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Being Bored, Happy or Focused – Which Is Best for Creative Thinking? How Different Emotional States Influence Creativity

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Abstract: We aim to extend the body of research on boredom as a potentially creativity-enhancing state. Therefore, 124 students were assigned to one of five 6-minute interventions (boredom-discomfort, boredom-equanimity, boredom-continuation, joy, and concentration) and the effects on figural as well as verbal fluency and diversity as measures of creativity were examined. It was verified whether the emotional state changed during the intervention. In addition, the emotional dimensions, valence, arousal, and alertness were controlled before and after the test. Boredom-discomfort, joy, and concentration altered the emotion experienced during the intervention in the intended way. The boredom-equanimity and boredom-continuation groups served as control conditions for various boredom states, and less boredom resulted for subjects in these groups. Figural and verbal measures of creativity were differently influenced by the interventions. For verbal fluency, we obtained a significant interaction between time and group, in particular, the performance differed between the intervention with either concentration, or joy. Verbal creativity decreased after intervention in all groups, most for joy and boredom-discomfort groups and least for concentration. In contrast, figural performance increased in four groups, most for boredom-discomfort but not for concentration. Subsequent analyses revealed significant interaction effects between time and group with respect to both verbal and figural measures of creativity. The interventions had not only short-term effects on subjects' emotions but also, in some cases, a significant longer-term impact on emotion dimensions at the end of the study. After discussing methodological aspects, conclusions are drawn for further research approaches.

Keywords: boredom, creativity, joy, concentration, emotion induction, video.

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1. Introduction

The importance of creativity for humanity's future has often been highlighted (e.g. Glaveanu et al., 2020; Marope et al., 2018; Runco, 2017; Williams et al., 2016). Creative thinking is included as a key competence in education policies (Lucas and Spencer, 2017; OECD, 2017; 2019). At the same time, research has revealed a decline in creative competencies due to, for example, technological developments but also because of a trend toward more conformist educational systems since the 1990s, that push towards more conservative, norm-favouring thinking styles (Kim, 2011; Runco et al., 2017; Sternberg, 2007; Sternberg and Lubart, 1995). Such thinking is necessary in tasks with rather convergent, concentration-requiring, or intelligence-related demands (Kim and Pierce, 2013; Zhu and Zhang, 2011). In contrast, divergent, free-associative thinking is necessary for creativity (Fink et al., 2006; 2007; 2009; Mölle et al., 1999). Research suggests that emotional states such as boredom, relaxation, or pleasure favor free-associative processes, making it easier to think creatively (Baas et al., 2008; Baird et al., 2012; Bledow et al., 2013; Dijksterhuis and Meurs, 2006; Gasper and Middlewood, 2014; Gilhooly et al., 2013; Mann and Cadman, 2014). The extent to which boredom can be a creativity-enhancing state compared to pleasure and concentration is experimentally investigated in this study.

2. Theory

Studies that examine how creativity can be influenced by training or work techniques emphasize that the essential components necessary for creativity have been largely neglected (Schuler and Görlich, 2007; Scott et al., 2004; Valgeirsdottir and Onarheim, 2017). Specifically, empirical work highlights emotional factors as fundamental to the modulation of creative thinking (Baas et al., 2008; Conner and Silvia, 2015; Davis, 2009; Ivcevic and Hoffmann, 2017). We derive a definition of creativity from previous work that underpins the potential relationship between emotions and creativity and highlights possible emotion-sensitive cognitive processes for boredom, joy, and concentration. The induction of these emotional states is discussed in the final part of the theory.

2.1. Definition of Creativity

The creative cognition approach, particularly connectionism (Martindale, 1995) has roots in psychodynamic and associationist theories. According to these theories, creativity takes place as a process of flexible alternation between primary and secondary cognition processes in which unconscious, free-associative thoughts alternate with abstract-logical ones (Kris, 1952). In this context, the thought processes of creative individuals are characterized by a flatter degree of association hierarchies with a wide range of associative elements (Mednick, 1962). The related defocused attention is accompanied by a steady but diminished activity of multiple cortex areas in which the activated neuronal areas are simultaneously interconnected (Martindale, 1989; Mendelsohn, 1976). Brain activity exhibits various functional rhythms that are measurable by electroencephalography (EEG) (Berger, 1929). The alpha rhythm occurs particularly at rest and with eyes closed and decreases during attention-demanding mental activities that are accompanied by a beta rhythm (Berger, 1929; Laufs et al., 2003). According to the ´low-arousal theory´ (Martindale and Hasenfus, 1978; Martindale, 1989), a reduced cortical activation level, i.e., a decrease in the beta components measurable in the EEG in favor of increased alpha activity,

is fundamental for finding original ideas (Fink et al, 2009; Fink and Benedek, 2014). These results indicate establishing this low-arousal state is an active process based on the synchronization of alpha activity in the neuronal areas involved and active inhibition of obstructive processes (Fink and Benedek, 2014; Klimesch et al., 2007; Sauseng et al., 2005). Accordingly, during creative processes, the brain is in a state of cooperation between several cortical areas with simultaneous, targeted inhibition of zones whose activity would potentially impede or disrupt creative thinking. Based on these findings and Guilford's (1950) concept of divergent thinking, we define creativity in this paper as a way of thinking that enables the finding of ideas. We distinguish between the rapid availability of many ideas (idea fluency) and the breadth of associations (idea diversity) (Guilford, 1950; 1967; Jäger et al., 1997).

2.2. Boredom, Joy, Concentration, and their Association with Creativity

Unfortunately, we rarely succeed in finding ideas on command or in switching from concentrated thinking to a mode of free, creative thinking at the right moment and being creative at will. Rather, creative processes often develop unplanned and outside of work or scientific activity in moments of boredom, relaxation, or everyday banality: "… the three B's, the Bus, the Bath, and the Bed. That is where the great discoveries are made in our science" (Jaynes, 1990, p. 44). For the definition of boredom as an aversively perceived concomitant of unused cognitive potential (Eastwood and Gorelik, 2019), a positive reinterpretation of this fallow potential is found with the prefixed word ´creative`. Creative boredom is understood as a state of openness and receptivity to information and impressions (Csikszentmihalyi, 2010; Doehlemann, 1991; Kast, 2003; Mann and Cadman, 2014; Quindlen, 2002). Studies show that tasks without strain of working memory support creative thinking by triggering mind wandering and daydreaming (Smallwood and Schooler, 2009). This suggests that the disruption of a solution-oriented effort with an interval of non-effort in which daydreaming or mind wandering is possible, could be conducive to creativity. Goetz et al. (2014) postulated different types of boredom that are phenomenologically distinct, e.g., indifferent boredom described by relaxed and withdrawn behavior, or reactive boredom, which is more likely to be perceived as unpleasant, angry, or motivated to leave the situation. Indifferent boredom is associated with creativity (Goetz et al., 2014).

