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REVIEW

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How to study psychological mechanisms of mania? A systematic review on the methodology of experimental studies on manic mood dysregulation of leading theories on bipolar disorder

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Abstract

Introduction: Although there are several psychological theories on bipolar disorders (BD), the empirical evidence on these theories through experimental studies is still limited. The current study systematically reviews experimental methods used in studies on the main theories of BD: Reward Hypersensitivity Theory (RST) or Behavioral Activation System (BAS), Integrative Cognitive Model (ICM), Positive Emotion Persistence (PEP), Manic Defense theory (MD), and Mental Imagery (MI). The primary aim is to provide an overview of the used methods and to identify limitations and suggest areas of improvement.

Methods: A systematic search of six databases until October 2023 was conducted. Study selection involved two independent reviewers extracting data on experimental study design and methodology.

Results: A total of 84 experimental studies were reviewed. BAS and RST were the most frequently studied theories. The majority of these experimental studies focus on mechanisms of reward sensitivity. Other important elements of the reviewed theories, such as goal setting and—attainment, situation selection (avoidance or approach), activation, affective/emotional reactivity, and regulatory strategies, are understudied. Self-report and neuropsychological tasks are most often used, while mood induction and physiological measures are rarely used.

Conclusion: There is a need for more consensus on the operationalization of psychological theories of mania. Standardization of test batteries could improve comparability among studies and foster a more systematic approach to experimental research. Research on affective (activated) states is still underrepresented in comparison with studies on trait vulnerabilities.

KEYWORDS
bipolar disorder, BIS/BAS, mania, psychological theory, reward, RST, study design, systematic review

This review was registered on PROSPERO international prospective register of systematic reviews with ID number: CRD42023253710.

1 | INTRODUCTION

Bipolar disorder (BD) is a highly disruptive psychiatric illness with a significant recurrence rate and often long-lasting negative social and occupational consequences.[1,2] (Hypo)mania is the core phenomenon separating BD from unipolar depressive disorder and characterized by changes in behavior, affect, and cognition, such as disinhibition, increases in risk taking, increased excitement, goal setting, and goal directed behavior.[3] It is estimated that 39–60% of the patients will, after their first (hypo)manic episode, experience recurrence of a mood episode within a year.[4,5] While there are well-studied psychological theories on the onset and maintenance of other psychiatric conditions such as depression (e.g. cognitive bias), anxiety disorders (e.g. classical conditioning), and personality disorders (e.g. attachment theory), much less is yet understood about the psychological mechanisms of mania. Despite the fact that several persuasive psychological models have been formulated for BD,[6–10] they do not consistently explain the vulnerability to develop manic states.

One of the reasons why little research has been aimed at psychological aspects might be that mania traditionally has been perceived as a primarily biological phenomenon. As such, research has tended to focus more on biological aspects (e.g. pharmacology, circadian rhythm disturbance) than psychological aspects. Moreover, a challenge faced by researchers is that mania often only appears for a relatively short period, in which patients are often unable or unmotivated to participate in research. Nevertheless, one could investigate what makes people with BD prone to specifically develop a manic state. Insights coming from such studies could further refine psychological interventions for BD. Next to naturalistic studies that investigate specific patients' characteristics and relate these to the longitudinal illness course, there is also a need for more fundamental, experimental approaches to test specific mechanisms involved in manic mood dysregulation. Although naturalistic studies give insight in factors that are associated with specific clinical characteristics, both basic mechanisms and causal directions are difficult to disentangle. Controlled (laboratory) experiments are more suitable to investigate causal associations, for instance, through specific manipulations, even though generally constructs are simplified in experimental studies. Systematically following the scientific cycle of shaping and testing theories through experimental studies followed by validation in naturalistic designs could advance the understanding of BD and facilitate the formulation of a more comprehensive psychological model. A good example of this way of studying a psychiatric disorder can be found in the field of anxiety disorders. For instance, the wealth of studies into the role of avoidance has been approached from the field of experimental psychology, clinical psychology, psychiatry, and behavioral sciences. The acquired knowledge has increased our understanding of the psychological and brain processes involved in learning, expression, and reduction of avoidance behavior. By building on these principles of avoidance, clinical interventions for maladaptive avoidance have been improved over the years.[11]

Various models have been proposed to understand the phenomenon of manic dysregulation. For this review, we chose to focus on six psychological models on which experimental studies have been performed and of which the core features are psychological mechanisms (and not mainly biological, such as chronobiological theories of BD). These are all models that explain bipolar mood dysregulation: the Behavioral Activation System (BAS) dysregulation or Reward Hypersensitivity theory,[12–14] Integrated Cognitive Model,[7] Positive Emotion Persistence,[10] Mental Imagery,[15] and the Manic Defense theory.[16] Although these theories are overlapping in the sense that they all aim to explain underlying mechanisms of affective dysregulation in BD, they differ in the emphasis they put on the specific (neuro-)psychological 'domain' that is involved in the (dys-)regulation: cognitive (ICM), behavioral (BAS/RST) or affective domain (PEP, MI, and Manic Defense). For feasibility reasons, we chose to limit this review to clearly outlined and experimentally investigated theories. This means that certain relevant psychological elements that have been associated with BD fell outside the scope of this review, such as research into specific affective regulation styles. The theories will be briefly explained below.

