is suggested to predict subsequent rumination (brooding and reflection), depressed mood, positive beliefs regarding the use of rumination, the need to control thoughts and lack of cognitive confidence. Bidirectional connections in the temporal network model even indicate that temporal loops might arise between cognitive self-awareness on the one hand, and brooding, depressed mood, and thoughts about the need to control thinking on the other hand.

Interestingly, a central role for cognitive self-awareness has also been suggested in some recent network analytical studies, like the study by Anyan et al. (2023) which indicated that cognitive self-awareness was strongly connected to rumination, as well as the DAG by Tamm et al. (2024) where cognitive self-awareness was even expected to have a prominent

role in directly predicting rumination. Nonetheless, these results do diverge from a multitude of studies which have reported that not cognitive self-awareness, but negative beliefs about rumination and the need to control thoughts, have shown to be most strongly related to rumination and depressive symptomatology (for a review, see: Cano-López et al., 2022).

Visual inspection of the current study's temporal network model further revealed another interesting finding, as the need to control thoughts appeared to play a rather indirect role in the model: actively holding onto this belief did not directly predict more ruminative thinking or depressed mood at a subsequent timepoint. While this finding is in line with the temporal predictions from Tamm et al. (2024), it does contradict results from another cross-sectional network study where need for cognitive control was the node with the strongest connections to depressive symptomatology (Anyan et al., 2023) and meta-analytic findings from Cano-López et al. (2022) where a need for cognitive control appeared to be the second strongest connected to depressive symptomatology out of all the metacognitive domains. Notably, the results of this thesis do suggest that need for control has the potential to indirectly influence all of the other dysfunctional metacognitions, ruminative components and depressed mood through its positive and bidirectional connections with cognitive self-awareness and negative beliefs about uncontrollability of rumination in the temporal network model.

Lastly, the temporal network model suggests that fluctuations in the (lack of) cognitive confidence node are a by-product of the other nodes. Specifically, participants' lack of cognitive confidence was predicted by previous increased depressed mood and cognitive self-awareness, while the cognitive confidence node itself did not temporally predict any of the other nodes in the network. These results are in line with predictions from the directed DAG from Tamm et al. (2024), where lack of cognitive confidence was not expected to predict any of the metacognitive or ruminative variables.

Furthermore, in order to answer the second research question regarding the concurrent associations between rumination components and the other variables, I constructed and visually inspected a contemporaneous network model. Based on results from the undirected network model from Tamm et al. (2024), I hypothesized that at least one of the rumination components in the contemporaneous network model would be positively associated with concurrent depressed mood, as well as with concurrent negative beliefs about the uncontrollability of rumination, positive beliefs about rumination, cognitive self-awareness of thoughts and (lack of) cognitive confidence. Support for multiple of these expectations was found in the contemporaneous network model.

First of all, both of the ruminative components appeared to be significantly connected with each other and with concurrent depressed mood and cognitive self-awareness – similar to the connections in the temporal network model. Secondly, the rumination component of brooding (not reflection) was directly associated with concurrent negative beliefs about

rumination in the contemporaneous network model, further corroborating the undirected findings from Tamm et al. (2024). It is interesting to note that such a direct connection was not present in the temporal network model.

Thirdly, the rumination component of reflection was directly and significantly connected to positive beliefs about rumination and to a lack of cognitive confidence in the contemporaneous network model, further corroborating the findings from Tamm et al. (2024). Results additionally indicate that reflection shared a quite small but direct and positive connection with concurrent need to control thoughts. While such a direct link between rumination and need to control thoughts was not present in the temporal network or in results from Tamm et al. (2024), this finding is in line with the meta-analytic results from Cano-López and colleagues (2022). Thus, current empirical findings on the role of the need to control thoughts appears to be inconclusive, indicating the need for future research aimed at further elucidating its role in both concurrent and temporal dynamics of rumination and depressive symptoms.

Importantly, those results suggest that the use of reflective rumination in daily life often goes hand in hand with positive beliefs about rumination, experiencing a lack of confidence in one's own thinking processes and memory, and the need to control thoughts. Brooding rumination, on the other hand, is suggested to be accompanied more often by negative beliefs about the uncontrollability of rumination. Moreover, it is remarkable that positive beliefs about rumination were only significantly associated with reflective rumination (and not with brooding) in the contemporaneous network model, while the opposite was true in the temporal network model. Taking metacognitive theory into account (Wells & Matthews, 1996; Papageorgiou & Wells, 2003), these results might suggest that triggering positive beliefs about rumination can initially lead to the immediate employment of reflective rumination, but would eventually result in the employment of brooding rumination in the foreseeable future.

In line with previous research findings on rumination components and depressive symptoms (Treyner et al., 2003), brooding showed the strongest connections with concurrent depressed mood when compared with reflection. Combined with the findings from the temporal network model, which suggest that brooding has the potential to both maintain itself (through autocorrelations) as well as maintain depressed mood and dysfunctional metacognitions (through bidirectional temporal connections), the current study's findings support and expand on the well-evidenced notion that brooding functions as a more maladaptive ruminative component (e.g. Cole et al., 2015; Miranda et al., 2013; Treyner et al., 2003).

Moreover, this thesis's findings imply that viewing reflection as an adaptive rumination component might be too simplistic. Specifically, results from the current study suggest that reflection is able to instigate more depressed mood (and vice versa), and that reflection and

brooding not only co-occur but are predictive of one another through time. Thus, it is possible that reflection instigates maladaptive effects directly as well as indirectly through its positive influence on brooding and depressed mood, which is in line with some previous research findings (Bernstein et al. 2019; Junkins & Haeffel; 2017; Kim & Kang, 2022). Therefore, the current study supports a more nuanced approach of brooding and rumination, expanding on the current theoretical and empirical knowledge regarding rumination and its components. The differential associations in both network models further imply that brooding and reflection might have different roles to play in metacognitive network models of rumination and depression as a whole. Thus, future research on dysfunctional metacognitions and could further advance theoretical development and empirical grounding of metacognitive theory by distinguishing between ruminative brooding and reflection.