In addition, there is evidence that joy as a positive emotion, characterized by a pleasant state (Lazarus, 1991) also support creative performance (Gasper and Middlewood, 2014; Jaussi et al., 2017; Mastria et al., 2019). For example, by establishing a coherent psychophysiological state through positive emotions, new ideas can be developed more easily (Bledow et al., 2013; (Tomasino, 2007). Similarly, Baas et al. (2008) reported increased creativity in combination with positive emotions compared to neutral or negative emotions in their meta-analysis. It has been found for both boredom and joy that these emotions lead to higher alpha activity thereby facilitating creativity processes (Fink et al., 2011; Fink and Benedek, 2014; Martindale, 1989). The free-associative cognitive processes involved are described by Andreasen (2005) as random episodic silent thought. As its neurobiological basis, the default mode network (DNM) is a structure that is active during sleep, rest, daydreaming, or "...when a person is engaged in free-ranging and uncensored thought" (Andreasen, 2011, p. 51). In this phase, the creative process runs unconsciously and without concentration on the problem (Jaynes, 1990).

In contrast to boredom and joy, the brain brought to concentration tends to dwell on a particular solution to a problem and ignore alternatives (Bilalic and McLeod, 2014). However, this facilitates concentrated consciousness processes (Dijksterhuis and Meurs, 2006). Studies show that concentration and cognitive effort prevent creative mind wandering, especially when processing is accompanied by high working memory load (Baird et al., 2012). This leads to decreased alpha activity of the default mode network and thus the search for creative ideas may be inhibited (Horn et al., 2014; Zhong et al., 2008).

It can be concluded that interventions requiring concentration and cognitive effort should have a rather negative influence on creativity, whereas boredom and joy should have a positive influence on creativity. To the best of our knowledge, there has been no previous research comparing boredom, joy, and concentration with respect to their impact on creative performance. With the present research we want to contribute to this gap in creativity research. More specifically, we want to investigate, which of the three states (boredom, joy, concentration) has the most facilitating impact on creative performance (RQ1). According to previous findings, we predict a stronger facilitation of creative performance for boredom and joy when compared to concentration.

2.3. Induction of Emotions in Experimental Research

For experimental psychological research, standardized methods are also indispensable for interventions conducted on groups (Schleicher, 2009). It has been found that video films are particularly well suited as stimulants for emotions in psychological experiments and that the triggering of specific emotions can be achieved with the help of video films (Gross and Levenson, 1995; Rottenberg et al., 2007). However, relevant studies in this field as well as psychological archives on emotion induction harness video clips either based on sequences from American motion pictures (Gilman et al., 2017; Gross and Levenson, 1995; Israel et al., 2021; Rottenberg et al., 2007; Schaefer et al., 2010; Zempelin et al., 2021), or on amateur work from video-hosting websites (Samson et al., 2016). Despite the call to use culture-fair, language-free films without country-, culture-, or time-specific content in experimental research (Schleicher, 2009), it has remained common practice to use sequenced feature film scenes (Israel et al., 2021). Zeißig (2018) provided a video archive of artist-developed, language-free video films that were explicitly developed in the artistic exploration of the emotion in question, but the validation of the video films with regard to emotion induction is still pending. However, we decided to use three of the videos and to control for the different intervention conditions in terms of emotional manipulation immediately after the intervention. This implemented Hunter's (2015) requirement that the control of emotions triggered by the intervention be conducted immediately following the emotion induction, rather than after the creativity task.

To our knowledge, there have been no previous attempts to compare methods of boredom induction with respect to the different types of boredom, e.g. indifferent or reactant boredom, postulated by Goetz et al. (2014). In our work, therefore, it is important to try to evoke indifferent boredom, which is associated with relaxation and not with anger. At the same time, we also try to evoke unpleasant boredom. For this reason, we used two different video films: The video boredom that led to expressions of discomfort from the audience during screenings, e.g. clearing of throats, groaning, feet shuffling (condition boredom-discomfort) and the video equanimity

(condition boredom-equanimity), which according to recipient statements is rather perceived as pleasant and relaxing (Zeißig, 2018). An additional control condition in which subjects had to continue the verbal task for six additional minutes was included to induce another boredom form with negative valence (condition boredom-continuation). This was in line with Haager et al. (2018), who showed that continuing a creativity task induces boredom. We therefore wanted to investigate which of the three boredom interventions (discomfort, equanimity, continuation) led to the strongest signs of boredom without inducing anger (RQ2).

It is well known that a strong and long-lasting manipulation of emotions is difficult to achieve in experimental settings (Janke and Weyers, 2008). But in contrast, one study showed that the effect of triggered emotions on creativity may depend on the pre-existing emotional state (Forgeard, 2011). We therefore tested whether the interventions have a longer-term impact on emotional dimensions (RQ3).

3. Method

3.1. Sampling

An a priori power analysis (Faul et al., 2007) was performed to determine the sample size for this study, assuming a strong effect according to Cohen (1988), revealing an optimal sample size of 25 subjects per group, i.e. a total of 125 partipcipants. In selecting the sample, we opted for a group of people characterized as practical-technical/intellectual-researching (Holland, 1985). In doing so, we wanted to avoid having the sample consist of individuals who prefer open-ended, unstructured activities, which might have an advantage in terms of creative behavior (Schuler and Höft, 2001). The sample consisted of students majoring in mechanical engineering. Students were informed through a faculty member and invited to participate. Participation was voluntary. Students received no compensation or perks for participation but did receive a creative kit consisting of fun craft instructions and information on creativity. Participants were randomly assigned to the different groups.