1.1 | Behavioral Activation System (BAS) sensitivity theory or Reward Hypersensitivity Theory (RST)

The BAS/reward hypersensitivity model of bipolar disorder states that abnormalities in reward processing and approach-related affect play an important role in particularly the occurrence of hypomanic/manic symptoms.[3,17] BAS is conceptualized as the motivational system that facilitates approach and goal directed behavior.[12] The model argues that risk for (hypo-)mania is characterized by a hypersensitivity to goal- and reward-relevant cues. This hypersensitivity can lead to an excessive increase in approach-related affect and motivation during situations that involve rewards or goal striving and attainment. Dysregulation of the BAS is hypothesized to be involved in BD in the sense that overstimulation leads to vulnerability for a manic state, while understimulation leads to vulnerability for a depressed state. The theory also states that activation of the BAS leads to behavior aimed at achieving goals, such as seeking rewarding contexts, giving more attention to rewarding cues, and an increased effort and willingness to achieve an ambitious goal despite potential risks, which may then result in further activation of the BAS. Contrary to the BAS is the Behavioral Inhibition System (BIS), responsible for inhibited and avoidant behavior, and associated with depression. In the literature, 'reward hypersensitivity' (RST) refers to a dysregulated BAS and both theories focus on reward sensitivity as a central aspect of manic mood dysregulation. In this review, we have opted to discuss BAS and RST within the same sections, in line with previous literature on these theories (e.g. Nusslock et al.[17]).

1.2 | Mental Imagery (MI)

MI, the capacity of forming mental, visual representations, is a transdiagnostic phenomenon that first received attention within the

context of Cognitive Behavioral Therapy (CBT) for Post-Traumatic Stress Disorder (PTSD) and social anxiety. MI in the context of BD proposes that mood instability in BD is associated with amplified mental imagery and anxiety as well. Holmes et al.[15] applied it to the context of BD, as it appears that people with BD use more imagery in daily life and report stronger emotional arousal to imagery, as mental images have stronger emotional impact than verbal cognitions. MI is currently applied in clinical practice, for example in Imagery-focused Cognitive Therapy (ImCT).[18]

1.3 | Integrative Cognitive Model (ICM)

The ICM in the context of BD proposes that extreme negative and positive appraisals about internal states contribute to mood dysregulation.[7] An ego syntonic assumption about internal feelings can enhance a certain emotion. For example, a cognitive appraisal about an internal state is: 'the way I am feeling right now (energetic and spontaneous) is how I truly am and how people should know me'. Imaginably, this attribution will lead to activating behavior, such as pursuing this energetic feeling. More activation reinforces appraisals of internal states itself, creating a vicious circle associated with mania. Likewise, ICM states that negative appraisals of internal states contribute to deactivating behavior. ICM is a model that is sometimes integrated in treatment for BD as well, such as in cognitive behavioral therapy.[19]

1.4 | Manic defense

One of the earliest psychological theories of mania was the manic defense hypothesis. It states that hypomanic behavior is a form of dysfunctional defense to ward of depressive thoughts, such as failure.[20] However, in the psychoanalytic tradition, the term 'manic defense' is not limited to BD but is seen as a broader concept for warding off internal ambivalence. More recently, an updated version of the manic defense hypothesis states that strong fluctuations in self-esteem can partly explain manic dysregulation as negative schemas are activated more easily, which makes people with BD more sensitive to negative information that is threatening to self-esteem or mood.[9]

1.5 | Positive Emotion Persistence (PEP)

Positive Emotion Persistence (PEP) refers to the more extensive pattern of pleasant emotional states that people with BD experience.[10] Positive emotions are predominantly positive self-focused emotions, such as pride and joy. The PEP theory describes that these emotions occur in BD in response to a wider range of positive, but also more ambiguous or negative stimuli and contexts, compared to people without BD. It also states that people with BD experience these positive emotions more frequently and with greater intensity. This specific vulnerability to positive emotion dysregulation is seen as an explanatory mechanism of the high risk of developing manic states in BD.

While the aforementioned theories contribute to our understanding of manic dysregulation, the empirical evidence is still limited. Despite the acknowledged significance of naturalistic studies, experimental studies are an initial, and somewhat overlooked and important step in formulating and refining psychological theories in BD. Therefore, the scope of this review is specifically focused on experimental study designs, in which manic mood dysregulation, and not depression, is examined. In order to interpret and validate results in the field of manic mood dysregulation, it is necessary to provide a comprehensive overview of how these studies are conducted. The aim of the current paper is to systematically review the experimental methodology that is used to test the theories outlined above. The main questions are: what is studied within the framework of each theory, how was it studied, and in which population? We provide an overview of research methods that have been used and suggest which methods should be replicated in future studies more systematically. Additionally, we aim to identify possible limitations of currently used methodologies and propose areas of improvement. This way, our objective is to contribute to a better understanding of how to study the psychology of mania and guide future fundamental research.

2 | MATERIALS AND METHODS

For the current review, we followed the PRISMA guideline for systematic reviews for all applicable items.[21] We chose to guide our search based on the six most relevant models on manic dysregulation known to the authors. This review was registered on PROSPERO international prospective register of systematic reviews with ID number: CRD42023253710.

2.1 | Eligibility criteria

Initial screening criteria were aimed at identifying studies on manic mood dysregulation, at least one of the theories, and study designs aimed at cause-and-effect relationships specifically. Because of this, only (quasi-)experimental research designs on one of the models mentioned were included. Experimental designs are controlled tests to objectify the relationship between two variables. Experiments manipulate a predictor variable and test what is the effect of the predictor variable on an outcome variable that is hypothesized to be affected by the manipulated predictor variable. The predictor variable of an experiment is the proposed cause and the outcome variable the main effect that is expected.[22] Having BD or not having BD for example is a type of (quasi-)experimental variable that can be manipulated, as the study design evaluates the effect of a manipulation (experimental), but groups could not be assigned randomly (quasi).

In this review, only studies on bipolar spectrum disorder were included. The population that was included in this review was either clinical groups with BD, at-risk groups (e.g. genetic risk), or non-clinical groups in which a BD relevant predictor variable was used to identify group differences (e.g. high HPS vs. low HPS group or a mood induction task related to BD). We chose to included non-clinical groups as well as commonly first phases of fundamental research are initially performed in a healthy population. The idea of experimental designs is to standardize the entire test procedure, in order to detect the effect of the manipulated variable that is different between groups. Studies with 'indirect' evidence, such as intervention or validation studies were therefore excluded. Reviews, book chapters, editorials, and conference papers were excluded as well. Language was restricted to English, and the year of publication was not restricted. All studies were screened for eligibility by two independent reviewers. Studies were grouped for syntheses based on the explanatory theory.