An important additional finding in the current Master's thesis, is that cognitive self-awareness appeared to be the most well-connected node in both the contemporaneous and temporal network model. Specifically, this thesis's results suggest that this variable might share concurrent and temporal connections with ruminative brooding and reflection, depressed mood and almost all of the metacognitive variables (except for the lack of cognitive confidence node in the contemporaneous network model). The contemporaneous findings are also in line with a majority of the results from the undirected network model from Tamm et al. (2024) where cognitive self-awareness showed to be directly and positively associated with all of the mentioned variables, except for depressive symptoms. Therefore, the current study's findings expand on existing literature by suggesting that being aware of one's own thought processes is a characteristic that is often shared in ruminative thinking and in activation of metacognitive beliefs, and that it can exert influence of other metacognitive beliefs on rumination through time.

Moreover, the current thesis's contemporaneous network findings largely corroborate the influential role of negative beliefs about rumination which was previously proposed by the undirected network model from Tamm et al. (2024) and the cross sectional network model from Anyan et al. (2023). The negative beliefs about rumination are well-connected in the contemporaneous network model, as activation of these beliefs appeared to go hand in hand with brooding rumination and depressed mood, as well as with the need to control thinking, cognitive self-awareness and lack of cognitive confidence.

Surprisingly, the role of the need to control thoughts appears to differ depending on the type of network model in this study. While the belief about the need to control thoughts did not share any direct *temporal* connections with rumination components, it did appear to *co-occur* more often with activation of reflective rumination in the contemporaneous network model – thereby contradicting findings from the undirected network model by Tamm et al. (2024). Thus, while the current study and previously published network models do appear to agree on

an important role for the need to control in its influence on other dysfunctional metacognitions (Anyan et al., 2023; Nordahl et al., 2022; Tamm et al., 2024), findings appear to be inconclusive on the role of the need to control thoughts in its dynamics with daily rumination and depressed mood. Therefore, future research should try and elucidate these dynamics.

Finally, visual inspection of both network models suggests that (lack of) cognitive confidence is one of the least-connected variables, which is in line with previous research (Anyan et al., 2023; Nordahl et al., 2022). However, in the contemporaneous model, small yet significant associations were observed: participants reporting lower cognitive confidence were more likely to engage in reflective rumination, experience concurrent negative beliefs about uncontrollability of rumination, and perceive the need to control their thoughts. These findings mirror those of Tamm et al. (2024), where the (lack of) cognitive confidence node appeared to be directly positively connected to the need to control thoughts-node and the rumination-node.

However, while this thesis's results on the cognitive confidence variable do appear to be in line with some previous studies, it is important to remark that the lack of cognitive confidence node might not have been well-connected in the network models due to its low within-subject variation (see methods section for descriptive statistics and intraclass correlations). The low within-subject variation could indicate that the measured variable is a relatively stable characteristic, which would be in line with metacognitive theory (Wells & Matthews, 1996). Another possibility is that the item was not formulated clearly, which might lead people to select similar responses and result in lower within-subject variation. The ESM item was tested in a piloting study in order to minimize this risk, however future intensive prospective ESM research should pay extra attention to item-selection and within-person variability of cognitive confidence.

Clinical implications

The current study results have multiple clinical implications. First and foremost, both the contemporaneous and temporal network models can help inform the clinical field on the relevance of targeting specific dysfunctional metacognitions in therapy to help decrease dysfunctional metacognitive beliefs, and in turn decrease psychopathological symptoms and distress (Jelinek et al., 2017; Muñoz-Navarro et al., 2022; Nordahl et al., 2017).

The theoretical foundations of metacognitive therapy state that negative beliefs about uncontrollability (e.g. uncontrollability of rumination) are responsible for the persistence of CAS-strategies, like rumination, in psychopathology (Wells, 2009). The clinical relevance of targeting negative beliefs about uncontrollability has also been suggested by empirical studies, with some network studies suggesting great influence of negative beliefs on the other metacognitive domains (Anyan et al., 2023) and intervention studies showing that change in negative metacognition can improve emotional symptoms, functioning and quality of life

(Muñoz-Navarro et al., 2022). The current study corroborated the influential role of negative beliefs in the contemporaneous network model and found important bidirectional connections with depressed mood in the temporal network model. Thus, this study provides further evidence in support of targeting negative beliefs about rumination in people who struggle with depressed mood and persistent ruminative thinking.

Importantly, there has been a rise in evidence suggesting that different dysfunctional metacognitions should be targeted in therapy depending on the specific type of symptom or CAS-strategy that a clinician aims to reduce. For example, the cross-sectional network analysis from Anyan et al. (2023) suggests that negative beliefs about uncontrollability of thinking are well connected to worry and anxiety, while the cognitive self-awareness domain would be strongly connected with rumination. The current study results corroborate these latter research findings, suggesting that cognitive self-awareness has a central role in influencing and connecting reflection and brooding rumination, depressive mood and other dysfunctional metacognitions. Targeting this metacognition could therefore lead to change in many of these psychological components, making it an interesting potential target for the treatment of people who struggle with perseverative rumination.

Furthermore, this study's findings suggest that targeting positive beliefs about rumination could also directly help with the reduction of ruminative brooding in daily life. This suggestion is in line with the empirically evidenced proposition that positive beliefs about rumination are able to instigate rumination (Cano-López et al., 2022). Specifically, the current study results indicate that positive beliefs about rumination and brooding can maintain and strengthen each other throughout the day. Thus, reducing positive beliefs about rumination could help break this self-perpetuating cycle.

Lastly, the study's results indicate that the need to control thoughts might play a rather indirect but possibly important role when it comes to metacognitions and their impact on rumination and depressed mood. It might be helpful to reduce the need to control thoughts because the current study's results suggest that this dysfunctional metacognition is able to exacerbate two of the most clinically relevant metacognitions for rumination in daily life: cognitive self-awareness and negative beliefs about uncontrollability of rumination.