3.2. Sample

In the experiment participated 124 students (26 females and 98 males, mean age: $M = 20.4$, $SD = 2.64$). The mean age was similar in all groups, ranging from 19.2 years to 21.3 years. Non-parametrically testing for age differences between groups revealed no significant group differences, $p = .114$. The chi-square test for distribution of sex across the groups also indicated no differences, $\chi 2(4, N = 117) = 3.11$, $p = .54$. The inspection of other sociodemographic data (already completed training, already completed degree, course of study, number of semesters, additional job held) did not provide any conspicuous features with regard to the aims of the study. Seven subjects had to be excluded from the study sample due to incomplete data.

3.3. Material

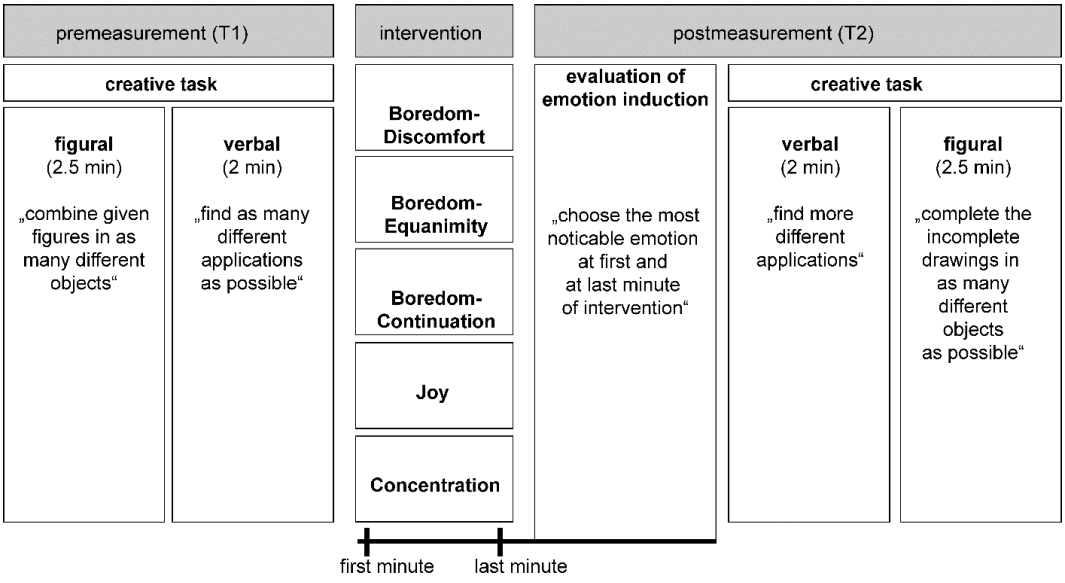
The intervention methods differed with respect to the type of intervention: (boredom-discomfort, boredom-equanimity, boredom-continuation, joy, and concentration. In three of the five intervention groups, we presented videos. First, the boredom-discomfort video contains a play scene in clichéd banality that creates an indefinable bleakness and arbitrariness. Second, the

boredom-equanimity video is contemplative and equanimous. Each of both videos had a length of about six minutes and did not include film edits, shot changes, or camera pans (Zeißig, 2018). Third, boredom was also induced by continuing for another six minutes with the verbal creativity task. This intervention condition is similar to a natural situation and it was shown that a creativity task could also induce boredom (Haager et al., 2018). Fourth, joy was induced by another six-minute video from the video archive by Zeißig (2018). According to de Bono (1992), joy is created by the sudden departure from a predetermined narrative track. The selected video film meets this criterion since it was shown several times in front of an audience and induced a lot of cheerfulness in the recipients. Fifth, concentration was induced with the paper-pencil concentration-performance-test KLT-R (Düker et al., 2001) which induces a continuous strain of concentration via arithmetic operations and a high strain of working memory.

3.4. Procedure

Participants were informed about the study in advance. Participation was voluntary, anonymous and without incentives and could be discontinued at any time. The entire process of information and preparation in the groups, as well as the execution of the experiment, took place in the same, standardized manner in all groups. The experimenter read out the instructions and any questions that arose were answered. Then participants completed an assessment of their emotional status (valence, arousal, and alertness) before the experimental run began (Figure 1).

Figure 1. Experimental Procedure



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All subjects worked on a figurative creativity task for 2.5 minutes and a verbal creativity task for 2 minutes according to the test manual. The start and end of each task was indicated by a specific signal, where the respective task sheet had to be turned over immediately. Afterwards the different types of intervention began, immediately followed by a recording of the participants' emotional state during the first and last minute of the intervention. Participants then continued

the verbal creativity task by searching for more solutions (2 minutes) followed by another 2.5 minutes completing the figural task. At the end of the experiment, participants completed a final rating of their emotional status (valence, arousal, and alertness).

4. Measures

4.1. Emotional Dimensions and Intervention-related Emotional State

4.1.1. Emotional Dimensions

Valence, arousal, and alertness, as three dimensions of the emotional status, were measured with the Multidimensional Mood Questionnaire (MDMQ, Steyer et al., 1997) before and after the examination. Two different forms of the questionnaire were used for pre- and posttest. The questionnaire measures current psychological state on the three dimensions of valence (good vs. bad), alterness (awake vs. tired), and arousal (calm vs. nervous), each with four items from which resulted a total score per dimension.

4.1.2. Intervention-related Emotional State

To test the different interventions, we examined what subjects felt most strongly in the first minute of the intervention and in the last minute for the subjects. Participants were each given a list of eight choice categories (relaxed, bored, annoyed, inspired, pleased, concentrated, strained, and curious). Retrospective assessment of emotional state in the first and last minute was chosen to reduce the risk of intervention disturbance due to self-perception through rating.

4.2. Creativity

Creative performance is measured in terms of fluency and diversity of figural and verbal ideas. Achievements in creativity were obtained with figural and verbal creativity tasks from the Berlin Intelligence Structure test (BIS, Jäger et al., 1997; Süß and Beauducel, 2015). The tasks allow to identify two dimensions of divergent thinking: fluency and diversity of ideas. Fluency is obtained by the number of ideas, while diversity is measured by the number of different categories of ideas produced. In the pre-measurement the figural creativity task OJ (Object designing, given geometrical figures have to be combined resulting in as many as possible different objects) and the verbal creativity task AM (Options for utilization, as many different applications as possible for provided objects have to be found) were used. The post-measurement included the continuation of the verbal creativity task AM and the figural creativity task ZF (Drawing completion, given incomplete drawings have to be completed resulting in as many different objects as possible).