2.2 | Information sources

Databases searched were PubMed, Embase, APA PsycInfo, Web of Science, and Scopus. These databases were searched from inception to October 11, 2023. An additional search in gray literature, Google Scholar, resulted in 21 articles.

2.3 | Search strategies

A specific search strategy was constructed for each database (see Appendix A). Each search string entailed a combination of all of the models (BAS, RST, ICM, PEP, MI, or manic defense). The models were combined (AND) with a search string aimed at bipolar spectrum disorder in order to, for example, exclude articles that were solely aimed at depressive or psychotic disorders. During title and abstract, and full text, screening articles exclusively aimed at depression in BD, and not mania, were excluded.

2.4 | Selection process

Duplicates were removed after the final search. The final set was transferred to an excel file and divided into three sections. Each section was screened independently, based on eligibility criteria, by one of the authors (MK, RK, ER) and RG was the second reviewer for all studies.

2.5 | Title and abstract screening

All selected articles were screened based on title and abstract in separate excel files. Articles were excluded based on the following criteria: language other than English; aimed at a non-BD population or not aimed at manic mood specifically; did not perform experimental research with humans (e.g. evidence based on the narrative of one patient, or research on mice); aimed at a different research area than psychology (e.g. pharmacotherapy); book chapter, conference abstract, or review. Only when both authors independently marked an article as having met one of the exclusion criteria, it was excluded during title and abstract screening. All other articles were screened in full text.

2.6 | Full-text screening

Exclusion criteria remained the same during full-text reading. Discrepancies were resolved by discussion, and in case of final discrepant judgments, the entire review team was involved. The final screening process is shown in Figure 1.

2.7 | Data collection process

An excel file designed for this study was used to extract data systematically from the remaining studies. The primary results for this review contained the following study characteristics: theoretical model, methods (e.g. fMRI or self-report questionnaires), main predictor, and outcome variable. All of these essential characteristics were independently collected by two reviewers in two excel files, and then combined. Discrepancies were resolved by discussion. Secondary results were as follows: diagnosis of research and/or control population, size of population, behavioral tasks, physiological measures, domain and the operationalization of the predictor and outcome variable. For feasibility reasons, the secondary results were retrieved by one reviewer (RG) and were, not independently, checked by a second reviewer (ER, MK, RK).

Synthesis of study variables resulted in categories based on four psychological domains as well: the behavioral, affective, neuropsychological, and cognitive domain. The domain was based on a combination of method and the predictor variable. For example, a study was categorized under the neuropsychological domain if they used EEG and fMRI methodologies and in the behavioral domain if a study design involved a predictor variable that assessed a change in observable behavior. All assimilated data were entered into the excel file (see Refs. [23–105] in Appendix B for all data items).

3 | RESULTS

After duplicates were removed, 642 studies were identified. Of these studies, 84 met the inclusion criteria and were eligible for full data extraction. An overview of the process of study selection is depicted in Figure 1.

The full scope of all studies based on primary variables on methodology and design included in this review is shown in Table 1. As can be seen in the table, most experimental research was aimed at BAS or RST (75%). There were 17 studies that combined two theories, which were mostly combinations of BAS and RST,[23] but also a combination of

