Hedonic Tone and Activation Level in the Mood–Creativity Link: Toward a Dual Pathway to Creativity Model

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To understand when and why mood states influence creativity, the authors developed and tested a dual pathway to creativity model; creative fluency (number of ideas or insights) and originality (novelty) are functions of cognitive flexibility, persistence, or some combination thereof. Invoking work on arousal, psychophysiological processes, and working memory capacity, the authors argue that activating moods (e.g., angry, fearful, happy, elated) lead to more creative fluency and originality than do deactivating moods (e.g., sad, depressed, relaxed, serene). Furthermore, activating moods influence creative fluency and originality because of enhanced cognitive flexibility when tone is positive and because of enhanced persistence when tone is negative. Four studies with different mood manipulations and operationalizations of creativity (e.g., brainstorming, category inclusion tasks, gestalt completion tests) support the model.

Keywords: mood, creativity, cognitive flexibility, emotions, arousal

What enables scientists to make notable contributions, engineers to develop innovative products, and work teams to creatively solve their problems? What hinders stand-up comedians from being funny and refrains poets from being original? When are people creative, and why? What hinders creativity, and when? Partly because of the importance of creativity for human progress and adaptation, these questions are as old as the human sciences (Simonton, 2003). Apart from its obvious, problem-solving function (Mumford & Gustafson, 1988), creative ideation allows individuals to remain flexible (Flach, 1990), giving them the capacity to cope with the advantages, opportunities, technologies, and changes that are a part of their day-to-day lives (Runco, 2004). Accordingly, creativity is studied in a variety of disciplines, including psychology, organizational behavior, and communication sciences.

Creativity is usually defined as the generation of ideas, insights, or problem solutions that are new and meant to be useful (Amabile, 1983; Paulus & Nijstad, 2003; Sternberg & Lubart, 1999). Among the many variables that have been shown to predict creativity, mood stands out as one of the most widely studied and least disputed predictors (e.g., George & Brief, 1996; Isen & Baron, 1991; Mumford, 2003). For example, Ashby, Isen, and Turken (1999) noted that

> It is now well recognized that positive affect leads to greater cognitive flexibility and facilitates creative problem solving across a broad range of settings. These effects have been noted not only with college samples but also in organizational settings, in consumer contexts, in negotiation situations . . . and in the literature on coping and stress. (p. 530)

In a similar vein, Lyubomirksy, King, and Diener (2005) concluded that people in a positive mood are more likely to have richer associations within existing knowledge structures, and thus are likely to be more flexible and original. Those in a good mood will excel either when the task is complex and past learning can be used in a heuristic way to more efficiently solve the task or when creativity and flexibility are required. (p. 840)

Although many studies support the idea that positive mood states trigger more creative responses than do neutral mood control conditions, studies in which positive and negative mood states were compared appear to be less conclusive: "There is also a large literature on negative affect, which indicates that the impact of negative affect is more complex and difficult to predict than is the case for positive affect" (Ashby et al., 1999, p. 532). Indeed, whereas some studies suggest that positive mood states trigger more creativity than do negative mood states (e.g., Grawitch, Munz, & Kramer, 2003; Hirt, Levine, McDonald, Melton, & Martin, 1997; Hirt, Melton, McDonald, & Harackiewicz, 1996), other studies report similar levels of creativity (Bartolic, Basso, Schefft, Glauser, & Titanic Schefft, 1999), and still other studies

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report that negative moods promote creative performance more than do positive or neutral moods (e.g., Carlsson, 2002; Gasper, 2003; Kaufmann & Vosburg, 1997; Madjar & Oldham, 2002). This has led some to call into question the general conclusion that positive mood states produce more creativity than do negative mood states (Shalley, Zhou, & Oldham, 2004) or that negative mood states undermine creative performance (Gasper, 2003; George & Zhou, 2007).

