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RESEARCH ARTICLE

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Do you feel up when you go up? A pilot study of a virtual reality manic-like mood induction paradigm

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Abstract

Objectives: In order to understand the working mechanisms of mania, it is necessary to perform studies during the onset of manic (-like) mood states. However, clinical mania is difficult to examine experimentally. A viable method to study manic mood like states is mood induction, but mood induction tasks thus far show variable effectiveness.

Methods: In this pilot study, a new paradigm to induce mood through virtual reality (VR) is examined. Both state characteristics, namely changes in emotion, and trait characteristics, such as high and low scores on the hypomanic personality scale (HPS), were measured in 65 students. These students participated in either a neutral VR mood induction or an activating VR mood induction in which excitement, goal directedness, and tension (being aspects of mania) were induced. All participants performed a risk-taking behavioural task, Balloon Analogue Risk Task (BART).

Results: The experimental VR task induced excitement and tension. In participants with higher sensitivity to hypomanic personality (HPS), irritation increased in response to activation whereas it decreased in the low HPS group, and excitement increased more steeply in the low HPS group. There were no effects on the behavioural task.

Conclusions: The VR task is effective in inducing relevant state aspects of hypomania and is suitable as a paradigm for future experimental studies. Activation of dual affective states (excitement and tension) is an essential aspect in manic-like mood induction paradigms.

KEYWORDS

excitement, mania, mood induction, reward hypersensitivity theory, virtual reality

Practitioner points

- New method to study psychological mechanisms involved in (hypo)manic mood dysregulation.
- Insight into the pattern of emotional reactivity for people that were more sensitive to manic dysregulation, specifically for emotions such as excitement and irritation.

INTRODUCTION

In the past two decades, there has been growing attention for psychological mechanisms that may contribute to the increased sensitivity to affective instability in bipolar disorder (BD). BD is a mental illness characterized by extreme mood fluctuations and ongoing affective instability, also known as episodes of depression and (hypo)mania. Since depressive symptoms occur in many mental disorders, (hypo-) manic mood state is the most distinctive characteristic of BD (Kessler et al., 2003) and there is particular interest in factors associated with the sensitivity to this increased state of elation and energy. Most research is aimed at people with BD in euthymic state, and only little research is aimed at individuals in a (hypo)manic state. To include individuals with clinical (hypo)mania in an experimental study is challenging, both practically and ethically, so other methods must be developed to study this mood state. It is necessary to perform studies during manic (-like) mood states in order to distinguish trait from state characteristics of BD and to gain insight into the possible working mechanisms of manic mood as well.

A viable way to investigate mechanisms of manic mood dysregulation is through mood induction. Since it is unethical and undesirable to induce a full-blown manic state in an individual with BD, this line of work is often aimed at subclinical groups, usually comparing affective reactivity in healthy subjects with BD-associated characteristics, compared to subgroups without these characteristics. Often a specific mood state is induced to investigate these affective mechanisms. For instance, in a recent study by Vannucci et al. (2022) subjects with either high or low hypomanic-like experiences, as measured with the Mood Disorder Questionnaire (MDQ; Hirschfeld et al., 2000), were exposed to either an 'elated' or 'calm' mental imagery condition. During the imagery task participants were asked to generate vivid images. The high-MDQ group reported more affective reactivity after the positive imagery condition compared to the low-MDQ group. This and other studies illustrate that mood induction is a method that is particularly relevant in examining the association between BD-associated mood states and psychological mechanisms, such as reward sensitivity, impulsivity, and risk taking, and might help elucidate whether these are state or trait features (Roiser et al., 2009). However, regarding the designs of these studies there are four methodological issues that need to be taken into account.

First, what kind of affective state characteristics do we induce if we want to approximate a manic-like mood state? The typical description would be 'euphoria' or an extreme state of happiness and energy. However, increasing evidence points towards the dual nature of mania, including both hedonically pleasant (e.g., euphoria, increased energy, confidence, and goal-directedness) and unpleasant symptoms (e.g., racing thoughts, irritability, and even anxiety) (Benazzi & Akiskal, 2003; Carpenter et al., 2020). Thus, mania could be described as an excited, energetic state with increased drive and goal directedness that also includes feelings of tenseness or irritation. This means that mania is a multifaceted affective state, and thereby complex to induce. In previous mood induction studies on BD mechanisms often only one or two elements of the manic-like state were induced. For instance, there are studies that focus on inducing a happy, excited, or positive state by using video clips (Hayden et al., 2008; Pyle & Mansell, 2010; Roiser et al., 2009; Van Meter & Youngstrom, 2016) or a more goal-directed activated state through exercise or positive feedback (Dodd et al., 2013;

Lowenstein et al., 2015). One study by Davies et al. (2012) induced a broader spectrum of affective states by showing different video clips containing manic themes such as elevated or expansive mood, inflated self-esteem or grandiosity, heightened energy, decreased need for sleep, goal attainment, and thrill seeking. However, none of these studies were able to induce dual facets of mania at the same time in the same study.

A second methodological issue is how the desired affective state can be established without interference of the experiment itself. Self-report questionnaires pre- and post-mood induction are an effective and common method to assess affect, but these are always a reflection of the subjective experience of the participant. More objective measures to measure the effect of affective states are true (changes on) behavioural tasks. Pyle and Mansell (2010) have done this in their study in which performance on cognitive tasks was observed in two groups: with and without mood induction. However, in this study the mood induction failed, so mood-related changes on the tasks could not be identified.