Two independent raters evaluated the creative performance of the test participants. The intraclass correlation coefficient (ICC, Shrout and Fleiss, 1979) determined the interrater agreement of the evaluator data of both raters on the basis of the raw data without selecting individual subjects. The obtained interrater agreement revealed for all scales of the test data on creativity, $r(123) > .9$, $p < .01$, which are above the coefficient of $r > .75$ (Portney and Atkins, 1993) classified as good. In case of disagreement in judgments, we followed the decision of rater 2, who was blind to our hypotheses.

4.3. Data Analysis

All analyses of data reported here were carried out using IBM SPSS Statistics 27. Analysis of changes in creativity performance triggered by the intervention between T1 and T2 were subjected to mixed analyses of variance (Salkind, 2010) after testing for preconditions. The assumption of normal distribution was met for most of the creativity variables (for 28 out of 40 variables), as assessed by the Shapiro-Wilk test ($p > .05$). Simulation studies have shown that the mixed ANOVA is relatively robust to violations of the normal distribution assumption (Glass et al., 1972). There was homogeneity of the error variances, as assessed by Levene's test ($p > .05$) and homogeneity of covariances, as assessed by Box's test ($p > .05$). In the ANOVA, when the sphericity assumption was violated, the Greenhouse-Geisser correction was applied. Under this circumstance, corrected results are reported. In addition, partial eta squared values are reported to demonstrate the potential practical significance of differences.

5. Results

5.1. Homogeneity of Intervention Groups

5.1.1. Emotional Dimensions at T1

Valence, alertness, and arousal were determined at T1 to test homogeneity of the intervention groups and to rule out interactions with the induced emotional state. Mean differences were compared by simple analyses of variance and revealed no significant differences between groups. Accordingly, the groups did not differ before the start of the intervention, in terms of valence, $F(4,112) = 1.023$, $p = .40$, $\eta^2 = .035$; alertness, $F(4,112) = .956$, $p = .44$, $\eta^2 = .033$; and arousal, $F(4,112) = .66$, $p = .62$, $\eta^2 = .023$.

5.1.2. Creativity at T1

Comparison of the groups' differences in creativity performance revealed significant differences in the group means of figural creativity at T1 despite random group assignment. For figural fluency, $F(4,112) = 3.011$, $p = .021$, $\eta^2 = .097$, Tukey post-hoc analysis revealed a significant difference ($p = .010$) between boredom-discomfort and concentration group, -1.96, 95%-CI[-3.59, -.34]. For figural diversity, $F(4,112) = 2.728$, $p = .033$, $\eta^2 = .089$, also Tukey post-hoc analysis revealed a significant difference ($p = .047$) between boredom-discomfort and concentration group,-1.21, 95%-CI[-2.42, -.01]. The groups did not differ in terms of verbal creativity at T1, $F_{verbal\ fluency}(4,112) = 1.724$, $p = .150$; $F_{verbal\ diversity}(4,112) = 2.094$, $p = .086$.

5.1.3. Influence of Emotional Dimensions on Creativity at T1

In order to clearly demonstrate the effect of the induced emotional state by the intervention, we had to ensure that valence, alertness, and arousal of our participants before the start of our investigation had no influence on creativity in the T1 measurement before the intervention. Pearson's correlations were determined between the three dimensions (valence, alertness and arousal) and the four creativity scales (fluency and diversity in the figural and the verbal domain). No correlations ($r < .1$, $p > .5$) were found between the emotional dimensions and the creativity

measures. Therefore, the subjects' emotional status prior to the intervention was not related to their pre-intervention creativity performance shown at T1.

5.2. Intervention-related Emotional State

In the next step, we examined the emotional states that were triggered by the different types of intervention (see Fig. 2). We therefore recorded what subjects felt most strongly at the beginning and the end of the intervention (first minute vs. last minute). This was done in order to register possible changes during the intervention. In the groups where videos were shown, most subjects felt curiosity at the beginning of the video. At the end of the video boredom-discomfort, 64% of the subjects felt bored, 11% relaxed, and no one curious. Of the subjects who watched the boredom-equanimity video, 38% reported being bored, 24% relaxed, and 19% curious at the end of the intervention. The video joy resulted in 59% feeling satisfied, 12% feeling inspired, and no one feeling bored at the end.

In contrast, the largest proportion of subjects in the concentration and boredom-continuation groups felt focused at the beginning of the intervention. In the concentration group, 39% of the participants were focused at the end, 32% were tense, 11% were annoyed, and no one was bored. In the boredom-continuation group, 26% felt strained, 26% bored, 22% concentrated, and 13% relaxed.

5.3. Creativity

We examined whether creativity performance changed as a function of intervention between T1 and T2. On the figural creativity measure, the largest increase, and on the verbal measure, the smallest reduction between T1 and T2 represents the greatest creative achievement.

According to our hypothesis, figural creative fluency improved in the boredom-discomfort and joy groups compared to the concentration group with a significant main effect for time, $F(1, 112) = 14.297$, $p < .001$, $\eta p^2 = .113$. However, there was no statistically significant interaction effect of time and group on figural fluency. The strongest change in terms of figural diversity occurred in the boredom-equanimity group and the boredom-discomfort group, again with a significant main effect for time, $F(1, 112) = 32.174$, $p < .001$, $\eta p^2 = .223$, but no statistically significant interaction (Table 1).