In this article, we reconsider the link between mood and creativity and try to reconcile the seemingly contradictory findings and conclusions reviewed above. First, we argue that creativity can be a function of cognitive flexibility and of cognitive perseverance and persistence. Second, we argue that mood states can be conceptualized in terms of two underlying dimensions—hedonic tone (positive vs. negative) and activation (activating vs. deactivating). Whereas past work on mood states and creativity has predominantly focused on hedonic tone dimension and on cognitive flexibility, we argue that the extent to which mood states activate or deactivate and the tendency toward cognitive perseverance and persistence need to be taken into account also. More specifically, we propose that cognitive activation is a necessary precondition for creativity to come about and that hedonic tone determines the route— the flexibility route or the perseverance route—through which creative fluency and originality is achieved. In four studies, we tested (aspects of) the general idea that activating moods with positive tone are linked to cognitive flexibility and thereby promote creative performance, whereas the creativity enhancing effects of activating moods with negative tone are due to perseverance.

A Dual Pathway to Creative Performance

Creativity researchers often operationalize creativity with measures of fluency, originality, and flexibility (Guilford, 1967; Torrance, 1966). Because we will also use these measures in our studies, it is important to conceptually relate them to each other as well as to the general concept of creativity. Fluency is a measure of creative production and refers to the number of nonredundant ideas, insights, problem solutions, or products that are being generated. Originality is one of the defining characteristics of creativity and refers to the uncommonness or infrequency of the ideas, insights, problem solutions, or products that are being generated (Amabile, 1983; Guilford, 1967; Paulus & Nijstad, 2003; Sternberg & Lubart, 1999; Torrance, 1966). Fluency and originality may be correlated (e.g., quantity breeds quality; Diehl & Stroebe, 1987; Osborn, 1953), but they need not be. For example, creative fluency may manifest itself in a relatively large number of solved insight or perception problems, with the solutions themselves not being particularly new or uncommon (cf. Förster, Friedman, & Liberman, 2004). Moreover, states or traits that influence creative fluency do not necessarily also influence originality and vice versa.

Flexibility as a measure of creativity manifests itself in the use of different cognitive categories and perspectives and of broad and inclusive cognitive categories (Amabile, 1983; Mednick, 1962). Generating ideas in many different categories will, all other things being equal, be associated with more ideas overall (i.e., increased fluency; cf. Nijstad, Stroebe, & Lodewijkx, 2002) as well as with the generation of ideas in categories that are not usually thought of (i.e., originality; cf. Murray, Sujan, Hirt, & Sujan, 1990; also see Isen & Daubman, 1984; Mikulincer, Paz, & Kedem, 1990; Rietzschel, De Dreu, & Nijstad, 2007). It is important to note that besides being a measure of creative performance, flexibility also refers to a cognitive process. Many researchers have argued that in order to be creative (i.e., produce novel and appropriate products) people must think flexibly, must break set (e.g., Duncker, 1945; Smith & Blankenship, 1991; Smith, Ward, & Schumacher, 1993), and need flat associative hierarchies (e.g., Eysenck, 1993; Mednick, 1962; Simonton, 1999) to arrive at uncommon and disparate (and thus original) associations. Cognitive flexibility can thus not only be seen as a measure of creativity but also as a precursor of the production of many (fluency) and original responses.

However, in addition to cognitive flexibility, it is also possible to achieve creative fluency and originality through hard work, perseverance, and more or less deliberate, persistent, and in-depth exploration of a few cognitive categories or perspectives (Boden, 1998; Dietrich, 2004; Finke, 1996; Schooler, Ohlsson & Brooks, 1993; Simonton, 1997). Perseverance will manifest itself not in the use of many or broad cognitive categories but rather in the generation of many ideas within a few categories or in longer time-on-task. All other things being equal, generating many ideas in a few categories will also lead to more ideas overall (i.e., fluency; Nijstad et al., 2002). Furthermore, recent work suggests that fluency within categories is associated with originality of ideas within these categories: Because only a limited number of conventional and unoriginal ideas are possible in each category, perseverance within categories eventually leads to original ideas (Rietzschel, Nijstad, & Stroebe, 2007). Such within-category fluency (e.g., Nijstad & Stroebe, 2006; Nijstad et al., 2002; Nijstad, Stroebe, & Lodewijkx, 2003) can be illustrated with the example of an individual who generates ideas as to how to improve health. This person may think about physical exercise and sport and may start out with common ideas like, “people should spend more time doing physical exercise.” However, provided he or she continues generating ideas within this category, he or she might proceed to more unusual ideas within that category, like, “putting a strong string in your computer keyboard to make typing very hard work.” In previous work in which both flexibility (number of used categories) and within-category fluency were established, no systematic correlation between the two was observed (Nijstad et al., 2002, 2003).