A third methodological issue is how trait characteristics, factors that are both stable and group or person-related, have an effect on state effects, such as affect and behaviour. In line with the Behavioural Activation System (BAS) hypothesis (Alloy & Abramson, 2010) and the Reward Hypersensitivity Theory (RST), which states that people with BD have a more sensitive reward system, it is expected that people with bipolar trait characteristics will show more risky behaviour and higher goal setting when mood is elevated. In line with this, it can be expected that people with a higher risk for developing hypomania, as often measured by the Hypomanic Personality Scale (HPS), will be more inclined to respond with more hyperactivity, recklessness, euphoria, and frustration in an activated state.

A fourth methodological issue is how manic-like mood states are most effectively and safely induced. Both in the general literature and in the bipolar field, the most commonly used method is mood induction through a brief video clip, of which the content reflects the desired affective state. According to a recent meta-analysis this also appears to be the most effective mood induction method (Joseph et al., 2020). However, in the small number of studies that attempt to induce manic-like affective states, the mood induction did not have any effect on affective state (Pyle & Mansell, 2010) or did not show the expected effect (Van Meter & Youngstrom, 2016). A successful method that has been used in the bipolar field specifically is imagery: a task in which participants have to vividly imagine a certain image (Vannucci et al., 2022). The use of manipulated positive feedback (positive feedback irrespective of the actual performance) after specific performance tasks, was shown to be successful in one study (Roiser et al., 2009) but not in another (Dodd et al., 2013). One of the reasons that manic-like states are difficult to induce with these methods might be because mania is typically an activated, energetic state, while most mood induction methods are quite passive (e.g., watching a clip or performing a repetitive task). Ideally, a mood induction task combines activation with achievable but difficult goals and positive experiences, mixed with some negative feelings like tension.

Our pilot study investigates whether virtual reality (VR) is an effective and more appealing method to induce a more complex manic-like affective state. The benefit of VR compared to more traditional mood induction methods is that it allows for more immersive experiences since the participants engage in multifaceted affective content through multiple sensory modalities in a controlled setting (Bernardo et al., 2020; Chirico & Gaggioli, 2019).

Given the aforementioned issues in mood induction research, our study introduces a method to induce manic-like mood. We introduce an activating VR mood induction task in which we aimed for induction of excitement, irritation, and tension while trying to achieve and succeed in reaching a difficult goal. The primary aim of the current study is to investigate whether the VR task induces the desired mood state, measured through self-report and performance on a reward task (state effects). A second aim is to investigate whether specific BD-associated characteristics (measured with HPS) lead to increased affective reactivity or differences in performance on the reward task (trait effects). In this way, this experiment includes the dual nature of targeted affective states, adds virtual reality as methodology, and trait factors and behavioural outcome measures to the design.

MATERIALS AND METHODS

Participants

Participants were 65 students (70.8% female) between 18 and 31 years old ($M = 22.12$, $SD = 2.8$). Students were recruited via flyers and digital invitations and signed up via Sona Systems® (credit platform). Exclusion criteria included a lifetime diagnosis of any mood disorder or having used drugs or alcohol in the 12 h prior to the experiment. Upon completion participants were granted either .5 course credit or €4 as compensation plus the amount of money they gained during the experiment.

Procedure

On arrival at the laboratory, participants received written information and gave informed consent. Prior to the VR mood induction, participants completed the self-report measures. In order to determine baseline emotion, the last self-report measure before the mood induction task was the Visual Analogue Scale for emotion (T0). All participants were randomly assigned to either a neutral VR task or an excitement-inducing VR task. After the VR glasses were adjusted by the test leader and controllers were given, the mood induction VR task started. The VR task took 5 min on average. After completion of the VR task, T1 of the VAS scale and the behavioural task were completed. The total duration of the study procedure was 30 min. After completion participants were debriefed and received course credit or money. Figure 1 shows the study procedure.

Measures

To establish whether participants met the inclusion criteria, a short questionnaire was designed. Participants were excluded if they had received psychological treatment (lifetime) for a mood disorder (depressive disorder or BD) or if they had used drugs or alcohol in the 12 h prior to the experiment. Demographic characteristics (age, level of education, and gender) were collected. Experience with VR was assessed on a rating scale. Participants were asked how much experience they had with VR. The options were: 'no experience at all', 'I used VR once or twice', 'I used VR between 3 and 10 times' or 'I have my own VR glasses and/or used VR numerous times'.

Mood symptoms

The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) was administered to identify anxiety and depression symptoms. The HADS is a 14-item self-rating measure for symptoms in the last week. Scores range between 0 and 21 for the anxiety or depression scale. An average score of 8 or higher indicating the possibility of depression or anxiety. Internal consistency is in previous studies found to be $\alpha = .83$ on average for the HADS-A subscale and $\alpha = .82$ on overage for the HADS-D subscale and concurrent validity is good to very good (Bjelland et al., 2002). The HADS is found to be a useful screening instrument for depression and anxiety symptoms (Bocéréan & Dupret, 2014).