Figure 2. Relative frequencies of intervention-related emotional states during the first and last minute of the intervention for the different intervention groups

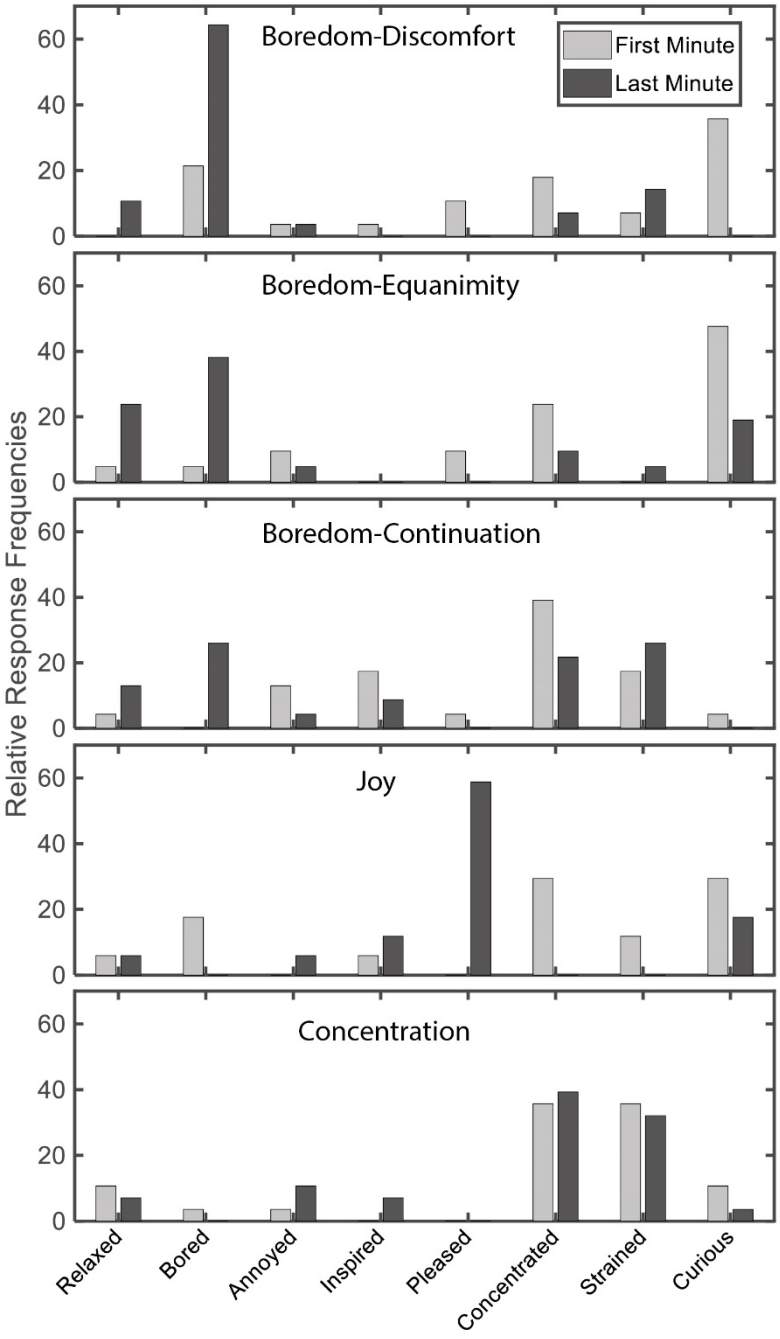

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Table 1. Mean differences of creativity measures between T1 and T2 and results of variance analysis comparisons between in the five intervention groups

creativity measures	Boredom-Discomfort (*N*= 28)		Boredom-Equanimity (*N*=21)		Boredom-Continuation (*N*=23)		Joy (*N*=17)		Concentration (*N*=28)		ANOVA		
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	ηp^2
figural fluency	1.21	2.44	.67	1.96	1.09	2.07	1.00	2.42	.00	2.21	1.285	.280	.044
figural diversity	1.32	2.16	1.05	1.53	1.39	1.83	1.12	2.29	.25	1.76	1.520	.201	.051
verbal fluency	-2.57	2.23	-1.86	1.90	-1.74	2.60	-3.47	2.83	-.89	3.03	3.141	.017	.101
verbal diversity	-1.25	1.67	- 1.19	1.33	- .78	2.02	-2.53	1.87	-.93	2.51	2.351	.058	.077

In contrast, the interaction of time and group for verbal fluency of ideas reached significance with the lowest reduction in creative performance between T1 and T2 in the concentration group and the highest in the joy group (Table 1). Also, in the boredom-continuation group that had six minutes more to think about more ideas in the verbal task, the difference was larger between T1and T2, and fewer ideas were found on average than in the concentration group. However, in terms of verbal diversity, the boredom-continuation group achieved the best creative performance with the lowest reduction and the joy group the worst with the highest reduction between T1 and T2 with a significant main effect for time, $F(1, 112) = 52.956$, $p < .001$, $\eta p^2 = .321$. But the interaction of time and group narrowly missed to reach significance (Table 1).

After the confirmatory analyses were completed, we noticed that the interventions appeared to have different effects on verbal and figural creativity in the different groups (Figure 3). Therefore, another further exploratory statistical analysis was conducted.

In all groups, as expected, fewer new and less diverse ideas were found in the verbal task in T2, since this task was the same as in T1. Nevertheless, this discrepancy was less pronounced in the concentration group. The figural task differed in T1 and T2 and more diverse ideas were found in T2 in all groups except the concentration group. A multivariate ANOVA with Bonferroni correction was performed for verification. The different changes in verbal and figural creativity between T1 and T2 in the different groups showed up in significant interaction effects for both fluency ($F(4,112) = 3.988$, $p = .005$, $\eta p^2 = .125$) and diversity ($F(4,112) = 2.586$, $p = .041$, $\eta p^2 = .085$). This means that the different groups showed opposite changes between T1 and T2 in terms of figural and verbal measurement.

5.4. Influence of interventions on the emotional status after the intervention

Finally, the influence of the interventions on the emotional dimensions, valence, arousal, and alertness tested between T1 and T2. Figure 4 shows the changes between T1 and T2 for the three dimensions comparing the groups. In the joy group, there was a descriptive increase between T1 and T2 in valence and arousal, and a minimal increase in alertness. For the boredom-discomfort group, there was an increase on arousal and a tendency toward the negative pole (bad, tired) on the other two dimensions. The concentration, boredom-equanimity, and boredom-continuation groups tended in all scales towards the negative pole in T2 (bad, nervous, tired).