Limitations and future directions

A first limitation of the current study's findings is their novelty and lack of replication in existing literature, which limits the conclusions that can be drawn. Thus, a first recommendation for future research would be to carry out more studies that apply network analysis on intensive ESM data, in order to come to a better understanding of the dynamics between rumination components, dysfunctional metacognitions and depressed mood in daily

life. This could provide replication of the current study's findings and further advance both the theoretical and clinical field of psychopathology.

Second, the ESM measures allowed to gather data from participants in everyday life, increasing the ecological validity of the findings. However, the ESM procedure also has its limitations, like measurement reactivity. Repeated ESM measures might be able to interfere and induce changes in a person's affect, their emotional awareness, and more (Eisele et al., 2023). Therefore, the amount of ESM signals per day had to be carefully considered. Furthermore, the amount of included variables and items had to be limited due to the intensive nature of the ESM measurements. Thus, most constructs were measured using single ESM items, which are unable to capture a construct as well as psychometrically validated questionnaires. In order to include relevant items that captured the essence of the constructs in the ESM survey, a pilot study was conducted and correlations were checked between the ESM items and the corresponding questionnaires – which should be done in future studies as well.

Third, due to the intensive nature of ESM procedures, it is difficult for participants to complete the required amount of observations. This was also the case in the current study: out of 129 participants who completed the ESM procedure, 34 participants had to be excluded for not meeting the response criterium. Future studies should take the issue into account and researchers should be alert to try to gather a sufficient amount of participants and data. Furthermore, due to voluntary participation and the fact that only people with access to certain devices with particular software could partake in the study, there was a possibility for sampling bias. After checking descriptive statistics, the sample appeared to be highly heterogeneous and no sampling bias appeared to be present. However, this is something that should always be checked in future research. The current study also relied on participants self-identifying as people who experience depression – however, future research could be conducted in a clinically diagnosed sample to ensure that findings can be generalized to a clinical population.

A fourth limitation is that existing literature supports the notion that multiple pathways towards rumination exist and that many other constructs might have an important role to play (e.g. Tamm et al., 2024), but only a limited number of these were included in the current study. It would be valuable to include some of these variables in future rumination research, while also taking into account that the amount of ESM items has to be limited. For example, results from the network study from Tamm et al. (2024) suggested a potential pathway that includes diminished effortful control. Watkins and Roberts (2020) have also empirically proven the relevance of goal discrepancies, habitual rumination and abstract processing styles in rumination research – yet all of these remain to be explored via prospective research designs that allow to capture fluctuations and dynamics, or via experimental designs which allow to test causal hypotheses (Tamm et al., 2024; Watkins & Roberts, 2020). Furthermore, Shi et al.

(2024) suggest relevance of including trait rumination in future prospective studies, as this trait component might play an important role in determining within-person variability in the use of momentary rumination. Lastly, many studies suggest inclusion of gender in future analyses due to gender differences in dysfunctional metacognitive beliefs (Cano-López et al., 2022; Anyan et al., 2023).

A fifth limitation, is that the current study included negative beliefs about uncontrollability of rumination but not the second subscale of the NBRS (Papageorgiou & Wells, 2001b). This was done in order to limit the ESM survey to the most relevant constructs and the decision was informed by results from Tamm et al. (2024) which suggest that the second subscale (negative beliefs about social consequences of rumination) would not have predictive value in a temporal network. Furthermore, results from a factor analysis on the NBRS performed by Cano-López et al. (2021) suggest a three-factor structure of the NBRS wherein the uncontrollability beliefs showed the strongest correlations with rumination, thereby underlining the importance of its inclusion in the current study. However, Cano-López et al. (2021) also suggest that negative beliefs about social consequences, not uncontrollability, are responsible for linking rumination with depressive symptoms. As previous research remains inconclusive about which of the negative belief components is responsible for rumination's deleterious effects on depression (Cano-López et al., 2021; Cano-López et al., 2022; Huntley & Fisher, 2016), this question should be explored in future prospective research.

Lastly, the current study's temporal network model does allow to draw conclusions about directionality of influence and can therefore suggest causal interpretations. However, best evidence for causal conclusions would stem from experimental manipulation studies or intervention studies that can demonstrate the effects of change in (specific) metacognitive beliefs (Wells, 2019). As such strong causal evidence is quite scarce, future studies could implement these research approaches to directly test effects of change in (metacognitive) variables that are suggested to have great impact on CAS-strategies and emotional symptomatology.

Conclusions

This study expands on existing literature by providing temporal and contemporaneous network models including five dysfunctional metacognitions, depressed mood and ruminative components in daily life. Results are in line with assumptions from the S-REF and the metacognitive model of rumination and depression, and partially support predictions generated by the directed acyclic graphs (DAG) published by Tamm et al. (2024). Furthermore, preliminary evidence for temporal loops are provided, and results suggest that cognitive self-awareness might play a central role in daily rumination dynamics. Differential connections in the network models suggest the need for differentiation between brooding and reflection components in future research, and support a more nuanced approach on the (mal)adaptiveness of reflective rumination. This study was the first to conduct a temporal network analysis including these variables of interest, providing a novel addition to the current literature as well as suggestions for advancing clinical practice by targeting influential dysfunctional metacognitions like positive and negative metacognitive beliefs about rumination, cognitive self-awareness and possibly also the need for cognitive control. Future directions for research include replication and intervention studies, inclusion of other relevant variables in network analysis of rumination, and more.