Taken together, creativity can be achieved through enhanced cognitive flexibility, set-breaking, and cognitive restructuring, which manifests itself in the use of many, broad, and inclusive cognitive categories. It can equally well be achieved through enhanced persistence and perseverance, which manifests itself in a higher number of ideas and insights within a relatively low number of cognitive categories, prolonged effort, and relatively long time-on-task. This may apply to idea generation and divergent thinking tasks, as well as to insight tasks that are typically characterized by being ultimately soluble by the average problem solver. Such insight tasks are likely to produce an impasse and a state of high uncertainty as to how to proceed and to produce a kind of “aha” experience when the impasse is suddenly overcome and the solution is discovered after prolonged efforts at solution (Förster et al., 2004; Schooler et al., 1993).

Discrete Moods, Creative Fluency, and Originality

A critical implication of the dual pathway model is that any trait or state influencing cognitive flexibility or cognitive persistence and perseverance may lead to novel yet appropriate insights and ideas. With regard to the influence of mood on creative fluency and originality, it may thus be that mood states influence creativity to the extent that they enhance cognitive flexibility, perseverance, or both; perhaps both positive and negative mood states lead to creative fluency and originality, but through different routes.

When thinking about mood states, valence, or hedonic tone, most readily comes to mind. Discrete moods such as anger, anxiety, sadness, and depression all have negative valence, or tone. Discrete mood states such as happiness, elation, and feeling relaxed and calm all have positive valence, or tone. However, in addition to hedonic tone, discrete moods differ in the extent to which they activate or deactivate (Barrett & Russell, 1998; Gray, 1982; Green, Goldman, & Salovey, 1993; Posner, Russell, & Peterson, 2005; Thayer, 1989; Watson, Clark, & Tellegen, 1988). Some mood states are positive in tone and deactivating (calm, relaxed), whereas others are positive in tone and activating (happy, elated). Likewise, some mood states are negative in tone and deactivating (sad, depressed), whereas others are negative in tone and activating (angry, fearful). This applies to temporarily activated and experimentally manipulated mood states (Russell & Barrett, 1999; Watson, Wiese, Vaidya, & Tellegen, 1999), as well as to trait-related differences in mood (Filipowicz, 2006). For example, trait extraversion is often equated with positive affectivity (positive, activating), and trait neuroticism is equated with negative affectivity (negative, activating; Cropanzano, Weiss, Hale, & Reb, 2003; Eysenck, 1993).

Activation, Hedonic Tone, and Creativity

Whether mood states are activating or deactivating may have important effects on creative performance. According to both classic and contemporary work on threat rigidity (Carnevale & Probst, 1998; Staw, Sandelands, & Dutton, 1981) and stress-performance linkage (Broadbent, 1972; Yerkes & Dodson, 1908), an individual's capacity for complex thinking is altered in a curvilinear fashion as arousal and activation increases. Low levels of arousal lead to inactivity and avoidance, neglect of information, and low cognitive and motor performance. Extremely high levels of arousal reduce the capacity to perceive, process, and evaluate information. However, at moderate levels of arousal, individuals will be motivated to seek and integrate information and to consider multiple alternatives. Provided they are not associated with intense arousal, activating moods are thus more likely than deactivating mood states to increase attention to and integration of information.

That activating mood states may foster creativity also follows from work on the interrelations among arousal, release of specific neurotransmitters such as dopamine and noradrenalin, and working memory capacity (cf., Ashby, Valentin, & Turken, 2002; Flaherty, 2005; Nieuwenhuis, Aston-Jones, & Cohen, 2005; Usher, Cohen, Servan Schreiber, Rajkowski, & Aston Jones, 1999). Working memory capacity refers to the ability to hold information transiently in mind in the service of comprehension, thinking, and planning (Baddeley, 2000). Activation and arousal associate with the release of dopamine and noradrenalin, which in turn play a major role in regulating the excitability of the cortical circuitry on which the working memory function of the prefrontal cortex depends (Dreisbach et al., 2005; Goldman-Rakic, 1996). Moderate levels of dopamine associate with improved working memory performance (Floresco & Phillips, 2001; Kimberg, D'Esposito, & Farah, 1997), more efficient processing of task-relevant information (Drabant et al., 2006), increased maintenance of task-relevant information (Colzato, Van Wouwe, & Hommel, 2007), and better switching between tasks (Dreisbach & Goschke, 2004). Moderate (but not extremely high) levels of noradrenalin enhance prefrontal cortex control of behavior, including (short-term) working memory (Robbins, 1984; Usher et al., 1999) and sustained selective attention on task-relevant information (Chamberlain, Muller, Blackwell, Robbins, & Sahakian, 2006).