Mania symptoms were assessed with The Altman Self-Rating Mania Scale (ASRM; Altman et al., 1997), which is a self-report questionnaire assessing the key features of mania: elevated mood, inflated confidence, decreased need for sleep, excessive physical activity, and talkativeness. Participants respond to each of the five items by choosing one of five statements that fits their current mood best (i.e., from 'I do not talk more than usual' to 'I talk constantly and cannot be interrupted'). Scores range from 0 to 20, with a score of >6 indicating the possibility of a current (hypo)manic state (Altman et al., 1997). The ASRM is a widely used instrument and has been shown to have adequate internal

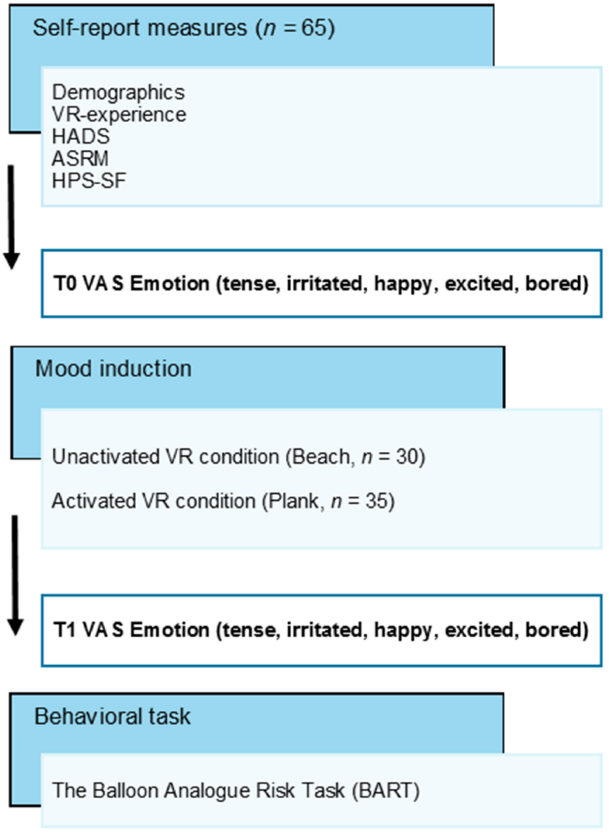

FIGURE 1 Study procedure.

consistency (Miller et al., 2009). Test–retest reliability is significant for the ASRM, $r = .86$, and the ASRM correlates significantly with other measures for mania symptoms ($r = .718–.766$; Altman et al., 1997). Sensitivity to correctly identify acute mania symptoms when participants score above the cut-off is 93% (Altman et al., 2001).

Hypomanic personality

To assess personality characteristics that are associated with vulnerability for mania, the Hypomanic Personality Scale—short form (HPS-SF) was completed. The HPS-SF consists of 20 true–false items capturing positive affect, energy, extraversion, and goal-driven behaviour. People with high hypomanic personality traits are at a higher risk for developing a (hypo)manic episode (Kwapil et al., 2000). Eckblad and Chapman (1986) showed that more than 75% of people with a high HPS score (two standard deviations above the mean) met criteria for a hypomanic episode. A high score on the HPS(-SF) thus corresponds with high mania proneness. Examples of the items of the HPS-SF are: 'I often feel excited and happy for no apparent reason'; 'I often have moods where I feel so energetic and optimistic that I feel I could outperform almost anyone at anything'; and 'There have often been times when I had such an excess of energy that I felt little need to sleep at night'.

Test–retest reliability and internal consistency are high (see Eckblad & Chapman, 1986; Klein et al., 1996). In our study, we chose to divide the group in a 'low-sensitive' group with HPS scores <9. This is in accordance with previous studies (Pyle & Mansell, 2010). The other group with scores ≥9 was categorized as a 'high-sensitive' group in this study. The latter categorization differs from other studies, but was chosen for practical reasons as there were no scores above 16 on the HPS in our group. Cronbach's alpha in the current sample was $a = .71$.

VAS—emotional responsiveness (state-dependent measure)

A visual analog mood scale (VAS) was used to measure the effect of the mood induction. The current emotional state was rated using a visual bar that ranged from 0 ('not at all') to 100 ('very much'). The bar indicated how much participants experienced relevant emotional states at that moment. Participants rated themselves on their level of excitement, boredom, irritation, tension, and happiness. As mood induction effects can rapidly decline (e.g., Frost & Green, 1982) it was essential to assess emotional responses as quickly as possible. Participants filled out the VAS before (T0) and right after (T1) mood induction. By subtracting T0 from T1, mood change following the mood induction was measured. In order to assess internal states quickly, VAS scales have been proven to be useful in patient and research settings (Stern et al., 1997). VAS scales are thought to be a time-efficient way to monitor changes in internal states (Killgore, 1999; van Rijsbergen et al., 2012).

Mood induction

Participants were randomly assigned to either the experimental or neutral mood induction VR task. In the neutral condition, participants sat on a wide and empty beach, and they were instructed to look at their surroundings. The experimental mood induction task, referred to as the activated condition, was based on the idea that mania is a multifaceted state that can be described as an excited, energetic state with increased feelings of drive and goal directedness, and that also includes feelings of tenseness or irritation. To achieve this type of state, the VR app '*Richie's plank experience*' (developed by Toast Interactive, 2017) was used. In this task, participants found themselves in an urban environment in VR. They were asked to step into an elevator where they pushed the button to reach the highest level. Here, the doors opened and participants saw a plank overhanging the city at an extreme height of 80 stories. The plank was approximately 1.5 m long and was attached to the exterior of the elevator. A cake was placed at the end of the plank, and the experiments' task was to walk over the plank, get a piece of cake using the controller and return to the elevator. After that, the elevator doors closed and the participant returned to the ground floor. Participants were then informed they completed the task correctly. Throughout both mood induction tasks, a test instructor was present in the room who could assist the participant, if necessary, and ensure participant's safety.