References

- Aadahl, V., Wells, A., Hallard, R., & Pratt, D. (2021). Metacognitive Beliefs and Suicidal Ideation: An Experience Sampling study. *International Journal of Environmental Research and Public Health/International Journal of Environmental Research and Public Health*, *18*(23), 12336. <https://doi.org/10.3390/ijerph182312336>
- Anyan, F., Nordahl, H., & Hjemdal, O. (2023). The network structure of dysfunctional metacognitions, CAS strategies, and symptoms. *Cogent Psychology*, *10*(1). <https://doi.org/10.1080/23311908.2023.2205258>
- Arana, F. G., & Rice, K. G. (2017). Cross-Cultural validity of the ruminative responses scale in Argentina and the United States. *Assessment*, *27*(2), 309–320. <https://doi.org/10.1177/1073191117729204>
- Bernstein, E. E., Heeren, A., & McNally, R. J. (2019). Reexamining trait rumination as a system of repetitive negative thoughts: A network analysis. *Journal of Behavior Therapy and Experimental Psychiatry*, *63*, 21–27. <https://doi.org/10.1016/j.jbtep.2018.12.005>
- Bolger, N., & Laurenceau, J.-P. (2013). *Intensive longitudinal methods: An introduction to diary and experience sampling research*. Guilford Press.
- Borsboom, D. (2008). Psychometric perspectives on diagnostic systems. *Journal of Clinical Psychology*, *64*(9), 1089–1108. <https://doi.org/10.1002/jclp.20503>
- Borsboom, D., & Cramer, A. O. J. (2013). Network Analysis: An Integrative Approach to the Structure of Psychopathology. *Annual Review of Clinical Psychology*, *9*(1), 91–121. <https://doi.org/10.1146/annurev-clinpsy-050212-185608>
- Bos, F. M., Snippe, E., De Vos, S., Hartmann, J. A., Simons, C. J. P., Van Der Krieke, L., De Jonge, P., & Wichers, M. (2017). Can We Jump from Cross-Sectional to Dynamic Interpretations of Networks Implications for the Network Perspective in Psychiatry. *Psychotherapy and Psychosomatics*, *86*(3), 175–177. <https://doi.org/10.1159/000453583>
- Bringmann, L. F., Pe, M., Vissers, N., Ceulemans, E., Borsboom, D., Vanpaemel, W., Tuerlinckx, F., & Kuppens, P. (2016). Assessing Temporal Emotion Dynamics Using Networks. *Assessment*, *23*(4), 425–435. <https://doi.org/10.1177/1073191116645909>
- Cano-López, J. B., García-Sancho, E., Fernández-Castilla, B., & Salguero, J. M. (2022). Empirical Evidence of the Metacognitive Model of Rumination and Depression in Clinical and Nonclinical Samples: A Systematic Review and Meta-Analysis. *Cognitive Therapy and Research*, *46*(2), 367–392. <https://doi.org/10.1007/s10608-021-10260-2>
- Cano-López, J. B., Salguero, J. M., García-Sancho, E., & Ramos-Cejudo, J. (2021). Testing the Metacognitive Model of Rumination and Depression in Non-clinical Population: New Data about PBRs and NBRs Scales. *Journal of Psychopathology and Behavioral Assessment*, *43*(2), 240–250. <https://doi.org/10.1007/s10862-020-09828-1>

Cartwright-Hatton, S., & Wells, A. (1997). Beliefs about Worry and Intrusions: The Meta-Cognitions Questionnaire and its Correlates. *Journal of Anxiety Disorders*, 11(3), 279–296. [https://doi.org/10.1016/s0887-6185\(97\)00011-x](https://doi.org/10.1016/s0887-6185(97)00011-x)

Cole, A., Wingate, L. R., Tucker, R. P., Rhoades-Kerswill, S., O’Keefe, V. M., & Hollingsworth, D. W. (2015). The differential impact of brooding and reflection on the relationship between perceived stress and suicide ideation. *Personality and Individual Differences*, 83, 170–173. <https://doi.org/10.1016/j.paid.2015.04.013>

Connolly, S. L., & Alloy, L. B. (2017). Rumination interacts with life stress to predict depressive symptoms: An ecological momentary assessment study. *Behaviour Research and Therapy*, 97, 86–95. <https://doi.org/10.1016/j.brat.2017.07.006>

Contreras, A., Nieto, I., Valiente, C., Espinosa, R., & Vázquez, C. (2019). The Study of Psychopathology from the Network Analysis Perspective: A Systematic Review. *Psychotherapy and Psychosomatics*, 88(2), 71–83. <https://doi.org/10.1159/000497425>

Crowe, E., Daly, M., Delaney, L., Carroll, S. A., & Malone, K. M. (2019). The intra-day dynamics of affect, self-esteem, tiredness, and suicidality in Major Depression. *Psychiatry Research-neuroimaging*, 279, 98–108. <https://doi.org/10.1016/j.psychres.2018.02.032>

Csikszentmihalyi, M., & Larson, R. W. (1987). Validity and Reliability of the Experience-Sampling Method. *Journal of Nervous and Mental Disease*, 175(9), 526–536. <https://doi.org/10.1097/00005053-198709000-00004>

Curran, S. L., Andrykowski, M. A., & Studts, J. L. (1995). Short Form of the Profile of Mood States (POMS-SF): Psychometric information. *Psychological Assessment*, 7(1), 80–83. <https://doi.org/10.1037/1040-3590.7.1.80>

Ebner-Priemer, U. W., & Trull, T. J. (2009). Ecological momentary assessment of mood disorders and mood dysregulation. *Psychological Assessment*, 21(4), 463–475. <https://doi.org/10.1037/a0017075>

Epskamp, S., Cramer, A. O. J., Waldorp, L. J., Schmittmann, V. D., & Borsboom, D. (2012). qgraph: Network Visualizations of Relationships in Psychometric Data. *Journal of Statistical Software*, 48(4), 1-18. <https://doi.org/10.18637/jss.v048.i04>

Epskamp, S., Deserno, M.K., & Bringmann, L.F. (2024). mlVAR: Multi-Level vector autoregression. *R package*. version 0.5.2.