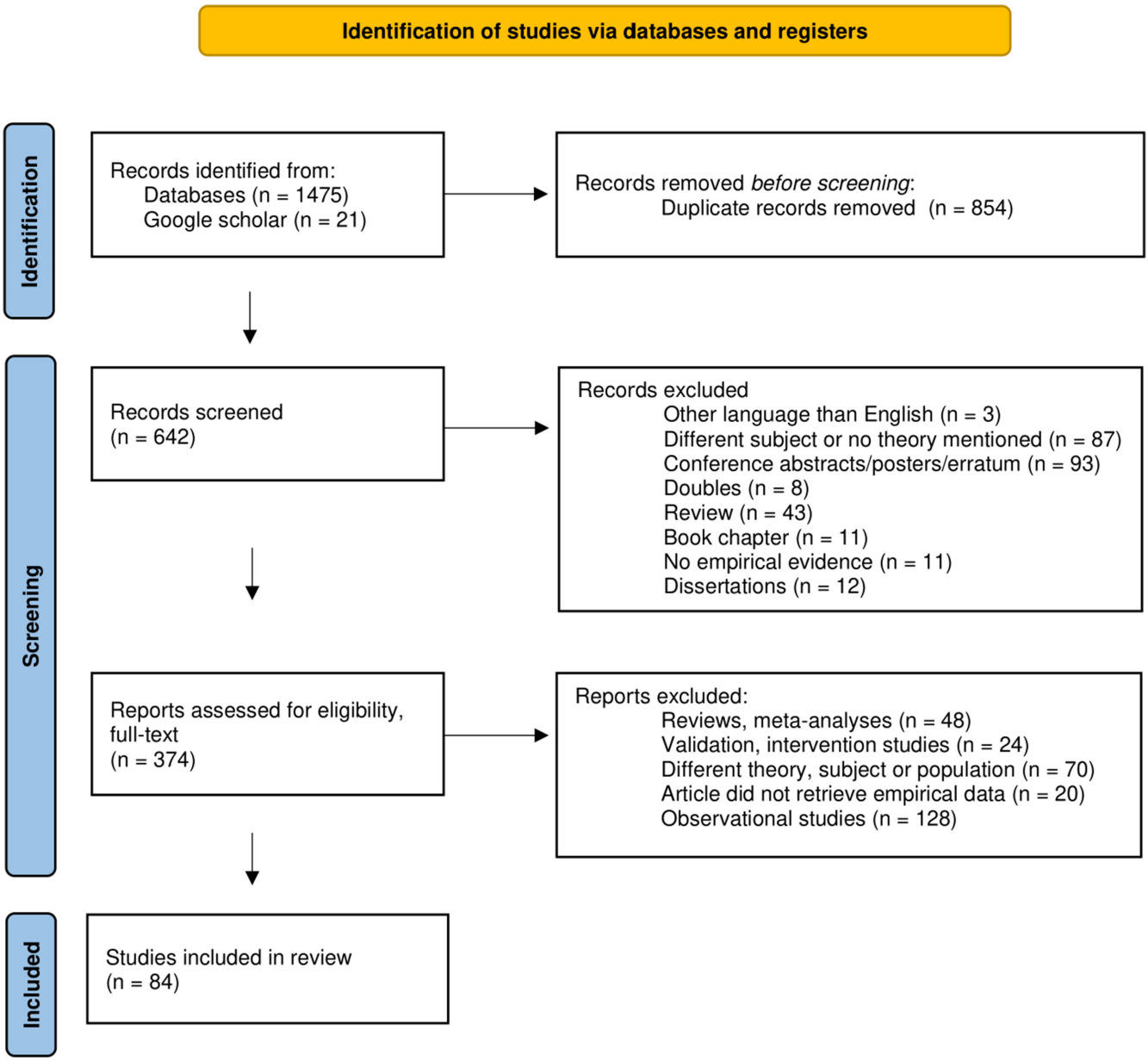

FIGURE 1 The PRISMA flow diagram for studies included in the review. Prisma Flow Diagram format is designed by Page et al.[21]

ICM and Mental Imagery,[24] and BAS and manic defense,[25] for example. Most studies ($N = 58$) were performed in a population with BD I or BD II as the predictor variable. All but two studies (98%) used a combination of a behavioral task with self-report questionnaires or a behavioral task during fMRI or EEG analysis. More rarely used methods were an additional mood induction (18%) or physiological measure (8%).

3.1 | Behavioral activation system (BAS) and reward sensitivity theory (RST)

Used methods in studies focusing on the BAS and RST were as follows: behavioral tasks (97% of the studies), self-report questionnaires (89%), fMRI (30%), EEG (16%), mood induction (13%), and physiological measures (3%). Proneness to BD or the BD risk group was relatively consistently (33%) measured with the BIS/BAS Scales[106] or the Hypomanic Personality Scale (HPS)[107] in 14% of the studies. Affective states were measured with the Internal State Scale (ISS)[108] in 14% of the studies, or with the Positive and Negative Affect Schedule (PANAS)[109] in 10% of the studies. Sensitivity to Punishment and Reward was measured in 10% of the studies with the SPSRQ.[110]

The predictor variable was most often a diagnostic classification (43%), for example BD versus HC (Table 1). Figure 2 shows the broad range of outcome variables that were used to measures the mechanisms described in these theories. Reward learning and (neuropsychological) responses to reward (both anticipation and receipt) were most often investigated. Most studies were performed primarily

TABLE 1 Summary table for six models on manic dysregulation for number of studies per theory, predictor/group variables, and methodology.

Total number of studies	Predictor/group variable	Methodology
Behavioral Activation System (BAS) hypersensitivity theory and Reward Hypersensitivity Theory (RST)		
63	BD versus HC[a] (27), proneness to hypomania or other BD trait such as impulsivity (19), BD versus other patient group (2) and HC (8), mood (7), genetic risk (4), age (2), BD versus HC versus unaffected first-degree relative (2)	Behavioral task (61), self-report questionnaire (56), fMRI (19), EEG (10), mood induction (8), physiological measures (2)
Mental Imagery		
11	Proneness to hypomania or other BD trait (5), BD versus HC versus other patient group (anxiety disorders/schizophrenia or MDD) (3), mood induction (1), genetic risk (2)	Behavioral task (11), self-report questionnaires (10), mood induction (5), fMRI (1)
Manic Defense Hypothesis		
6	BD versus HC (3), current mood (2), BD versus HC versus MDD (1), hypomanic personality style (1)	Behavioral task (6), self-report questionnaires (6)
Integrated Cognitive Model		
5	High hypomanic risk group versus low hypomanic risk group (3), BD versus HC (1), cognitive flexibility (1)	Behavioral task (5), self-report questionnaires (5), mood induction task (3)
Positive Emotion Persistence		
3	BD versus HC (2), BD versus MDD (1)	Behavioral task (3), self-report questionnaire (3), mood induction (2)

[a]Healthy control.

within the neuropsychological domain (44%) and in the behavioral domain (41%); fewer studies were based on an affective (10%) and cognitive (8%) paradigm.

3.1.1 | Neuropsychological domain

Studies within this domain are aimed at identifying neuropsychological differences associated with the reward circuit. Based on BAS/RST, it is expected that these studies would identify a neurocognitive response (in a reward-related brain area) while being confronted with (future) reward.

There were 28 studies within this domain of which 13 studies measured EEG or fMRI in response to reward anticipation and receipt. Within this domain, 24 of the 28 studies were aimed at some form of reward processing (either reward receipt or reward anticipation, or response to anger or loss). Positive urgency (the tendency to act rashly in response to positive emotions) was subject in only two studies. Decision making, risk taking, and vulnerability to mania or depression (in risk profiles based on activation in the left ventrolateral prefrontal activity in response to reward expectancy)[26] were outcome variables in one study each.

There were 15 different tasks used to measure elements of reward sensitivity during EEG or fMRI (see Table in the Appendix C). The Monetary Incentive Delay task (MID) or a different type of reward anticipation task was used in 15 of 28 studies. These types of reward tasks usually consist of a sequence of three visual stimuli, one for anticipation, one is the target, and one for feedback with either a gain, neutral, or loss condition. Success and feedback can be manipulated and brain activity in response to different reward conditions (e.g. anticipation in the task, responses to feedback, either win or loss) was measured. Although some of the tasks overlap between studies and there is more consistency than in the other domains, none of the studies was a pure replication of an earlier study.