Behavioural task

The Balloon Analogue Risk Task (BART; Lejuez et al., 2002) was used to assess behavioural changes after the different VR conditions. The BART is a computerized behavioural task that assesses impulsivity in a reward context. This task has been used before to investigate risk taking and impulsivity in BD (Hidiroglu et al., 2013; Holmes et al., 2009). At the start of the BART, the computer screen displayed a small balloon accompanied by a balloon pump, a reset button, a 'Total Earned' display, and a second display labelled 'Last Balloon' that denoted the points earned on the last balloon. Participants had to click on the pump to inflate the balloon. With each pump, the balloon was inflated by 1° and points were accumulated in a temporary bank. The explosion point of each balloon varied, and with each pump chances of a burst would increase slightly, with an average break point of 64 pumps. The first pump had a probability to burst of 1/128, the second pump a chance of 1/127, and so on. When balloons were pumped past their individual explosion points, the computer produced a bursting sound, and all points in the temporary bank for that balloon were lost. At any point during each trial, a participant could stop pumping the balloon and click the 'Collect $$$' button. This transferred all money from that trial to the permanent bank, while a slot machine payout sound played. Each successive pump on any trial increased the amount to be lost due to an explosion and decreased the relative gain of any additional pump. Data were collected on mean amount of puffs, bursts, amount of time spent, and mean amount of money earned.

Data analysis and statistics

For the main effect of the mood induction task, an independent samples t-test was used. An ANOVA was performed to compare mood induction effects for the low and high HPS group. Effects of mood induction on risky behaviour were investigated in two ways. First, we conducted an independent samples *t*-test on the number of non-burst puffs in the BART task as done by Lejuez et al. (2002). We also conducted tests for correlation between the number of non-burst puffs in the BART task and the post-induction mood scores.

RESULTS

Baseline measures

Means and standard deviations for the measures in both VR conditions are shown in Table 1. The mean score on the HADS-D was 3.38 (SD = 2.57), which is relatively low. The mean score on the ASRM was 5.12 (SD = 3.02), and 17 participants scored above cut-off score for the ASRM which can be interpreted as a relatively high score for the ASRM. However, since all participants were screened before inclusion on whether they have had received treatment for any mood disorder, it is unlikely that some participants were currently in a mood episode. Also, between both VR conditions, there were no significant differences in depression symptoms and (hypo)mania symptoms. There were no differences on the HPS-SF between both VR conditions and the baseline measure of intensity of five emotions on the VAS. Experience with VR was 'none' to 'almost none' for 58 of the 65 participants. The other seven participants had used VR between 3 and 10 times in total, of which two participants owned VR glasses or used VR numerous times. Average HPS-SF scores were 8.06, with a maximum score of only 16. In most studies, a score of >35 (Eckblad & Chapman, 1986) is considered to be a high-risk HPS group.

TABLE 1 Demographics and pre-measures for the neutral (beach) VR condition and the activated (plank) VR condition.

	Neutral VR condition (n = 30)		**Activated VR condition (n = 35)**	
	M	***SD***	***M***	***SD***
Age (years)	22.43	3.07	21.86	2.56
Gender				
Male		7		11
Female		23		23
Other		0		1
HADS-A	7.10	2.94	7.00	3.55
HADS-D	3.67	2.80	3.14	2.37
ASRM	4.80	2.63	5.57	3.31
HPS-SF	8.23	3.29	7.91	3.67

Abbreviations: ASRM, Altman Self-Rating Mania Scale; HADS-A, hospital anxiety depression, subscale-anxiety; HADS-D, hospital anxiety and depression scale, subscale depression; HPS-SF, Hypomanic Personality Scale—short form.

State effects

The mood induction task had an effect on experienced emotional intensity of different manic-like emotions. The results showed that participants in the activated condition experienced a larger increase in excitement, $t(63) = -4.66$, $p < .001$, $BF_{10} = 1071$, and tension, $t(63) = -4.68$, $p < .001$, $BF_{10} = 1127$, compared to the participants in the neutral condition, see Figure 2. Participants in the activated condition also showed a significantly larger decrease in boredom compared to the neutral condition, $t(63) = 3.50$, $p < .001$, $BF_{10} = 35.3$. There were no overall differences in the change of irritation and happiness between both conditions. Also, the results showed no differences between both VR conditions on the BART's measures of risky behaviour: the mean amount of puffs, bursts, amount of time spent, and mean amount of money earned. There were no significant correlations between the different post-induction mood measures and the mean amount of non-burst puffs.

Interaction effects for trait characteristics

Interaction effects for specific 'bipolar' trait characteristics were investigated by dividing participants in high- and low-sensitive (to hypomanic personality) groups based on their HPS score. The analysis showed that there were two interaction effects for the HPS groups of their emotional response to the mood induction. First, even though intensity of irritation did not change significantly between both conditions, a significant interaction effect for HPS group × VR Condition for change in intensity of irritation, $F(1, 61) = 6.81$, $p = .011$, $BF_{incl} = 4.57$, was found, see Figure 3. In the activated condition, irritation increased in the high HPS group, but decreased in the low HPS group. Second, there was an interaction effect for HPS-group x VR Condition for change in intensity of excitement as well, $F(1, 61) = 6.00$, $p = .017$, $BF_{incl} = 3.37$, see Figure 3. Excitement was