Epskamp, S., Waldorp, L. J., Möttus, R., & Borsboom, D. (2018). The Gaussian Graphical Model in Cross-Sectional and Time-Series Data. *Multivariate Behavioral Research*, 53(4), 453–480. <https://doi.org/10.1080/00273171.2018.1454823>

Faelens, L., Hoorelbeke, K., Soenens, B., Van Gaeveren, K., De Marez, L., De Raedt, R., & Koster, E. H. W. (2021). Social media use and well-being: A prospective experience-sampling study. *Computers in Human Behavior*, 114, 106510. <https://doi.org/10.1016/j.chb.2020.106510>

Fang, L., Marchetti, I., Hoorelbeke, K., & Koster, E. H. (2019). Do daily dynamics in rumination and affect predict depressive symptoms and trait rumination? An experience sampling study. *Journal of Behavior Therapy and Experimental Psychiatry*, 63, 66–72. <https://doi.org/10.1016/j.jbtep.2018.11.002>

Fergus, T. A., & Bardeen, J. R. (2019). The Metacognitions Questionnaire–30: An Examination of a Bifactor Model and Measurement Invariance Among Men and Women in a Community Sample. *Assessment*, 26(2), 223–234. <https://doi.org/10.1177/1073191116685807>

Fruchterman, T. M. J., & Reingold, E. M. (1991). Graph drawing by force-directed placement. *Software, Practice & Experience/Software, Practice and Experience*, 21(11), 1129–1164. <https://doi.org/10.1002/spe.4380211102>

Gabriel, A. S., Podsakoff, N. P., Beal, D. J., Scott, B. A., Sonnentag, S., Trougakos, J. P., & Butts, M. M. (2018). Experience Sampling Methods: A discussion of critical trends and considerations for scholarly advancement. *Organizational Research Methods*, 22(4), 969–1006. <https://doi.org/10.1177/1094428118802626>

Goodwin, R. D., Dierker, L. C., Wu, M., Galea, S., Hoven, C. W., & Weinberger, A. H. (2022). Trends in U.S. depression prevalence from 2015 to 2020: The widening treatment gap. *American Journal of Preventive Medicine*, 63(5), 726–733. <https://doi.org/10.1016/j.amepre.2022.05.014>

Henry, J. P., & Crawford, J. R. (2005). The short-form version of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample. *British Journal of Clinical Psychology*, 44(2), 227–239. <https://doi.org/10.1348/014466505x29657>

Hjartarson, K. H., Snorrason, I., Bringmann, L. F., Ögmundsson, B. E., & Ólafsson, R. P. (2021). Do daily mood fluctuations activate ruminative thoughts as a mental habit? Results from an ecological momentary assessment study. *Behaviour Research and Therapy*, 140, 103832. <https://doi.org/10.1016/j.brat.2021.103832>

Hoebeke, Y., Blanchard, M. A., Bernstein, E. E., McNally, R. J., & Heeren, A. (2023). Negativity is Key for Understanding the Interplay Between Rumination's Features, Attention Control, and Their Dynamic Nature: A Temporal Network Approach. *Cognitive Therapy and Research*. <https://doi.org/10.1007/s10608-023-10432-2>

Hoebeke, Y., Blanchard, M., Contreras, A., & Heeren, A. (2022). An experience sampling measure of the key features of rumination. *Clinical Neuropsychiatry*, 19(5), 288–297. <https://doi.org/10.36131/cnfioritieditore20220504>

Hoorelbeke, K., Van Den Bergh, N., Wichers, M., & Koster, E. H. W. (2019). Between vulnerability and resilience: A network analysis of fluctuations in cognitive risk and protective

factors following remission from depression. *Behaviour Research and Therapy*, 116, 1–9.
<https://doi.org/10.1016/j.brat.2019.01.007>

Huntley, C. D., & Fisher, P. L. (2016). Examining the role of positive and negative metacognitive beliefs in depression. *Scandinavian Journal of Psychology*, 57(5), 446–452.
<https://doi.org/10.1111/sjop.12306>

Jelinek, L., Van Quaquebeke, N., & Moritz, S. (2017). Cognitive and Metacognitive Mechanisms of Change in Metacognitive Training for Depression. *Scientific Reports*, 7(1).
<https://doi.org/10.1038/s41598-017-03626-8>

Johnson, S. U., Hoffart, A., Nordahl, H. M., Ulvenes, P., Vrabell, K., & Wampold, B. E. (2018). Metacognition and cognition in inpatient MCT and CBT for comorbid anxiety disorders: A study of within-person effects. *Journal of Counseling Psychology*, 65(1), 86–97.
<https://doi.org/10.1037/cou0000226>

Jones, N. D., Papadakis, A. A., Hogan, C. M., & Strauman, T. J. (2009). Over and over again: Rumination, reflection, and promotion goal failure and their interactive effects on depressive symptoms. *Behaviour Research and Therapy*, 47(3), 254–259.
<https://doi.org/10.1016/j.brat.2008.12.007>

Joubert, A. E., Moulds, M. L., Werner-Seidler, A., Sharrock, M., Popovic, B., & Newby, J. M. (2022). Understanding the experience of rumination and worry: A descriptive qualitative survey study. *British Journal of Clinical Psychology*, 61(4), 929–946.
<https://doi.org/10.1111/bjc.12367>

Junkins, M. B., & Haeffel, G. J. (2017). Rumination: Reflection can amplify the depressogenic effects of brooding. *International Journal of Cognitive Therapy*, 10(1), 34-46.
https://doi.org/10.1521/ijct_2016_09_19

Khattak, S. (2023). Metacognitions and Mental Health: Cross-Cultural Adaptation and Validation of the Metacognitions Questionnaire 30 (MCQ-30) in Depressive Patients. *Nature-Nurture Journal of Psychology*, 3(2), 31–42. <https://doi.org/10.53107/nnpj.v3i2.36>

Kim, B., & Kang, H. (2022). Differential roles of reflection and brooding on the relationship between perceived stress and life satisfaction during the COVID-19 pandemic: A serial mediation study. *Personality and Individual Differences*, 184, 111169.
<https://doi.org/10.1016/j.paid.2021.111169>