3.1.2 | Behavioral domain

Studies in this domain are designed to detect changes in behavior, which would be expected based on BAS and RST theory. At a more behavioral level, BAS and RST models focus on heightened sensitivity to reward, the tendency to seek rewarding contexts, aim for higher goals, rash or risky decision making, and impaired reward learning.

There were 26 studies within the behavioral domain, of which eight studies investigated reward or punishment learning (the ability to adjust behavior based on reward or punishment) in BD samples ($N = 5$), in a high HPS sample, in a sample at familial risk for BD, and in a sample in which different pubertal stages in adolescents with mood disorder were compared. Closely linked to reward learning were seven studies that tested (high and low risk) decision making. There were five studies that investigated behavioral responses to reward and three studies were on delay of gratification (the ability to resist an immediate reward for the possibility to obtain a higher value reward and closely linked to impulsivity). Goal setting, one of the central tenets of the BAS theory, was measured in only two studies.

Specific measures that were used relatively consistently in behavioral paradigms were a Probabilistic Learning Task (for reward learning), the IOWA Gambling Task (IGT; for decision making), or

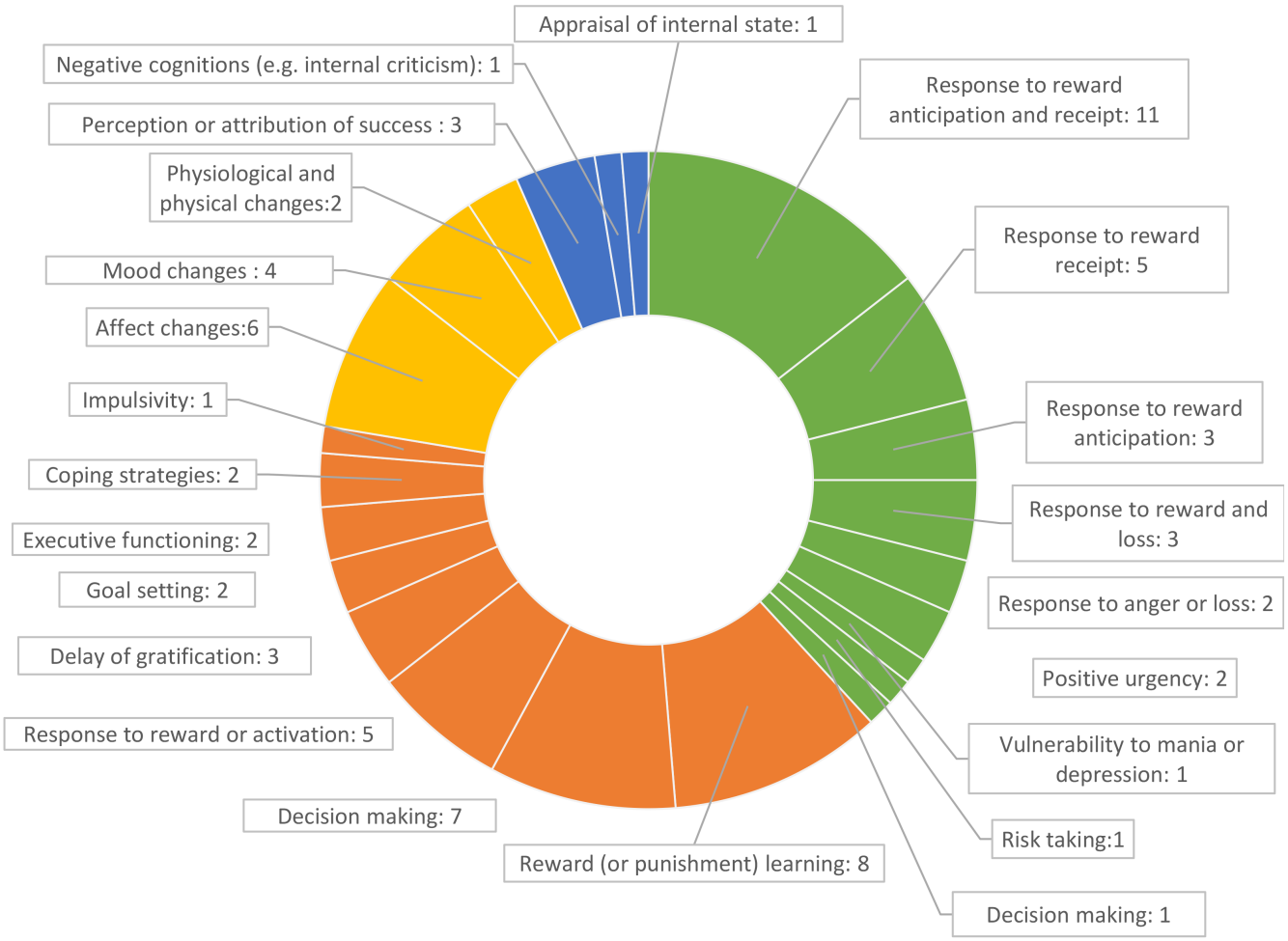

FIGURE 2 An overview of the main outcome variables in experimental studies on BAS and RST in different research domains. Green: Neuropsychological domain, orange: Behavioral domain, yellow: Affective domain, blue: Cognitive domain.

a Delay Discounting Task (for delay of gratification), see Table A. Studies that measured (physical) responses to activation or reward did this with various methods: with an antisaccade eye movement in an incentive reward task, a measurement of motor wrist activity, changes in reaction times (on a Point Score Reaction Test behavioral task) after introducing reward of punishment with money. Decision making was measured with the IGT in three studies, and in the other studies with a variety of tasks, like the Effort Expenditure for Rewards Task (EEfRT), the Wisconsin Card Sorting Test (WCST), and the Allais paradox. The outcome variable goal setting was operationalized by goal narratives (goal category, the involvement of others and the ambitiousness of the goal) and a VAS scale ('How successful do you think you will be on the next task, based on previous performance?').