Apart from a simple motivating effect of activation, the above indicates that activating mood states rather than deactivating mood states come together with higher levels of dopamine and noradrenalin and greater working memory capacity. Working memory capacity is often taken as a prerequisite for cognitive flexibility, abstract thinking, strategic planning, processing speed, access to long-term memory, and sentience (Baddeley, 2000; Damasio, 2001; Dietrich, 2004). In terms of the dual pathway model outlined in the previous section, it thus appears that both for the cognitive flexibility route and for the persistence route, working memory capacity is required and beneficial. Activating rather than deactivating moods increase working memory capacity, thereby facilitating cognitive flexibility and restructuring, as well as more deliberate, analytical, and focused processing and combining of information. Indeed, affect intensity, measured with both negative and positive high arousing terms, relates to higher levels of creativity in children (Russ & Grossman-McKee, 1990) as well as employees (George & Zhou, 2007).

Whether activating mood states produce creative fluency and originality through enhanced cognitive flexibility or perseverance may depend on that mood state's hedonic tone. According to the cognitive tuning model (Clore, Schwarz, & Conway, 1994; Schwarz & Bless, 1991), a positive affective state leads individuals to experience their situation as safe and problem free, to feel relatively unconstrained, to take risks, and to explore novel pathways and new possibilities in a relatively loose way, relying on heuristic processing styles (Fiedler, 2000; George & Zhou, 2007; Schwarz & Clore, 1988). Positive affect facilitates primary process cognition in the right hemisphere, which is holistic and analogical (Martindale & Hasenfus, 1978; Martindale, Hines, Mitchell, & Covello, 1984; also see Derryberry, 1989; Faust & Mashal, 2007; Fink & Neubauer, 2006). Consistent with this is a classic study on positive affect and creativity (Isen & Daubman, 1984). Participants in a state of mild happiness were asked to rate how prototypical several exemplars (e.g., bus, camel) were for a particular category (e.g., vehicle), with higher ratings for the weak exemplar (camel) indicating broad cognitive categories (Amabile, 1983; Eysenck, 1993). Results showed that compared with the control condition, happy participants had higher prototypicality ratings, that is, had broader and more inclusive cognitive categories (also see Isen, Niedenthal, & Cantor, 1992; Mikulincer & Sheffi, 2000; Murray et al., 1990). Other work showed that individuals in happy moods choose a global rather than a local visual configuration and perform faster on visual insight tasks that require set-breaking

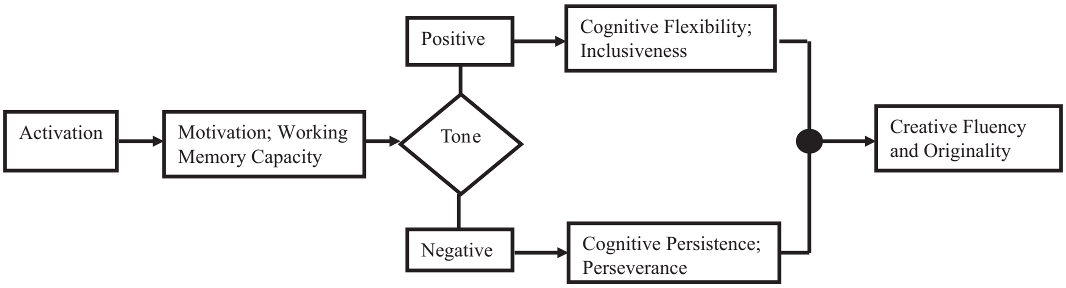

Figure 1. Schematic overview of the roles of activation and tone in the dual pathway to creativity model.

(Fredrickson & Branigan, 2005; Gasper, 2003; Wadlinger & Isaacowitz, 2006).