Kircanski, K., Thompson, R. J., Sorenson, J. A., Sherdell, L., & Gotlib, I. H. (2015). Rumination and Worry in Daily Life: Examining the Naturalistic Validity of Theoretical Constructs. *Clinical Psychological Science*, 3(6), 926–939.
<https://doi.org/10.1177/2167702614566603>

Kircanski, K., Thompson, R. J., Sorenson, J. A., Sherdell, L., & Gotlib, I. H. (2018). The everyday dynamics of rumination and worry: precipitant events and affective consequences. *Cognition & Emotion*, 32(7), 1424–1436. <https://doi.org/10.1080/02699931.2017.1278679>

Koster, E. H. W., Fang, L., Marchetti, I., Ebner-Priemer, U. W., Kirsch, P., Huffziger, S., & Kuehner, C. (2015). Examining the relation between mood and rumination in remitted depressed individuals. *Clinical Psychological Science*, 3(4), 619–627.

<https://doi.org/10.1177/2167702615578129>

Kubiak, T., Zahn, D., Siewert, K., Jonas, C., & Weber, H. (2014). Positive Beliefs about Rumination Are Associated with Ruminative Thinking and Affect in Daily Life: Evidence for a Metacognitive View on Depression. *Behavioural and Cognitive Psychotherapy*, 42(5), 568–576. <https://doi.org/10.1017/s1352465813000325>

Lane, A. N., Terry, P. C., Stevens, M., Barney, S., & Dinsdale, S. (2004). Mood responses to athletic performance in extreme environments. *Journal of Sports Sciences*, 22(10), 886–897. <https://doi.org/10.1080/02640410400005875>

Lane, A., & Terry, P. (2000). The nature of mood: Development of a Conceptual Model with a Focus on Depression. *Journal of Applied Sport Psychology*, 12(1), 16–33.

<https://doi.org/10.1080/10413200008404211>

Lee, S., & Kim, W. (2014). Cross-Cultural adaptation, reliability, and validity of the revised Korean version of Ruminative Response Scale. *Psychiatry Investigation*, 11(1), 59.

<https://doi.org/10.4306/pi.2014.11.1.59>

LeMoult, J., Arditte, K. A., D'Avanzato, C., & Joormann, J. (2013). State Rumination: Associations with Emotional Stress Reactivity and Attention Biases. *Journal of Experimental Psychopathology*, 4(5), 471–484. <https://doi.org/10.5127/jep.029112>

Limesurvey GmbH. / LimeSurvey: An Open Source survey tool /LimeSurvey GmbH, Hamburg, Germany. <http://www.limesurvey.org>

Lovibond, S.H. & Lovibond, P.F. (1995). *Manual for the Depression Anxiety Stress Scales*. (2nd. Ed.) Sydney, Australia: Psychology Foundation.

Mansueto, A. C., Wiers, R. W., Van Weert, J. C., Schouten, B. C., & Epskamp, S. (2023). Investigating the feasibility of idiographic network models. *Psychological Methods*, 28(5), 1052–1068. <https://doi.org/10.1037/met0000466>

Marchetti, I., Mor, N., Chiorri, C., & Koster, E. H. W. (2018). The Brief State Rumination Inventory (BSRI): validation and psychometric evaluation. *Cognitive Therapy and Research*, 42(4), 447–460. <https://doi.org/10.1007/s10608-018-9901-1>

Miranda, R., Polanco-Roman, L., Tsypes, A., & Valderrama, J. M. (2013). Perceived discrimination, ruminative subtypes, and risk for depressive symptoms in emerging adulthood. *Cultural Diversity & Ethnic Minority Psychology*, 19(4), 395–403.

<https://doi.org/10.1037/a0033504>

Moberly, N. J., & Watkins, E. R. (2008). Ruminative self-focus and negative affect: An experience sampling study. *Journal of Abnormal Psychology*, 117(2), 314–323.

<https://doi.org/10.1037/0021-843x.117.2.314>

Muñoz-Navarro, R., Medrano, L. A., Limonero, J. T., González-Blanch, C., Moriana, J. A., Ruíz-Rodríguez, P., & Vindel, A. C. (2022). The mediating role of emotion regulation in transdiagnostic cognitive behavioural therapy for emotional disorders in primary care: Secondary analyses of the PsicAP randomized controlled trial. *Journal of Affective Disorders*, 303, 206–215. <https://doi.org/10.1016/j.jad.2022.01.029>

Nolen-Hoeksema, S. (1991). Responses to depression and their effects on the duration of depressive episodes. *Journal of Abnormal Psychology*, 100(4), 569–582. <https://doi.org/10.1037/0021-843X.100.4.569>

Nolen-Hoeksema, S., & Morrow, J. (1991). A prospective study of depression and posttraumatic stress symptoms after a natural disaster: The 1989 Loma Prieta earthquake. *Journal Of Personality And Social Psychology*, 61(1), 115–121. <https://doi.org/10.1037/0022-3514.61.1.115>

Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking Rumination. *Perspectives on Psychological Science*, 3(5), 400–424. <https://doi.org/10.1111/j.1745-6924.2008.00088.x>

Nordahl, H., Anyan, F., Hjemdal, O., & Wells, A. (2022). The network structure of dysfunctional metacognition: Analysis of the MCQ-30. *Acta Psychologica*, 227, 103622. <https://doi.org/10.1016/j.actpsy.2022.103622>

Nordahl, H., Nordahl, H. M., Hjemdal, O., & Wells, A. (2017). Cognitive and metacognitive predictors of symptom improvement following treatment for social anxiety disorder: A secondary analysis from a randomized controlled trial. *Clinical Psychology & Psychotherapy*, 24(6), 1221–1227. <https://doi.org/10.1002/cpp.2083>

Normann, N., & Morina, N. (2018). The Efficacy of Metacognitive Therapy: A Systematic Review and Meta-Analysis. *Frontiers in Psychology*, 9. <https://doi.org/10.3389/fpsyg.2018.02211>