3.1.3 | Affective domain

Studies ($N=12$) in this domain are designed to detect changes in affect (either mood or emotion) in response to reward. Based on BAS and RST, it is expected that people with heightened sensitivity to reward tend to experience more intense positive emotions in response to reward. Goal oriented affect can be characterized as happiness and hope,[12] confidence, elation, or excitement, but also frustration when rewards are not achieved.

Partly in line with this, most studies measured affective reactivity ($N=6$) in different groups (BD versus HC, a group with BD that were different in their willingness to pursue rewards based on the WASSUP, groups with high and low risk for BD, and a group with BD in different mood states) to specific triggers (mood induction, frustration during a task). Changes in mood symptoms during a longer period after the initial experiment was measured as well ($N=4$) in groups based on reward risk profiles measured with fMRI, BD versus HC and groups based on different impulsivity levels. In two studies, physiological and behavioral responses to activation or reward (vocal aspects such as pitch and frequency during a task in which participants had to imagine and describe a goal, and facial expressiveness) were administered.

Assessing a change in affect was often measured (see Table A), with VAS mood rating scales (e.g. 'How triumphant/threatened do you feel right now'?) or the Positive And Negative Affect Scale (PANAS). Mood symptoms were administered with semi-structured interviews, like the Exp-SADS or the MOODS. Five of the 12 studies

in this domain used a mood induction task, like watching an affective movie, to manipulate affective responses.

3.1.4 | Cognitive domain

Studies in this domain are designed to detect differences in cognitions related to reward. Based on BAS and RST, it is expected that people with high reward sensitivity show increased positive appraisal of rewards, different beliefs about success, and have different cognitive strategies to cope with reward or loss.

There were five studies that studied cognitive aspects of BAS and RST. The outcome variable in three studies was the perception or attribution of success, meaning how people (with BD correlated characteristics in these studies) attribute the reasons for their achievements, for example if these were internal ('it was because of my skills') or external ('the circumstances were right'). One study measured negative cognitions in the context of schemas, namely, whether parental- and self-criticism, and perfectionism, after negative feedback were associated with heightened BAS. Another outcome variable was delay of gratification.

Operationalization of the variables was different in these five studies. Attribution of success was administered with a belief update paradigm (a task in which participants are asked what the likelihood of a certain event in their life will be), an attribution questionnaire after mood induction, and VAS scales that measured success feedback ('Please check how successful you think you were on the task'). Appraisal of internal state was measured with a task in which participants had to create a sentence out of scrambled words. It was hypothesized that people with BD in remission would suppress sentences that signal upcoming manic phases, specifically in a reward condition ('I like doing risky things').

3.2 | Mental Imagery (MI)

Experimental research on MI focuses on imagery as a cognitive mechanism that amplifies emotion, which can be intensified positive but anxious emotion for example as well. MI in the context of BD states that people with BD are more image susceptible[15] and it is hypothesized that this quality is associated with increased mood dysregulation.

There were 11 studies on MI. The methodology used in MI studies was a behavioral task (100%), which was in almost all studies combined with self-report questionnaires (90%), sometimes preceded by a mood induction task (45%), or fMRI (9%). In these experiments, the predictor variable was most often proneness to hypomania or BD (45%), which was measured with the HPS or MDQ, see Table 1, or having BD compared to healthy controls and non-BD groups (27%). Figure 3 shows the main outcome variables that were used to study MI in BD. Most studies were focused on some form of emotional or affective reactivity after exposure to specific images. Most studies were performed primarily within the cognitive domain (73%) and in the affective domain (18%). Some studies had outcome variables in two domains, for example both cognitive and affective outcome measures.

3.2.1 | Outcome variables

There were four studies on memories in the cognitive domain, in which, for example, it was measured how many intrusive memories of a film shown during the experiment were experienced in the upcoming week. Four studies were on (one of the) cognitive aspects of imagery, like image generation or manipulation.[111] Two studies assessed the qualities of images, for example the vividness of the memory (either self-generated or seen in a video clip). Five studies measured affective aspects as well. Three studies were on emotional aspects of images, for example how strongly the images seen in the experiment had an emotional impact, and three studies measured mood or affective changes after (positive) image generation tasks, film or 'elated' mental imagery. One study used fMRI to measure functional connectivity of an emotional response to unpleasant pictures.

There were varying tasks that were used to operationalize imagery proneness, such as a memory recall task or an involuntary memory dairy. Cognitive stages of imagery were measured with a

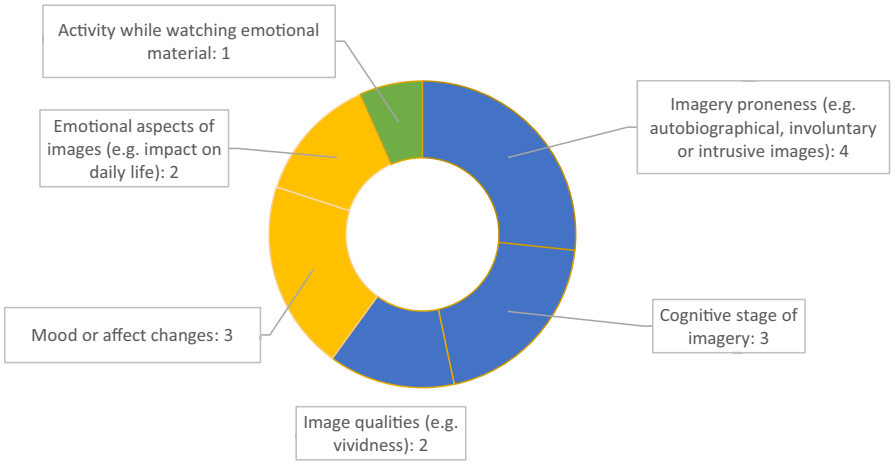

FIGURE 3 An overview of the main outcome variables in experimental studies on MI in different research domains. Blue: Cognitive domain, yellow: Affective domain, green: Neuropsychological domain.

type of Rotation Task. Imagery qualities were measured with self-rating scales and affect changes with the PANAS. Emotional impact of images was measured with the Mental Imagery Interview, which explores the image content of each mood state. Mood induction was often used in MI research, namely, in five of the 11 MI studies. Mood induction consisted of watching affective films or positive stimuli aimed at elation, followed by a measurement of one of the outcome variables. A common self-report questionnaire is the Spontaneous Use of Imagery Scale (SUIS)[112] as a measure of the use of mental imagery in daily life.