Figure 3. Changes in Figural and Verbal Creativity Scores between T1 and T2, Differentiated by Intervention Groups

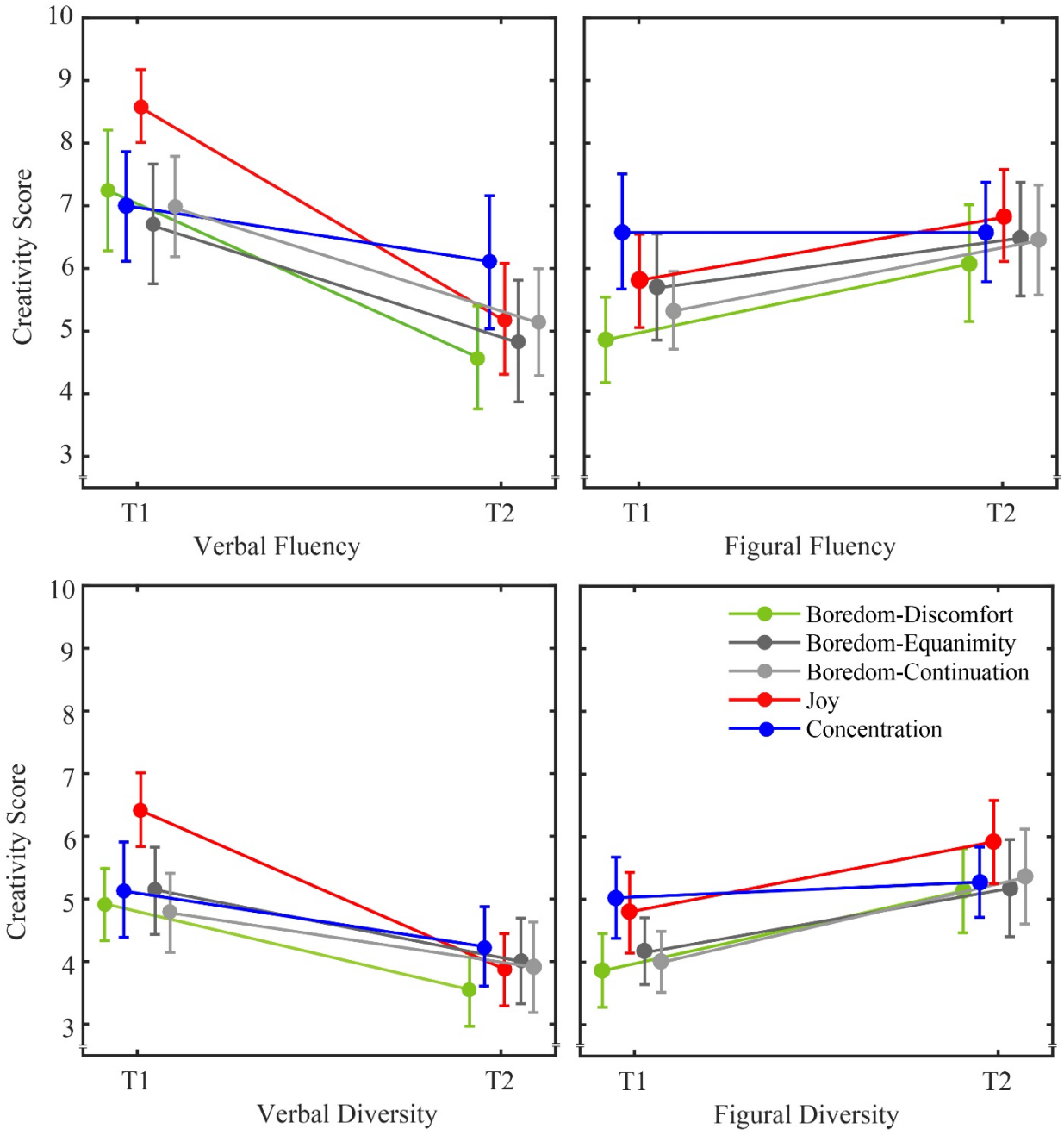

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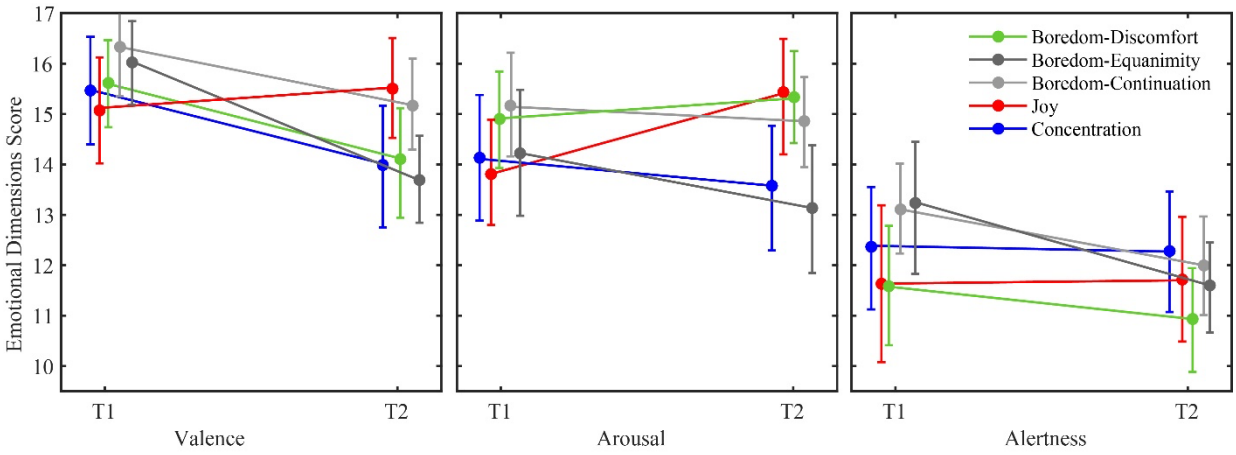
Figure 4. Intervention-related Changes in Emotional Dimensions between T1 and T2



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Differences between the five intervention groups for the three dimensions (valence, alertness, arousal) were tested using a mixed ANOVA. Significant interaction effects between time and group are found for the dimension Valence ($F(4, 112) = 3.011$, $p = .021$, $\eta p^2 = .097$). The significance level was narrowly missed for the arousal dimension ($F(4, 112) = 2.361$, $p = .058$, $\eta p^2 = .078$) and conspicuously missed for the alertness dimension ($F(4, 112) = 1.293$, $p = .277$, $\eta p^2 = .044$).