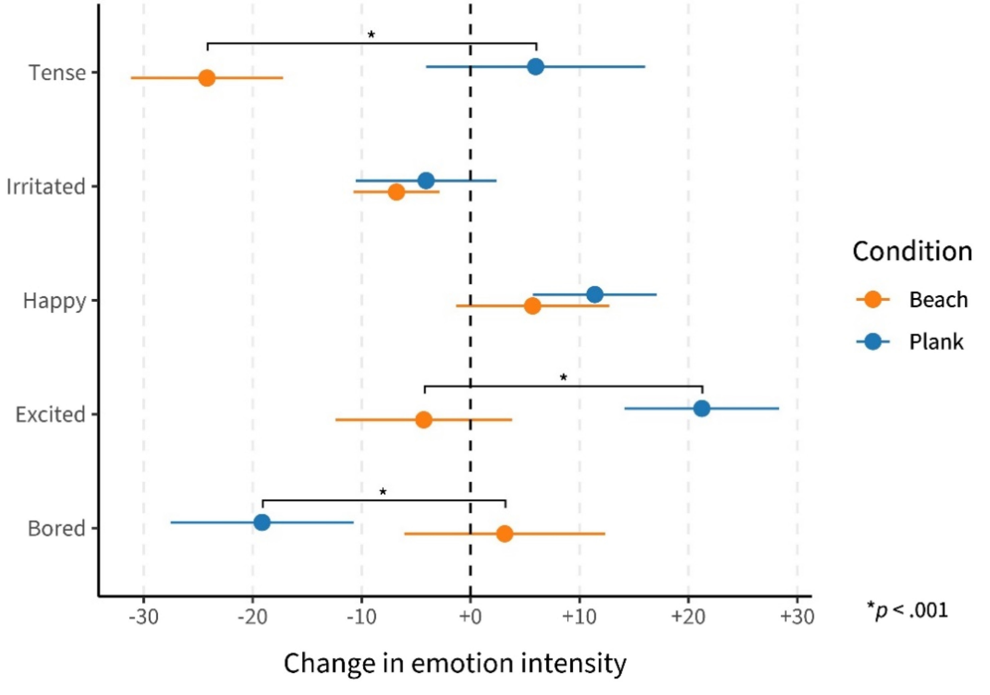

FIGURE 2 Changes in intensity of emotion, measured pre- and post-mood induction, for the activated (Plank) and neutral (Beach) VR condition. Extending lines indicate 95% CI.

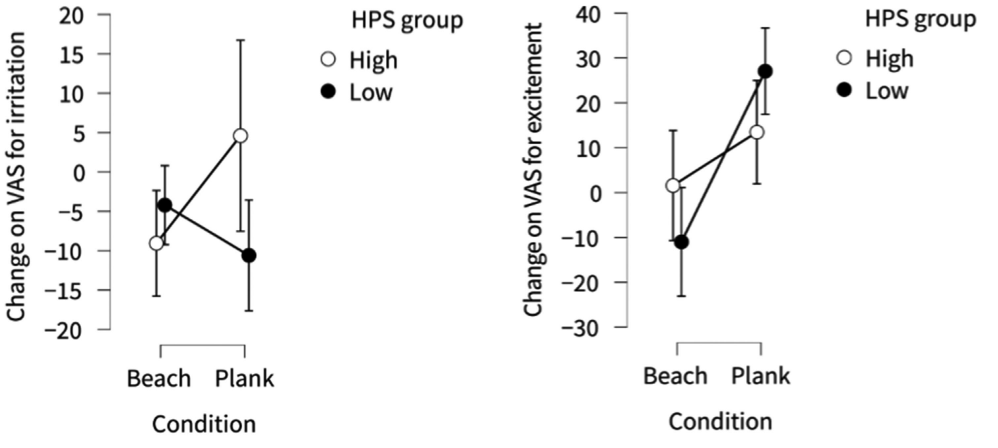

FIGURE 3 The interaction effect for changes in intensity of emotion between both VR conditions and HPS groups. Error bars indicate 95% CI.

higher at baseline in the high HPS group, $t(46.24) = -2.10$, $p = .041$, $BF_{10} = 1.75$ (suggesting data insensitivity) but surprisingly the increase of excitement was steeper in the low HPS group. This means there was a significant difference in the change in excitement between the low HPS group in the neutral versus activated condition compared to the high HPS group. No effects were found of trait characteristics on changes in tenseness, boredom and happiness, as was expected. Finally, there were no differences found between the low and high HPS group on the BART in risk taking and impulsive behaviour.

DISCUSSION

Inducing manic-like mood states is an essential method in experimental research on mechanisms of manic dysregulation. Which element of manic mood should be targeted with what particular method is however subject of debate. The aim of our study was to develop a mood induction paradigm with virtual reality aimed at inducing a proxy of a hypomanic mood state and test its asset for future experimental research. The VR paradigm was successful in inducing dual-faceted affective states of mania, both excitement and tension, in response to an activating and goal-directed task. These affective states increased in the activated VR condition, and boredom decreased. Additionally, the results showed that the pattern of emotional reactivity in response to the activating mood induction task was different in groups with high versus low hypomanic personality (HPS) characteristics. More specifically, in the group with more hypomanic personality sensitivity (high HPS) irritation increased, while in the group with low HPS irritation decreased in the activated condition. Also, excitement increased less steeply in the high HPS group compared to the low HPS group, which seems rather counterintuitive. However, the high HPS group was significantly more excited before the mood induction compared to the low HPS group. The latter might be explained by the fact that high-sensitive people are more easily activated in the prospect of an exciting experience (participating in a VR experiment). There are studies that show increased activation in response to the prospect of rewards in patients with BD (Johnson et al., 2012; Maresh et al., 2019). In our study excitement might already have been activated in the prospect of rewards in the high-sensitive group and consequently have had reached a ceiling effect on T1. Finally, even though the VR task did have an effect on the experienced affective state immediately after the VR task, it did not have any additional effects on performances on the risk-taking task.

The results highlight the importance of targeting more complex, positive as well as negative, emotions in mood induction in the context of BD. The Reward Hypersensitivity Theory (RST) proposes that people with BD have high sensitivity to approach motivation (Alloy et al., 2015). Warr et al. (2021) applied RST to the field of affect and emotion in which affect was proposed to be a combination of valence of the emotion (unpleasantness vs. pleasantness) and the degree of activation of the emotion. The circumplex of affect (e.g., Russell, 1980; Yik et al., 2011) combines these two axes: the valence of affect (unpleasant to pleasant) and level of activation of affect (low to high), see Figure 4, copied from Warr (2007).