The cognitive tuning model, and related accounts, thus posits that positive affect allows individuals to be inclusive in their thinking, to switch cognitive categories, and to explore uncommon perspectives; positive affect, in other words, increases cognitive flexibility (cf., Ashby et al., 1999). Negative affect, in contrast, informs the individual that his or her situation is problematic, threatening, and troublesome. Specific action must be taken to remedy the current situation, and this calls for a more constrained, systematic, and analytical approach (Ambady & Gray, 2002; Chaiken, Liberman, & Eagly, 1989; Schwarz & Bless, 1991). Negative affect enhances risk aversion and bolsters detail-oriented processing. It facilitates left hemispherical, secondary process cognition, which is more verbal, sequential, and analytical (Martindale & Hasenfus, 1978; Martindale, Hines, Mitchell, & Covello, 1984; also see Derryberry, 1989; Faust & Mashal, 2007; Fink & Neubauer, 2006). Negative mood states such as anxiety promote narrow perceptual processing, resulting in impaired detection of peripheral (but not central) visual information and impaired performance on secondary (but not primary) tasks; provided it does not become too extreme, such narrowed processing accompanying negative mood states may be adaptive in that it helps prevent distraction while focusing attention on the most important information (Derryberry & Reed (1998). Indeed, negative activating moods such as fear and anxiety lead to narrow cognitive categories (Mikulincer et al., 1990), lowered ability to shift attention (Derryberry & Reed, 1998), and reduced cognitive flexibility (e.g., Carnevale & Probst, 1998). It is important to note that negative activating moods also increase persistence and perseverance (Gasper & Clore, 2002; Gray & Braver, 2002; Strauss, Hadar, Shavit, & Itskowitz, 1981; but see Baumann & Kuhl, 2005). For example, Verhaeghen, Joormann, and Khan (2005) showed that rumination (persisting, conscious, and negatively valenced self-related thoughts) correlated with creative fluency and originality and that this relationship appeared to be due to greater seriousness about and more time spent on creative activities.

According to our dual pathway model, creative fluency and originality may be achieved through enhanced cognitive flexibility, increased persistence and perseverance, or some combination thereof. On the basis of stress-performance literature and psychophysiological and neuroimaging work on arousal and working memory capacity, we argued that activating moods enhance creative fluency and originality more than do deactivating moods. From a combination of this with the cognitive tuning model (Schwarz & Bless, 1991), the broaden-and-build perspective (Fredrickson, 1998), and the work on visual and conceptual focusing (e.g., Derryberry, 1989), it follows that activating moods that are positive in tone increase creative fluency and originality primarily through enhanced cognitive flexibility, whereas activating moods that are negative in tone increase creative fluency and originality primarily through enhanced persistence and perseverance. Put differently, whereas we would not necessarily expect differences in creative fluency and originality between activating positive (e.g., happy, elated) moods and activating negative (angry, fearful) moods, we would expect activating positive moods to associate with broader and more inclusive cognitive categories, with greater diversity in the cognitive categories used to generate ideas, and with fast completion times in creative insight tasks. Vice versa, we would expect activating negative moods to associate with more ideas within specific cognitive categories and with relatively long completion times in creative insight tasks.[1]

Figure 1 provides a schematic overview of the way activation and hedonic tone influence the two routes toward creative fluency and originality. As can be seen, the level of activation associated with a particular mood state serves as the critical entry point, with higher activation leading to greater fluency and originality. However, which pathway is used depends on a mood state's hedonic tone, with positive tone facilitating the cognitive flexibility route and negative tone facilitating the cognitive perseverance route.

Some indirect evidence for our model is available, albeit outside the domain of creative performance. In their review of the psychological, neurochemical, and functional neuroanatomical mediators of the effects of positive and negative mood on executive

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[1] Activation not only varies as a function of mood but also, for example, as a function of physical exercise (see also Kaufmann & Vosburg, 1997). Work on physical exercise and creativity is somewhat inconclusive, however, with some finding no differences between exercise and baseline conditions (Isen et al., 1987; Vosburg, 1998), and others finding physical exercises to lead to more divergent thinking (Blanchette, Ramocki, O'Del & Casey, 2005; Steinberg, Sykes, Moss, Lowery, & LeBoutillier, 1997). Unfortunately, in most of these studies, no manipulation checks for exercise-induced arousal or activation and no controls for participants' physical condition were included, and it is unclear whether the exercise induced low, moderate, or high physical arousal. Furthermore, the tasks used in these experiments capitalized on cognitive flexibility (e.g., functional fixedness, remote associations), which may explain why, in a few cases (e.g., Isen et al., 1987; Vosburg, 1998), happiness (activating positive mood) produced more creativity than did exercise-induced arousal. We return to this in the Conclusions and General Discussion section.