Papageorgiou, C., & Wells, A. (2001a). Positive beliefs about depressive rumination: Development and preliminary validation of a self-report scale. *Behavior Therapy*, 32(1), 13–26. [https://doi.org/10.1016/s0005-7894\(01\)80041-1](https://doi.org/10.1016/s0005-7894(01)80041-1)

Papageorgiou, C., & Wells, A. (2001b). Metacognitive beliefs about rumination in recurrent major depression. *Cognitive and Behavioral Practice*, 8(2), 160–164. [https://doi.org/10.1016/s1077-7229\(01\)80021-3](https://doi.org/10.1016/s1077-7229(01)80021-3)

Papageorgiou, C., & Wells, A. (2003). An Empirical Test of a Clinical Metacognitive Model of Rumination and Depression. *Cognitive Therapy and Research*, 27(3), 261–273. <https://doi.org/10.1023/a:1023962332399>

Parola, N., Zendjidian, X. Y., Alessandrini, M., Baumstarck, K., Loundou, A., Fond, G., Berna, F., Lançon, C., Auquier, P., & Boyer, L. (2017). Psychometric properties of the Ruminative Response Scale-short form in a clinical sample of patients with major depressive

disorder. *Patient Preference and Adherence, Volume 11*, 929–937.

<https://doi.org/10.2147/ppa.s125730>

Prolific. (n.d.). *Prolific Academic*. Retrieved from <https://www.prolific.com>

Rich, A., Haynos, A. F., Anderson, D. A., Ehrlich, L. I., & Anderson, L. (2022). The role of rumination and positive beliefs about rumination in eating pathology. *Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity, 27*(3), 979–988.

<https://doi.org/10.1007/s40519-021-01209-1>

Robinaugh, D. J., Hoekstra, R. H. A., Toner, E. R., & Borsboom, D. (2020). The network approach to psychopathology: a review of the literature 2008–2018 and an agenda for future research. *Psychological Medicine, 50*(3), 353–366.

<https://doi.org/10.1017/s0033291719003404>

Schoofs, H., Hermans, D., & Raes, F. (2010). Brooding and Reflection as Subtypes of Rumination: Evidence from Confirmatory Factor Analysis in Nonclinical Samples using the Dutch Ruminative Response Scale. *Journal of Psychopathology and Behavioral Assessment, 32*(4), 609–617. <https://doi.org/10.1007/s10862-010-9182-9>

Selby, E. A., Kranzler, A., Panza, E., & Fehling, K. B. (2016). Bidirectional-Compounding Effects of Rumination and Negative Emotion in Predicting Impulsive Behavior: Implications for Emotional Cascades. *Journal of Personality, 84*(2), 139–153.

<https://doi.org/10.1111/jopy.12147>

Shevchenko, Y., Kuhlmann, T., & Reips, U. D. (2021). Samply: A user-friendly smartphone app and web-based means of scheduling and sending mobile notifications for experience-sampling research. *Behavior Research Methods, 1-21*. <https://doi.org/10.3758/s13428-020-01527-9>.

Shi, X., Huang, X., Guo, Z., & Gordon, S. (2024). Intraindividual variability and stability in rumination: examining the effect of rumination on negative affect across domains.

International Journal of Contemporary Hospitality Management. <https://doi.org/10.1108/ijchm-06-2023-0783>

Solem, S., Håland, Å. T., Vogel, P., Hansen, B., & Wells, A. (2009). Change in metacognitions predicts outcome in obsessive–compulsive disorder patients undergoing treatment with exposure and response prevention. *Behaviour Research and Therapy, 47*(4), 301–307. <https://doi.org/10.1016/j.brat.2009.01.003>

Strauman, T. J. (2017). Self-Regulation and Psychopathology: Toward an Integrative Translational Research Paradigm. *Annual Review Of Clinical Psychology, 13*(1), 497–523.

<https://doi.org/10.1146/annurev-clinpsy-032816-045012>

Sunde, T. O. L., Johnson, S. U., Himle, J. A., Bertelsen, T., Haaland, V. Ø., Vogel, P., Walseth, L. T., & Haaland, Å. T. (2021). Metacognitions and Obsessive Beliefs in Obsessive–Compulsive Disorder: A Study of Within- and Between-Person Effects on Long-Term

Outcome. *Cognitive Therapy and Research*, 45(6), 1105–1119.

<https://doi.org/10.1007/s10608-021-10210-y>

Tamm, G., Koster, E., K. Hoorelbeke (2024). Multiple paths to rumination within a network analytical framework. *Scientific Reports*, 14 (1), 10874.

<https://doi.org/10.1038/s41598-024-61469-6>

Temple, J., Cherry, M. G., Gray, V., Jones, A., & Fisher, P. (2024). Experience sampling methodology study of anxiety and depression in adolescents with epilepsy: The role of metacognitive beliefs and perseverative thinking. *Epilepsy & Behavior*, 151, 109599.

<https://doi.org/10.1016/j.yebeh.2023.109599>

Thielsch, C., Ehring, T., Nestler, S., Wolters, J., Kopei, I., Rist, F., Gerlach, A. L., & Andor, T. (2015). Metacognitions, worry and sleep in everyday life: Studying bidirectional pathways using Ecological Momentary Assessment in GAD patients. *Journal of Anxiety Disorders*, 33, 53–61. <https://doi.org/10.1016/j.janxdis.2015.04.007>

Treynor, W., Gonzalez, R., & Nolen-Hoeksema, S. (2003). Rumination Reconsidered: A Psychometric Analysis. *Cognitive Therapy and Research*, 27(3), 247–259.