Based on this affective circumplex in combination with the RST theory, it can be hypothesized that manic emotions are situated at the top of the activation axes. Our study's finding on irritation might be in line with this hypothesis, namely that irritation (high activation emotion) is more easily activated in participants with increased hypomanic personality traits.

Our study had two limitations. First, we included a sample with limited variance in HPS scores. The mean HPS score was relatively low, only 8.06, compared to other studies that recruited student samples with an average of 15.98–16.03 (Dodd et al., 2011; Haigh & Dodd, 2017). In most studies, a score of >35 is considered a high-risk group. HPS scores were low as we were not in the position to pre-select a student group with the top and bottom percentage of HPS scores, as most other studies did. Still, despite the limited HPS variance, we were able to detect differences between trait groups. In future studies, for example, to be able to detect differences in behavioural patterns as well, it is advisable to include participants with 'extreme' low or high scores on the trait measures or to include patient samples.

Second, the temporal aspect of emotional states in mood induction studies is difficult to establish with self-report. A recent meta-analysis showed that the average time mood induction procedures (MIP) have an effect on mood is 4 min (Gillies & Dozois, 2021). Besides that, positive mood induction (vs. negative mood induction) has more difficulty eliciting effects on risk-taking tasks (Um et al., 2023). This means that it is difficult to exactly define whether the change in affect actually did or did not have an effect on behaviour as emotions might have 'cooled off' before the task was completed. Adding physiological measures in future studies might show changes in affect more accurately than self-report measures (Bunford et al., 2017; Hoffmann et al., 2022).

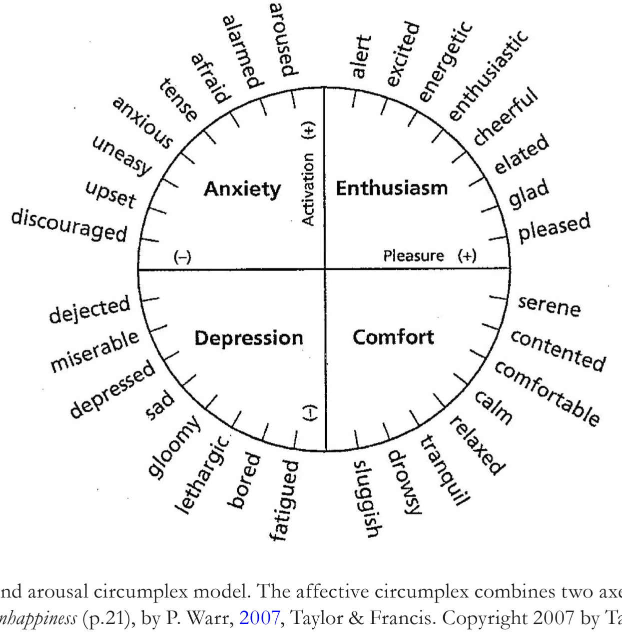

FIGURE 4 Valence and arousal circumplex model. The affective circumplex combines two axes: valence and activation. From *Work, happiness, and unhappiness* (p.21), by P. Warr, 2007, Taylor & Francis. Copyright 2007 by Taylor & Francis. Reprinted with permission.

CONCLUSION

Despite the relatively small sample, our study offers a valuable (hypo)manic mood like mood induction paradigm to address the influence of different states. The advantage of the current mood induction task, compared to those used in previous studies, is that it has potential of inducing both excitement and tension so it can more realistically resemble a hypomanic mood state. Moreover, this was the first experimental study on the mechanisms of manic mood induction that included virtual reality. Like the study of Vannucci et al. (2022), our design, aimed at a comparison between a group with and without mood induction, is a viable way to compare the effects of both state characteristics (in this case, mood states) and trait characteristics (sensitivity to mood dysregulation). In conclusion, this type of design proves useful in expanding our understanding of how changes in mood states have an effect on mechanisms of mood dysregulation.

AUTHOR CONTRIBUTIONS

Roanne V. F. J. Glas: Conceptualization; writing – original draft; methodology; validation; visualization; writing – review and editing. **Roy E. de Kleijn:** Software; formal analysis; project administration; data curation; resources; methodology; validation; visualization; funding acquisition. **Eline J. Regeer:** Conceptualization; writing – review and editing; supervision. **Ralph W. Kupka:** Conceptualization; writing – review and editing; supervision. **Manja A. Koenders:** Conceptualization; writing – original draft; writing – review and editing; methodology; validation; funding acquisition; investigation; data curation; project administration.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the Data S1 of this article.

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REFERENCES

Alloy, L. B., & Abramson, L. Y. (2010). The role of the behavioral approach system (BAS) in bipolar spectrum disorders. *Current Directions in Psychological Science*, *19*(3), 189–194.

Alloy, L. B., Nusslock, R., & Boland, E. M. (2015). The development and course of bipolar spectrum disorders: An integrated reward and circadian rhythm dysregulation model. *Annual Review of Clinical Psychology*, *11*, 213–250. https://doi.org/10.1146/annurev-clinpsy-032814-112902

Altman, E., Hedeker, D., Peterson, J. L., & Davis, J. M. (2001). A comparative evaluation of three self-rating scales for acute mania. *Biological Psychiatry*, *50*(6), 468–471.

Altman, E. G., Hedeker, D., Peterson, J. L., & Davis, J. M. (1997). The Altman self-rating mania scale. *Biological Psychiatry*, *42*(10), 948–955.