functions, Mitchell and Phillips (2007) concluded that negative mood effects on executive functioning are mediated by serotonin, whereas positive mood effects may be mediated by dopamine, with serotonin being particularly involved in effortful processes associated with goal-directed activity and dopamine being particularly involved in switching flexibly between categories and tasks (e.g., Ashby et al., 1999). Spering, Wagener, and Funke (2005) found no overall differences in complex problem solving between positive and negative mood states but did find that negative mood states produced a stronger focus on seeking and using information. Brand, Reimer, and Opwis (2007), finally, showed that participants in a negative mood solved transfer tasks less efficiently than did those in a positive mood; negative mood participants needed more repetitions to reach a mastery level but did not differ from those in a positive mood in their ultimate problem-solving ability. Thus, indeed, there is some evidence that a mood state's hedonic tone alters the processes by which individuals perform cognitive tasks and solve problems.

The Present Study: Overview and Hypotheses

To test our model on creative fluency and originality as a function of a mood state's activation and tone, we conducted four studies. In the first three studies, we used self-generated imagery to induce different mood states (cf., DeSteno, Petty, Rucker, Wegener, & Braverman, 2004; Strack, Schwarz, & Gschneidinger, 1985), some of which were negative in tone (anger, fear, sadness, depression) and some of which were positive in tone (happiness, elation, calm, relaxation). Apart from a hedonic tone contrast, this design allowed us to compute an activation contrast (activating moods [angry, fearful, happy, elated] versus deactivating moods [sad, depressed, calm, relaxed]) that is orthogonal to the hedonic tone contrast or their interaction. In Study 4, we surveyed individuals' self-reported mood states— negative activating, positive activating, negative deactivating, or positive deactivating—and used regression analyses to relate these mood dimensions to creative performance. We also used, across studies, different tasks to assess creative performance. In Studies 1 and 4, we engaged participants in a brainstorming task. Apart from creative fluency and originality, from coded ideas we also derived indices of cognitive flexibility (i.e., the number of cognitive categories from which ideas were sampled) and perseverance (i.e., the number of ideas within a particular cognitive category; cf., Rietzschel, De Dreu, & Nijstad, 2007). In Study 2, we focused on cognitive inclusiveness and breadth of cognitive categories that people use, and in Study 3, we assessed performance on a Gestalt Completion Test (Ekstrom, French, Harman, & Dermen, 1976; Friedman & Förster, 2000; Schooler & Melcher, 1995), a classical insight problem in which participants view a series of fragmented pictures of familiar objects and attempt to perceptually integrate and recognize them, to close each gestalt. According to Förster et al. (2004), "this task may also be seen as requiring visual insight inasmuch as each item is ultimately soluble by the average problem solver and is likely to produce an impasse that may be suddenly overcome after continued efforts at solution" (p. 179).

Study 1

In Study 1, we induced one of four different mood states—anger, sadness, happiness, and relaxation—and subsequently asked participants to brainstorm on ways to improve teaching at their university. We predicted that both positive and negative activating moods (happy, angry) would be related to greater creative fluency and originality than would both positive and negative deactivating moods (sad, relaxed; Hypothesis 1), that activating positive moods (happy) would be related to greater category diversity than would any other mood state (Hypothesis 2), and that activating negative moods (angry) would be related to greater within-category fluency than would any other mood state (Hypothesis 3).

Method

Design and participants. Undergraduate students (N = 58, 73% women, 27% men) at the University of Amsterdam participated for €5 (approximately U.S. $6.50), and participants were randomly assigned to one of four different mood conditions (anger, sadness, happiness, relaxation). Gender had no effects, and it is not discussed further. Dependent variables were self-reported activation and hedonic tone, as checks for the mood manipulation, and creative performance during brainstorming as reflected in number of unique ideas, originality of the ideas, number of cognitive categories used (cf. cognitive flexibility), and within-category fluency (cf. cognitive persistence).