3.3 | Manic defense (MD)

Based on MD, it is assumed that people experiencing manic states are warding off depressive feelings with hypomanic behavior, because, in short, internal negative schemes are easily activated or felt. Research on manic defense, in the context of BD, studies implicit internal processes that occur during mood dysregulation.

There were six studies found on MD. The predictor group was most often a comparison between BD and HC (50%), or current mood (33%). One study was based on a comparison between BD, MDD, and HC (17%) and one study on scores on the HPS (17%). One study combined mood and BD versus HC. A behavioral task combined with self-report questionnaires was used in all designs.

3.3.1 | Outcome variables

All MD studies were based on a cognitive paradigm. Implicit or unconscious information processing was the main outcome variable in four studies, and attributional style in three studies. Activated negative schemata were subject in one study as well in which defensive depression avoidance was measured.

An emotional Stroop Task was a common measure of implicit information processing, and a scrambled sentences test and recall task was used as well. For attributional style, the Pragmatic Inference Task was used twice, as well as the self-reported Dysfunctional Attitude Scale (DAS). The DAS measures negative thinking style associated with depression.

3.4 | Integrative Cognitive Model (ICM)

ICM research studies the interpretation of changes in internal states. Appraisals of internal states in BD have been assumed to have more extreme personal meaning (e.g. success or weakness), which enhances behavior to either prevent or promote the internal state.[7] ICM studies this escalating cycle of internal appraisals, behavior and (hypomanic) mood.

There were five studies on ICM. The method used in all studies on ICM was a behavioral task, which was combined with self-report questionnaires, sometimes preceded by a mood induction task (50%). In these experiments, the predictor was most often a comparison between a BD high-risk group and a low-risk group (67%), which was measured with the HPS, Hypomanic Attitudes and Positive Predictions Inventory (HAPPI)[113] or the General Behavior Inventory (GBI),[114] or having BD compared to healthy controls and other patient groups (17%), or risk profiles based on cognitive flexibility (17%), which was measured with a conditional reasoning task. Most studies are performed primarily within the cognitive domain (60%), and some in the affective domain (40%).

3.4.1 | Outcome variables

Four of the five studies were aimed at identifying cognitive appraisal strategies, for example by examining whether the ability to give disabling counterexamples in a reasoning task predicted the use of more self-referent appraisals of internal states (e.g. 'When my moods drive upwards there is nothing I can do about it'). Two of the five studies measured changes in affect, for example by assessing whether the ability to (re)appraise would have an effect on affect after mood induction. In this study, it was observed how much bipolar-relevant (activated) behavior was present in an academic achievement interview after a failure induction task.

Cognitive appraisal was measured with Internal State Appraisals Task (ISAT),[115] HAPPI and free recall of a list of trait words in which these words had to be applied to either self or others. Changes in affect measured by observing bipolar-relevant behavior like pressure of speech and conversation domination during the interview. Also, physical and physiological measurements were used to assess changes in affect, by measuring facial expression during mood induction and skin conductance response, or with self-report (PANAS).

3.5 | Positive Emotion Persistence (PEP)

PEP states that positive (reward and achievement like) emotions increase more strongly in BD, and across a wider variety of contexts. PEP studies the intensity, type and context in which BD-related emotions occur.[10]

There were three experimental studies on PEP, of which two were combined with either BAS theory or ICM. The design of these studies was based on a behavioral task with a self-report questionnaire and two studies included a mood induction task as well. The predictor group was BD versus HC in two studies and BD versus MDD in one study.

3.5.1 | Outcome variables

Two studies were based on affective measures in which changes in affect were measured after mood induction. One of these studies included a self-report measure of emotion regulation strategies as well. The mood induction task consisted of watching affective movie

clips. In one study cognitive control, the ability to resist distraction of irrelevant signals to maintain focus on a task was measured after watching affective pictures.

4 | DISCUSSION

The purpose of this study was to systematically review the main psychological theories of bipolar mood dysregulation and the methods that have been used to test these theories in experimental studies. The most important findings were that the BAS sensitivity theory and the RST model were the most frequently studied, whereas the manic defense theory, mental imagery, ICM, and PEP were relatively understudied in comparison. Additionally, no direct replication studies were identified for any of the theoretical frameworks, which illustrate the heterogeneity of these study designs. While there appears to be consensus on the one hand about the measurements used to assess bipolar disorder itself (standardized interviews and symptom questionnaires) and bipolar characteristics (using questionnaires such as the BIS/BAS questionnaire or Hypomanic Personality Scale (HPS)), the core mechanisms of the different theories on the other hand are tested with a wide range of different tasks and tests. Below we will summarize the most important findings and our recommendations.