Benazzi, F., & Akiskal, H. S. (2003). The dual factor structure of self-rated MDQ hypomania: Energized-activity versus irritable-thought racing. *Journal of Affective Disorders*, *73*(1–2), 59–64. https://doi.org/10.1016/s0165-0327(02)00333-6

Bernardo, P. D., Bains, A., Westwood, S., & Mograbi, D. C. (2020). Mood induction using virtual reality: A systematic review of recent findings. *Journal of Technology in Behavioral Science*, *6*, 3–24.

Bjelland, I., Dahl, A. A., Haug, T. T., & Neckelmann, D. (2002). The validity of the hospital anxiety and depression scale: An updated literature review. *Journal of Psychosomatic Research*, *52*(2), 69–77.

Bocéréan, C., & Dupret, E. (2014). A validation study of the hospital anxiety and depression scale (HADS) in a large sample of French employees. *BMC Psychiatry*, *14*(1), 1–11.

Bunford, N., Evans, S. W., Zoccola, P. M., Owens, J. S., Flory, K., & Spiel, C. F. (2017). Correspondence between heart rate variability and emotion dysregulation in children, including children with ADHD. *Journal of Abnormal Child Psychology*, *45*, 1325–1337.

Carpenter, R. W., Stanton, K., Emery, N. N., & Zimmerman, M. (2020). Positive and negative activation in the mood disorder questionnaire: Associations with psychopathology and emotion dysregulation in a clinical sample. *Assessment*, *27*(2), 219–231. https://doi.org/10.1177/1073191119851574

Chirico, A., & Gaggioli, A. (2019). When virtual feels real: Comparing emotional responses and presence in virtual and natural environments. *Cyberpsychology, Behavior, and Social Networking*, *22*(3), 220–226.

Davies, C., Malik, A., Pictet, A., Blackwell, S. E., & Holmes, E. A. (2012). Involuntary memories after a positive film are dampened by a visuospatial task: Unhelpful in depression but helpful in mania? *Clinical Psychology & Psychotherapy*, *19*(4), 341–351. https://doi.org/10.1002/cpp.1800

Dodd, A. L., Mansell, W., Beck, R. A., & Tai, S. J. (2013). Self appraisals of internal states and risk of analogue bipolar symptoms in student samples: Evidence from standardised Behavioural observations and a diary study. *Cognitive Therapy and Research*, *37*(5), 981–995. https://doi.org/10.1007/s10608-013-9541-4

Dodd, A. L., Mansell, W., Bentall, R. P., & Tai, S. (2011). Do extreme beliefs about internal states predict mood swings in an analogue sample? *Cognitive Therapy and Research*, *35*, 497–504.

Eckblad, M., & Chapman, L. J. (1986). Development and validation of a scale for hypomanic personality. *Journal of Abnormal Psychology*, *95*(3), 214–222. https://doi.org/10.1037/0021-843X.95.3.214

Frost, R. O., & Green, M. L. (1982). Velten mood induction procedure effects: Duration and postexperimental removal. *Personality and Social Psychology Bulletin*, *8*(2), 341–347. https://doi.org/10.1177/0146167282082024

Gillies, J. C., & Dozois, D. J. (2021). How long do mood induction procedure (MIP) primes really last? Implications for cognitive vulnerability research. *Journal of Affective Disorders*, *292*, 328–336.

Haigh, M., & Dodd, A. L. (2017). Extreme cognitions are associated with diminished ability to use disconfirming evidence. *Psychology and Psychotherapy: Theory, Research and Practice*, *90*(1), 70–83. https://doi.org/10.1111/papt.12096

Hayden, E. P., Bodkins, M., Brenner, C., Shekhar, A., Nurnberger, J. I., Jr., O'Donnell, B., & Hetrick, W. P. (2008). A multimethod investigation of the behavioral activation system in bipolar disorder. *Journal of Abnormal Psychology*, *117*(1), 164–170. https://doi.org/10.1037/0021-843X.117.1.164

Hidiroglu, C., Esen, O. D., Tunca, Z., Yalcin, S. N. G., Lombardo, L., Glahn, D. C., & Ozerdem, A. (2013). Can risk-taking Be an Endophenotype for bipolar disorder? A study on patients with bipolar disorder type I and their first-degree relatives. *Journal of the International Neuropsychological Society*, *19*(4), 474–482. https://doi.org/10.1017/S1355617713000015

Hirschfeld, R. M., Williams, J. B., Spitzer, R. L., Calabrese, J. R., Flynn, L., Keck, P. E., Jr., Lewis, L., McElroy, S. L., Post, R. M., Rapport, D. J., Russell, J. M., Sachs, G. S., & Zajecka, J. (2000). Development and validation of a screening instrument for bipolar spectrum disorder: The mood disorder questionnaire. *American Journal of Psychiatry*, *157*(11), 1873–1875.

Hoffmann, A., Ellmerer, P., Maran, T., & Sachse, P. (2022). Cardiovascular reactivity during sadness induction predicts inhibitory control performance. *Physiology & Behavior*, *254*, 113869.

Holmes, M., Bearden, C. E., Barguil, M., Fonseca, M., Monkul, E. S., Nery, F. G., Soares, J. C., Mintz, J., & Glahn, D. C. (2009). Conceptualizing impulsivity and risk taking in bipolar disorder: Importance of history of alcohol abuse. *Bipolar Disorders*, *11*(1), 33–40. https://doi.org/10.1111/j.1399-5618.2008.00657.x

Johnson, S. L., Fulford, D., & Carver, C. S. (2012). The double-edged sword of goal engagement: Consequences of goal pursuit in bipolar disorder. *Clinical Psychology & Psychotherapy*, *19*(4), 352–362.