6. Discussion

With the present study, we investigated the influence of boredom, joy, and concentration on creative performance. We presumed a greater promotion of creative performance for boredom and joy compared to concentration. Boredom was induced by three different interventions (boredom-discomfort, boredom-equanimity, boredom-continuation). We wanted to determine whether different types of boredom, with signs of boredom, relaxation, or anger, or combinations thereof, were elicited, as postulated by Goetz et al. (2014). The interventions with joy and concentration were also verified in terms of triggering the target emotion. In addition, we expected the different intervention to have only a short-term effect on emotion and not to be reflected in the emotional dimensions (arousal, valence, alertness) after the entire study and controlled for that.

Our first research question, about a creativity-enhancing potential of boredom cannot be answered unambiguously because different and partly opposite effects of the interventions were obtained for the respective creativity measures (fluency and diversity of figural and verbal ideas). In line with our assumptions, boredom strongly improved figural fluency, especially when compared with the condition of concentration. In contrast, for concentration we found the smallest decrease in verbal fluency. The different effects of the interventions on the measures of creativity emerged as a specific pattern and revealed significant differences between time, group, and verbal as well as figural fluency and diversity.

Our second research question was addressed to the elicitation of different emotional states by the interventions in each group. We found that the interventions triggered different emotional states. Our results show that the different boredom interventions induced boredom to varying degrees. In the video boredom-discomfort, 64% felt bored and 11% relaxed; in the video boredom-equanimity, 38% felt bored and 24% relaxed, but also 19% felt curious; and in the boredom-continuation condition, 26% felt bored and 13% relaxed, but also 26% felt strained and 22% concentrated. In none of the boredom groups anger was triggered by the intervention.The majority of subjects in the joy groups were pleased or inspired at the end of the intervention, and in the concentration group, the intervention caused participants to feel focused or strained.

The emotional status before the study in the dimensions of arousal, valence, alertness had no effect on creative performance at T1, but the interventions had an impact on the emotional status at the end of the study. For our third research question, about the change in the emotional dimensions before and after the investigation depending on the intervention, we did not expect significant changes. In fact, however, it appeared that the joy intervention led to a significant improvement for the dimension valence, whereas for all other groups we found a decrease.

6.1. Discussion of Creativity Results

Based on the assumption that creativity can be influenced (Scott et al., 2004), we assumed that different interventions would result in differential impact on creativity. According to previous findings boredom and joy were expected to enhance creative performance as opposed to concentration (Baas et al., 2008; Baird et al., 2012; Bledow et al., 2013; Dijksterhuis and Meurs, 2006; Gasper and Middlewood, 2014; Gilhooly et al., 2013). Our results only partially confirm earlier findings. In particular, the results are partly in contrast to previous results (Baas et al., 2008; Bledow et al., 2013) because the boredom-discomfort condition resulted in the greatest increase in figural creativity but the concentration condition was best for verbal creativity. It remains open whether this contradiction is due to different processes in verbal and figural tasks (Byron and Khazanchi, 2011). Experimental findings show structural correlates of left-sided processing primarily for linguistic information and right-sided processing for figural tasks and for creative processes (Bowden and Beeman, 2003; Flaherty, 2005; Jäncke, 2012; Ritter and Dijksterhuis, 2014). Therefore, the search for solutions in the verbal task may have benefited from concentrative effort, whereas boredom-discomfort and joy may have been supportive for idea finding in the figural task. Thus, further work should investigate the processing of different verbal and figural tasks in relation to different interventions. Furthermore, it should be considered whether it is rather the search for new ideas that is supported by different emotional states than the search for useful ideas. This raises questions regarding the so-called standard definition of creativity: creativity is a new work that is also useful (Runco and Jaeger, 2012; Stein, 1953). According to this definition, there are two aspects of creative products or processes (new and useful) that could potentially be influenced in opposite ways. Further studies comparing different test procedures of creativity and providing clues to the underlying processes could also contribute to better define the concept of creativity (Runco, 2017).

The aspect of processing time should also be discussed: The subjects had two and a half minutes to generate as many different ideas as possible for each task. It is, of course, important for the measurement of a latent trait that all subjects are studied within identical conditions, also

with respect to the time. However, individuals differ with respect to individual characteristics, such as processing speed. This may imply that the given time might be appropriate for one person but not for another. According to this, the conditions for creative thinking would not have been constant as actually required. It can therefore be assumed that the data collected are at least partially related to processing speed. Moreover, an increase in mental effort occurs under time pressure which might impair creative, free-associative processes (Andreasen, 2005; Martindale, 1989; Richter and Hacker, 2008). The intervention with the boring and the relaxing video aimed to induce digressing or daydreaming and thus initiate free-associative processes (Andreasen, 2011). An inverted U-shaped relationship with creative performance has been postulated for the duration of these unconscious mental processes (Yang et al., 2012). Therefore, it cannot be determined whether we were successfully induced such a free-associative state by boredom which was influenced by time pressure during the tasks, or whether the duration of the boredom induction had an impact. Our finding that boredom was accompanied with the greatest performance in the figural task suggests that boredom can induce such a free-associative state. Against this background, further experiments need to investigate how interventions with boring and relaxing videos of different lengths affect creativity (measures) and how time constraints influence the processing of creativity (tasks).

6.2. Discussion of the results for the control of the intervention conditions

We found that three interventions – boredom-discomfort, joy, and concentration – led to a certain coherence in the emotional state of most subjects in the respective groups. However, for the intervention with boredom-continuation and boredom-equanimity no such coherence was obtained. We consider this an important result, as the availability of induction methods of different emotional states has been described as insufficient and so far there are only a few language-free videos available (Israel et al., 2021; Janke and Weyers, 2008). In our study, the elicitation of boredom-discomfort and joy can be considered successful, especially since the third video boredom-equanimity, provides a comparison condition for intervention with a video that neither shows the postulated emotional state nor clearly highlights another one. However, it should be remembered that only eight categories were available and thus the target of emotional states was preselected.