<https://doi.org/10.1023/A:1023910315561>

Watkins, E. R., & Nolen-Hoeksema, S. (2014). A habit-goal framework of depressive rumination. *Journal of Abnormal Psychology*, 123(1), 24–34. <https://doi.org/10.1037/a0035540>

Watkins, E. R., & Roberts, H. (2020). Reflecting on rumination: Consequences, causes, mechanisms and treatment of rumination. *Behaviour Research and Therapy*, 127, 103573. <https://doi.org/10.1016/j.brat.2020.103573>

Wells, A. (2009). *Metacognitive Therapy for Anxiety and Depression*. Guilford Press. Retrieved from https://books.google.be/books?id=sWJgx5-1y4AC&printsec=frontcover&redir_esc=y#v=onepage&q&f=false

Wells, A. (2019). Breaking the Cybernetic Code: Understanding and Treating the Human Metacognitive Control System to Enhance Mental Health. *Frontiers in Psychology*, 10. <https://doi.org/10.3389/fpsyg.2019.02621>

Wells, A., & Cartwright-Hatton, S. (2004). A short form of the metacognitions questionnaire: properties of the MCQ-30. *Behaviour Research and Therapy*, 42(4), 385–396. [https://doi.org/10.1016/s0005-7967\(03\)00147-5](https://doi.org/10.1016/s0005-7967(03)00147-5)

Wells, A., & Matthews, G. (1994). *Attention and emotion: A clinical perspective*. Lawrence Erlbaum Associates, Inc.

Wells, A., & Matthews, G. (1996). Modelling cognition in emotional disorder: The S-REF model. *Behaviour Research and Therapy*, 34(11–12), 881–888. [https://doi.org/10.1016/s0005-7967\(96\)00050-2](https://doi.org/10.1016/s0005-7967(96)00050-2)

Wenze, S. J., & Miller, I. W. (2010). Use of ecological momentary assessment in mood disorders research. *Clinical Psychology Review, 30*(6), 794–804. <https://doi.org/10.1016/j.cpr.2010.06.007>

Wilhelm, P., & Schoebi, D. (2007). Assessing Mood in Daily Life: Structural validity, sensitivity to change, and reliability of a short-scale to measure three basic dimensions of mood. *European Journal of Psychological Assessment, 23*(4), 258–267. <https://doi.org/10.1027/1015-5759.23.4.258>

World Health Organization. (2023, March 31). *Depressive disorder (depression)*. <https://www.who.int/news-room/fact-sheets/detail/depression#:~:text=During%20a%20depressive%20episode%2C%20a,for%20at%20least%20two%20weeks>.

Zhang, R., Lei, L. S. M., Wells, A., Dang, L. S., & Wu, A. M. S. (2020). Validation of a Chinese version of the short form of Metacognitions Questionnaire (MCQ-30). *Journal of Affective Disorders, 277*, 417–424. <https://doi.org/10.1016/j.jad.2020.08.028>

Appendix A

ESM survey

Table A1. *List with ESM items and instructions*

Items	Construct
Think about the feelings and thoughts that you have experienced since the last responded signal. Rate each item to what extent did you feel or think this way on a scale from 0 to 100. 0 – not at all, 100 – almost all the time/very much. Insert a number from 0 to 100 into the text field.	
Energetic	Mood
Satisfied	Mood
Happy	Mood
Angry	Mood
Tense	Mood
Depressed	Mood
I focused on my negative feelings	Reflection
I focused on my problems	Brooding
I focused on achieving something rather than avoiding something bad to happen	Promotion focus/prevention
I got easily distracted while trying to focus my attention	Attentional control
I expected that rumination will help me solve problems.	Positive belief about rumination
I expected that rumination will result in uncontrollable thinking	Negative belief about rumination
I was constantly aware of my thinking	Cognitive self-awareness
I thought that I should be in control of my thoughts	Need to control thoughts
I had little confidence in my memory	(lack of) Cognitive confidence
I set higher goals for myself than most people	Strivings
I expected that people will not respect me if I do not do well all the time	Evaluative concerns

Appendix B

Edge weights

Table B1. *Significant edges for the temporal network model*

From		To	Edge weight
DEP	→	DEP	.30
BRO	→	DEP	.08
REF	→	DEP	.03
NBR	→	DEP	.05
AWS	→	DEP	.04
DEP	→	BRO	.14
BRO	→	BRO	.22
REF	→	BRO	.05
PBR	→	BRO	.05
AWS	→	BRO	.09
DEP	→	REF	.10
BRO	→	REF	.13
REF	→	REF	.14
AWS	→	REF	.09
BRO	→	PBR	.04
PBR	→	PBR	.22
AWS	→	PBR	.05
DEP	→	NBR	.09
NBR	→	NBR	.20
NCT	→	NBR	.06
DEP	→	AWS	.05
BRO	→	AWS	.04
NBR	→	AWS	.04
AWS	→	AWS	.18
NCT	→	AWS	.08
NBR	→	NCT	.04
AWS	→	NCT	.09
NCT	→	NCT	.16
DEP	→	CCE	.03
AWS	→	CCE	.04
CCE	→	CCE	.17

Note. DEP = Depressed Mood, BRO = Brooding, REF = Reflection, PBR = Positive Beliefs about Rumination, NBR = Negative Beliefs about Rumination, AWS = Cognitive Self-Awareness, NCT = Need to Control Thoughts, CCE = lack of Cognitive Confidence.

Table B2. *Edge weights contemporaneous network model*

	DEP	BRO	REF	PBR	NBR	AWS	NCT	CCE
DEP	-							
BRO	.30	-						
REF	.09	.45	-					
PBR	.00	.00	.09	-				
NBR	.07	.08	.00		-			
AWS	.05	.13	.07	.10	.07	-		
NCT	.00	.00	.03	.10	.13	.17	-	
CCE	.00	.00	.04	.00	.04	.00	.03	-

Note. DEP = Depressed Mood, BRO = Brooding, REF = Reflection, PBR = Positive Beliefs about Rumination, NBR = Negative Beliefs about Rumination, AWS = Cognitive Self-Awareness, NCT = Need to Control Thoughts, CCE = lack of Cognitive Confidence.