Joseph, D. L., Chan, M. Y., Heintzelman, S. J., Tay, L., Diener, E., & Scotney, V. S. (2020). The manipulation of affect: A meta-analysis of affect induction procedures. *Psychological Bulletin*, *146*(4), 355–375. https://doi.org/10.1037/bul0000224

Kessler, R. C., Berglund, P., Demler, O., Jin, R., Koretz, D., Merikangas, K. R., Rush, A. J., Walters, E. E., Wang, P. S., & National Comorbidity Survey Replication. (2003). The epidemiology of major depressive disorder—Results from the National Comorbidity Survey Replication (NCS-R). *Journal of the American Medical Association*, *289*(23), 3095–3105. https://doi.org/10.1001/jama.289.23.3095

Killgore, W. D. (1999). The visual analogue mood scale: Can a single-item scale accurately classify depressive mood state? *Psychological Reports*, *85*(3), 1238–1243. https://doi.org/10.2466/pr0.1999.85.3f.1238

Klein, D. N., Lewinsohn, P. M., & Seeley, J. R. (1996). Hypomanic personality traits in a community sample of adolescents. *Journal of Affective Disorders*, *38*(2–3), 135–143. https://doi.org/10.1016/0165-0327(96)00005-5

Kwapil, T. R., Miller, M. B., Zinser, M. C., Chapman, L. J., Chapman, J., & Eckblad, M. (2000). A longitudinal study of high scorers on the hypomanic personality scale. *Journal of Abnormal Psychology*, *109*(2), 222–226.

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., Strong, D. R., & Brown, R. A. (2002). Evaluation of a behavioral measure of risk taking: The balloon analogue risk task (BART). *Journal of Experimental Psychology: Applied*, *8*(2), 75–84. https://doi.org/10.1037//1076-898x.8.2.75

Lowenstein, J. A. S., Wright, K., Taylor, A., & Moberly, N. J. (2015). An investigation into the effects of different types of exercise on the maintenance of approach motivation levels. *Mental Health and Physical Activity*, *9*, 24–34. https://doi.org/10.1016/j.mhpa.2015.08.002

Maresh, E. L., Stim, J. J., Van Voorhis, A. C., Kang, S. S., Luciana, M., Sponheim, S. R., & Urošević, S. (2019). Neurophysiological correlates of cognitive control and approach motivation abnormalities in adolescent bipolar disorders. *Cognitive, Affective, & Behavioral Neuroscience*, *19*, 677–691.

Miller, C. J., Johnson, S. L., & Eisner, L. (2009). Assessment tools for adult bipolar disorder. *Clinical Psychology: Science and Practice*, *16*(2), 188–201.

Pyle, A., & Mansell, W. (2010). Cognitive biases in hypomanic personality: Preliminary findings indicating the relevance of self-versus-other encoding and high-versus-low levels of activation. *Behavioural and Cognitive Psychotherapy*, *38*(4), 459–472. https://doi.org/10.1017/S1352465810000299

Roiser, J., Farmer, A., Lam, D., Burke, A., O'Neill, N., Keating, S., Powell Smith, G., Sahakian, B., & McCuffin, P. (2009). The effect of positive mood induction on emotional processing in euthymic individuals with bipolar disorder and controls. *Psychological Medicine*, *39*(5), 785–791. https://doi.org/10.1017/S0033291708004200

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, *39*, 1161–1178. https://doi.org/10.1037/h0077714

Stern, R. A., Arruda, J. E., Hooper, C. R., Wolfner, G. D., & Morey, C. E. (1997). Visual analogue mood scales to measure internal mood state in neurologically impaired patients: Description and initial validity evidence. *Aphasiology*, *11*(1), 59–71.

Toast Interactive. (2017). *Richie's plank experience* [VR-app]. Toast VR. https://toast.games/

Um, M., Revilla, R., & Cyders, M. A. (2023). A meta-analytic review of the effectiveness of mood inductions in eliciting emotion-based behavioral risk-taking and craving in the laboratory. *Emotion*, *23*(1), 214–229. https://doi.org/10.1037/emo0001062

Van Meter, A. R., & Youngstrom, E. A. (2016). Distinct roles of emotion reactivity and regulation in depressive and manic symptoms among euthymic patients. *Cognitive Therapy and Research*, *40*(3), 262–274. https://doi.org/10.1007/s10608-015-9738-9

van Rijsbergen, G. D., Bockting, C. L., Berking, M., Koeter, M. W., & Schene, A. H. (2012). Can a one-item mood scale do the trick? Predicting relapse over 5.5-years in recurrent depression. *PLoS One*, *7*(10), e46796. https://doi.org/10.1371/journal.pone.0046796

Vannucci, C., Bonsall, M. B., Di Simplicio, M., Cairns, A., Holmes, E. A., & Heyes, S. B. (2022). Positive moods are all alike? Differential affect amplification effects of 'elated' versus 'calm' mental imagery in young adults reporting hypomanic-like experiences. *Translational Psychiatry*, *12*(1), 453. https://doi.org/10.1038/s41398-022-02213-4

Warr, P. (2007). *Work, happiness, and unhappiness*. Taylor & Francis.

Warr, P. B., Sánchez-Cardona, I., Taneva, S. K., Vera, M., Bindl, U. K., & Cifre, E. (2021). Reinforcement sensitivity theory, approach-affect and avoidance-affect. *Cognition and Emotion*, *35*(4), 619–635.

Yik, M., Russell, J. A., & Steiger, J. H. (2011). A 12-point circumplex structure of core affect. *Emotion*, *11*(4), 705–731.

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica*, *67*(6), 361–370. https://doi.org/10.1111/j.1600-0447.1983.tb09716.x

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