Goetz et al. (2014) demonstrated that different types of boredom can be phenomenologically distinguished. They assume that the type of boredom occurring as indifferent boredom in low-restrictive performance situations might be associated with creativity. Previously, creative processes were shown to benefit from low arousal (Martindale, 1989). In the future, this makes it necessary not only to induce different emotional states, but also to distinguish the essential aspects within an emotional category, especially for boredom (e.g. boredom with low arousal versus boredom with high arousal). Further investigation of the elicitation of joy, and different types of boredom with the used videos but also other interventions are required—also independent from the examination of creativity—using validated psychometric methods as well as biopsychological methods. Such comparisons should also be done with other previously validated boredom induction methods (Brewer et al., 1980; Gross and Levenson, 1995; Israel et al., 2021; Markey et al., 2014).

6.3. Discussion of the results regarding the emotional dimensions

An influence of the emotional dimensions before the intervention on the measurement of creativity can be ruled out because no emotional dimension before the examination was associated with creativity in the pre-measurement. However, a change in the emotional dimension valence after the intervention with joy is evident. It can therefore be assumed that the induction of different emotional states through a short intervention of six minutes can have an influence on the emotional status at the end of the study. This is an important and unexpected result. Especially for the induction of positive emotional states, it is considered to be difficult to implement induction methods that produce measurable positive changes of sufficient duration in the majority of the subjects (Janke and Weyers, 2008). With that in mind, it can be summarized that in this study the induction of joy succeeded in most of the subjects of this group and furthermore led to a measurable change in the valence dimension at the end of the study. For the arousal dimension, there was a change towards calmness in the boredom-discomfort and joy groups, while the other groups were at a descriptive level more aroused at the end of the study. We also measured the alertness dimension and found an increase between T1 and T2 exclusively in the joy group and the greatest changes toward tired at the end of the study in the boredom-discomfort, boredom-equanimity, and boredom-continuation conditions. These differences did not reach significance, but to the extent that a boredom induction method could be identified that is capable of eliciting low arousal without fatigue, it would be possible to determine whether creativity is also sensitive to the alertness aspect.

These results indicate that further research is needed to better understand the relationships and interactions between emotional states and creativity and other mediating factors (Chermahini and Hommel, 2012). In particular, because empirical studies suggest that emotional states associated with deactivation are conducive to creativity (Shofty et al., 2022; Stevens and Zabelina, 2019), it seems likely that there is an optimal level of deactivation for creative thinking.

6.4. Limitations of the present work

As an empirical psychological study, the present work is committed to methodological guidelines and is constrained to the statistical testing of hypotheses derived from theory. Thus, theoretical concepts were adopted and adjusted to become measurable by strictly calculated methodological settings. In following this empirical approach, views of other research traditions, such as philosophy, might not be sufficiently addressed. Due to the used procedures, instructions, survey instruments through consistent study conditions for the different groups and by shielding them from external interference, we are convinced that we achieved a high degree of objectivity. The inclusion of an external evaluator, who had no knowledge of the hypotheses and the assignment of subjects to experimental conditions, objectified the evaluation of the participant´s creative performance. With regard to the internal validity, time effects and bias due to experimental mortality, i.e. the loss of subjects throughout the study, can be excluded, because the pre- and postmeasurements took place within half an hour. Despite this short time period, practice effects between T1 and T2 cannot be excluded. The possibility of selection bias (Smart, 1966) is present. However, with respect to the demographic variables and the control variables of the emotional dimensions in T1, no systematic differences between the groups were found. By querying the emotional state before the intervention, a test effect induced by this measurement cannot be ruled

out. For example, a self-reflective perception could have been triggered, which might have influenced both the experience of the respective intervention condition as well as the task processing. Since all groups were exposed to these influences to the same extent, at least there should be no systematic biases. Participation in the study was voluntary, and the study and participants' task solving had no particular relevance or benefits. Social desirability tendencies and an influence of motivational factors on the creative processes (Amabile, 1996) are therefore not to be expected. External validity is limited by the experimental study design, sample selection, and conduct of the study. Although the investigation took place in the context of a university seminar, it is not possible on the basis of this study to make generalized statements about the relationship between boredom and creativity or causal conclusions about the effect of boredom, joy, or concentration on creativity. The findings may not be generalized to other contexts.

In order to measure creative performance in this study in an empirically sound manner and at the same time temporally proportional to intervention time, the BIS-IV (Jäger et al., 1997) was used. However, this test has been developed and validated for the assessment of personality-related ability traits, and an extension of the processing time should be discussed in order to purge the creativity measurement from an overlap of intelligence traits. In addition, the selection of tasks to assess fluency and diversity of ideas was low. Content validity is low when a test does not contain a sufficiently representative sample of questions, thereby examining only certain components and characteristics of creativity that are easy to operationalize and test (Runco and Sakamoto, 1999). To counteract this, verbal and figural task modalities were used. In retrospect, however, this also proves to be difficult because we cannot analyze whether the differences are related to different processing strategies of verbal and figural tasks or result from the arrangement of the tasks when conducting the experiment. A replication of the experiment with three groups (boredom-discomfort, joy, concentration) and only one, randomly assigned modality of the tasks (verbal or figural) per subject or both modalities and randomly changed task orders, could help to obtain further insights.

No existing instrument could be used to measure the emotional states triggered during the intervention because our target emotions are not captured in existing questionnaires. Moreover, we intended to keep the measurement as brief as possible so as not to overshadow the impact of the intervention on creativity. It should also be avoided that an extensive, introspection-requiring and time-consuming measurement of emotional states itself becomes an effective factor and interferes with the measurement of creative data. For this reason, this study asked as effectively as possible what the subjects felt most strongly during the first and last minutes of the intervention. The participants could choose one out of eight emotional states, which limits the validity. Therefore, these critical factors need to be considered in further studies on this topic to investigate the influence of emotional states altered by videos on creativity.

6.5. Practical relevance of the findings

Although the external validity of the present work is limited, concrete conclusions can be drawn on how the study can be methodologically improved. For example, it is necessary to prevent possible systematic biases by randomizing task sequences or by separately investigating verbal and figural modalities. Furthermore, it would be necessary to examine whether different induced

emotional states also have different effects on other measures of creativity (convergent thinking, associative thinking, originality). Reducing the number of study groups may increase the effect size and thus yield more precise results. The boredom-discomfort and concentration conditions stood out in this study as worthwhile interventions for further investigation.

With this study, we were able to extract important evidence for the fundamental existence of associations between different emotional states and creativity. We thereby add further circumstantial evidence for boredom as a condition potentially influencing creativity to the body of research.

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