Procedure and manipulation of discrete moods. Participants came to the laboratory, and they were seated in individual cubicles equipped with a chair, a desk, and a computer with keyboard. Participants were told that they would be asked to participate in two different and independent studies; one was an autobiographical memory task (the task used to manipulate discrete moods) and the other was a brainstorming task about possible ways to improve the quality of teaching in the psychology department (the task to assess creativity). Participants were then asked to write down their gender and age and to write a short essay about a situation that happened to them and that made them feel really _____ (depending on discrete mood condition: angry, sad, happy, relaxed). They were given an entire page to report their situation and were asked, after finishing their autobiographical story, to report those keywords or (parts of) phrases they considered vital in making them feel _____ (depending on discrete mood condition: angry, sad, happy, relaxed; In this experiment, and subsequent ones, the content of the stories participants wrote always adhered to instructions. Furthermore, we were unable to discern systematic differences between conditions in length of stories or particular topics participants wrote about.)

Upon completion of the mood manipulation task, participants were asked to brainstorm about possible ways to improve the quality of teaching in the psychology department. Participants were reminded that the department attracted more and more new students each year and that this put some pressure on the quality of teaching, "as some of you may have already experienced." They were further told that the departmental teaching staff was interested in their problem solutions and that they would be given 8 min to type in as many ideas, solutions, or suggestions as they could think of. We emphasized that idea generation would be anonymous and that no one would ever be able to link ideas to names or student identification numbers. Hereafter, participants were asked to start generating ideas. They could type in an idea, and by hitting the Enter key, they could submit this idea and receive a new opportunity to type in an idea. This procedure continued for 8 min, after which participants were informed that the brainstorming session was over, and they were asked to answer a few questions. Then, they were told that the experiment was over, and they were debriefed, paid, and dismissed.

Dependent variables. The ideas, problem solutions, and suggestions generated by the participants were coded and/or transformed into four different components of creativity. First, independent coders counted the number of unique ideas generated per participant (Cohen's K = .98). This was our measure of creative fluency. To obtain a measure of originality, independent coders rated each unique idea for originality, defined as "an idea or suggestion that is infrequent, novel, and original" (1 = *not original at all* to 5 = *very original*). Interrater agreement was satisfactory following criteria as per Cicchetti & Sparrow (1981; intraclass correlation, ICC[1] = .69) and we used the aggregation across raters as an indicator of originality.

To get at cognitive flexibility, we assigned each unique idea to one of the following seven categories: Ideas having to do with (a) university environment, such as (architecture of) lecture halls, seminar rooms, and opening hours; (b) student facilities, such as extracurricular activities, library access, and classroom interiors; (c) student quality, including selecting better students and increasing cooperation and contact among students; (d) teaching materials, such as readers, textbooks, handouts of PowerPoint presentations, examination issues, and grading systems; (e) teachers, such as teacher training and selection, use of teaching evaluations, and use of mentors and coaches; (f) policy, such as scholarships and other financial issues, information distribution, and reduced bureaucracy; and (g) other issues. The higher the number of categories used, the greater the participant's cognitive flexibility (e.g., Nijstad et al., 2002, 2003). Interrater agreement was good (Cohen's K = .71), and differences were solved through discussion. To get at perseverance, we assessed within-category fluency: the number of unique ideas divided by the number of categories from which these ideas were sampled.

To check the manipulation of hedonic tone and level of activation, we asked participants how positive they felt (1 = *not positive at all* to 5 = *very positive*) and how activated they felt (1 = *not very activated* to 5 = *very activated*).

Results

Manipulation checks. A 2 (activating vs. deactivating) × 2 (negative tone vs. positive tone) analysis of variance (ANOVA) on self-reported activation revealed only that activating moods (anger, happiness) produced somewhat higher activation than deactivating moods (sadness, relaxation; $M = 3.62$ vs. $M = 3.12$), $F(1, 54) = 3.78$, $p < .06$ (marginal). Such a 2 × 2 ANOVA on self-reported tone revealed only that positive moods (happiness, relaxation) produced more positive feelings than did negative moods (anger, sadness; $M = 2.43$ vs. $M = 1.94$), $F(1, 54) = 4.12$, $p < .05$. We conclude that our manipulations were successful.