This review showed that the content of experimental research was most frequently aimed at the BAS sensitivity theory and RST, with a predominant emphasis on neuropsychological and behavioral mechanisms. Neurological response to reward anticipation and receipt, and behavioral response to reward or activation, were the most commonly used outcome variables to test BAS or RST. The use of the Monetary Incentive Delay (MID) task or similar tasks during fMRI or EEG that investigate brain responses during or in the anticipation phase of reward proved to be a relative consistent method in most studies. However, other aspects of reward received less attention. For instance, most designs focused on mechanisms of reward sensitivity, but it seems that there is a lack of methods that can be used to test other important elements of these theories, such as goal setting and—attainment, situation selection (avoidance or approach), affective/emotional/physiological reactivity, and regulatory strategies. Naturalistic studies have given important suggestions about how manic symptoms might arise when these features are taken into consideration. For instance, Johnson et al.[116] showed increases in manic symptoms after the attainment of an important goal, with the additional feature that bipolar individuals continue to attempt to increase positive affect after goal attainment with increased goal pursuit, whereas individuals without BD tend to aim for some moderation of the positive affect, for example by 'coasting'. It is important to design experimental studies that include all these different elements to validate such causal mechanisms. Mood induction, goal setting tasks and the use of physiological measures (to directly measure activation for instance) could be suitable to elicit and measure changes in affective and activated states, but they are currently underrepresented methods.

Although the BAS and RST models are relatively well studied in experimental settings, and led to important knowledge on specifically reward sensitivity in BD, the other psychological models (the ICM, MI, PEP, and manic defense) are relatively understudied. These four models are all essentially (cognitive) emotion or affective regulation theories, in contrast to the behavioral and neuropsychological underpinned BAS/RST. They aim to describe the unique way that BD patients induce, respond to and regulate affective states. Studies into these mechanisms heavily depend on mood induction designs and often used self-report to measure internal regulation or appraisal strategies in the subjects. When considering important emotion regulation models like Gross's model however,[117] it becomes evident that exploring other strategies is important for a more comprehensive understanding of emotion regulation abnormalities. In the studies that we reviewed, there is an overall focus on response-focused strategies like cognitive change and response modulation (strategies that are used once the affective state has already begun). However, strategies that anticipate affective change, like situation selection and situation modification, are important elements that are not taken into account in the current experimental models. Additionally, studies into these four models (ICM, MI, PEP, and manic defense) rarely used more 'objective' methods like EEG, fMRI, or physiological measures to investigate affective reactivity. Physiological measures, like heart rate and heart rate variability, are a viable, additional, method to detect affective differences like arousal and excitement.[118] They have an important advantage over self-report measures, like the PANAS, because they assess changes more quickly, directly and objectively.

Furthermore, most research designs are not specifically aimed at manic mood dysregulation specifically but on BD as a whole. The predictor variable or 'the proposed cause' in most studies was a comparison of an euthymic patient group with BD and a healthy control group. This consequently means that most study findings are based on a difference in diagnostic classification, for example 'people with BD were more reward responsive than people without BD on a certain task'. Even though this does provide valuable information about the population with BD in general, it does not allow for cause-and-effect findings on manic mood dysregulation specifically. Studies are more often aimed at the question: 'how does an euthymic patient group with BD respond to a certain manipulation?', than 'what drives mood up?'. The latter question is especially relevant with regard to manic dysregulation.

There also seems to be an important overlap between the different models that were currently reviewed, with core elements such as upregulation of positive and activated affective states, appraisals of internal states, goal setting and pursuit, reward sensitivity, and impaired affective regulation. The field might benefit from a more comprehensive model that incorporates all these identified elements until now and can be further validated through experimental research.

A strength of this study is its methodological focus, guided by theoretical frameworks, aimed at providing a comprehensive overview of the research field. To the best of our knowledge, there are

only a few reviews[119] in different research areas that share a similar aim: to compare (research on) parameters of a fundamental psychological mechanism. The current review is the first in this field with a distinct aim for experimental designs, thereby synthesizing a large body of literature for comparative analysis of core principles. Because of the thorough literature search and the structured process of rating and selection, this review was able to give a very complete and rather detailed overview of all the experimental studies in this specific field and could therefore also identify important limitations in validation of psychological models in BD.

There are also some limitations to the current study. First, the reviews' search strategy might have led to exclusion of other relevant literature in this field. The search strategy was based on the theoretical frameworks the research group chose, which might have led to exclusion of relevant other (elements of) theories. It might also have led to exclusion of experimental studies that did not explicitly mention the theoretical framework in their article. By choosing to focus on experimental research, we might have excluded other (more ecologically valid) methods to study mania as well. A second limitation is that not all abstracted information from the papers was blindly assessed by two reviewers. For feasibility reasons, the research group chose a different strategy to enlarge reliability, namely, to review all primary variables double-blind and to review all secondary variables by checking the input from the first reviewer by the second reviewer.

5 | CONCLUSION

The BAS and RST models are the most extensively studied psychological theories with a focus on reward receipt and anticipation. These areas are mainly explored from a neuropsychological and behavioral perspective. Within the theories reviewed, we found important overlap with key elements such as goal setting and pursuit, reward sensitivity, upregulation of positive and activated affective states, and impaired affective regulation. However, other psychological models (ICM, MI, PEP, and MD), and most specifically mechanisms such as goal setting, and attainment, situation selection (avoidance or approach), activated states, affective/emotional reactivity, and regulatory strategies remain relatively understudied. Attention to these aspects might lead to the development of a more comprehensive model. A second recommendation for advancing research in this field is the development of a standardized battery of tests to reduce variability in outcome variables, enhancing comparability and guiding future research. Third, despite practical and ethical research difficulties, an emphasis in designs on manic mood dysregulation besides the sole BD diagnosis is necessary. Mood induction and physiological measures are currently underrepresented methods, but might provide added value in objectively testing affect. Fourth, as a research area that has its practical obstacles, it is recommended to openly share data where possible to enhance statistical power. Fifth and finally, establishing a shared future research agenda is crucial for increasing comparability in the field, representing the next step toward understanding bipolar mood dysregulation from a psychological perspective.

CONFLICT OF INTEREST STATEMENT

We have no known conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

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