Creative fluency and originality. We submitted the number of unique ideas to a four level (angry, sad, happy, relaxed) one-way ANOVA. No effects were significant, but a directional test of Hypothesis 1 with planned comparisons showed that more ideas were generated when participants were in an activating mood rather than in a deactivating mood, $t(54) = 1.65$, $p < .05$, $\eta^2 = .05$ (see also Table 1) Hedonic tone had no effects (*t*s < 1). We conclude that creative fluency is a function of the extent to which a mood activates or deactivates (cf., Hypothesis 1).

We submitted the averaged originality of ideas to a four level (angry, sad, happy, relaxed) one-way ANOVA. As predicted, mood influenced originality, $F(3, 54) = 3.42$, $p < .025$. A follow-up comparison showed that activating moods (happy, angry) produced more original ideas than did deactivating moods (sad, relaxed), $t(54) = 3.12$, $p < .003$, $\eta^2 = .15$ (for cell means, see Table 1). Hedonic tone did not matter: The planned comparison of positive states (happy, relaxed) with negative states (angry, sad) was not significant ($M = 2.52$ vs. $M = 2.39$), $t(54) < 1$, *ns,* nor was the interaction between tone and activation, $F(1, 54) < 1$, *ns*. From these results, we conclude that originality of produced ideas is a function of the extent to which a mood activates or deactivates. This supports Hypothesis 1.

Cognitive flexibility. We submitted the number of categories from which ideas were sampled to a four level (angry, sad, happy, relaxed) one-way ANOVA. Means were in the predicted direction (also see Table 1), but there were no significant effects to support the hypothesis (Hypothesis 2) that cognitive flexibility is highest among activating, positive moods.

Persistence. A four level ANOVA on persistence showed a trend for mood, $F(3, 54) = 2.44$, $p < .075$. Planned contrasts were computed to examine effects of activation, effects of hedonic tone, and their interaction on persistence. Neither the simple activation contrast nor the simple hedonic tone contrast was significant, $t(54) = 1.52$, $p < .14$, $\eta^2 = .04$, and $t(54) = -1.05$, $p < .43$, $\eta^2 = .01$, respectively. However, the Tone × Activation contrast was significant, $t(54) = 2.66$, $p < .025$, $\eta^2 = .06$, showing that anger

Table 1
Means and Standard Deviations for Fluency, Originality, Flexibility, and Perseverance as a Function of Mood (Study 1)

	Mood state							
	Angry		Sad		Happy		Relaxed	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Creative fluency	13.32	5.11	10.16	5.67	11.88	5.32	10.42	5.27
Originality	2.73_{a}	0.71	2.06_{b}	0.79	2.77_{a}	0.66	2.26_{b}	0.74
Flexibility	3.65	1.11	3.56	1.19	4.01	1.52	3.46	1.77
Perseverance	3.64_{a}	1.09	2.85_{b}	0.71	2.96_{b}	0.69	3.01_{b}	0.90

Note. Means within a row not sharing the same subscript differ significantly at $p < .05$.

produced greater persistence than did the other three mood states (see also Table 1). This supports Hypothesis 3.

Discussion and Introduction to Study 2

The results support the hypothesis (Hypothesis 1) that activating mood states produce greater creative fluency and originality than do deactivating mood states, and the results support the hypothesis (Hypothesis 3) that activating negative moods produce greater persistence than does any other mood state. One potential limitation of this support, which pertains to the persistence effect in particular, is that effects are tied to one specific mood state (anger). In the next studies, we deal with this by inducing multiple mood states that are similar in tone and activation (e.g., anger and anxiety vs. sadness and depression; elation and happiness vs. relaxation and calm). Replicating support for Hypothesis 1 and 3 would reduce the concern that effects are tied to aspects of a specific mood state other than activation and tone.

Although means were in the predicted direction, Study 1 did not support the hypothesis (Hypothesis 2) that activating positive moods produce greater cognitive flexibility than does any other mood state. Given the strong support in the literature that positive mood states foster cognitive flexibility (e.g., Ashby et al., 1999), the current failure may reflect a Type II error, and a conceptual replication is needed before concluding anything with regard to Hypothesis 2. Accordingly, in Study 2, we asked participants to complete the category inclusion task previously used by Isen and Daubman (1984). We predicted greater category inclusiveness for activating than for deactivating moods when tone is positive (cf., Hypothesis 2). Given that negative tone has been related to narrow perceptual focus (e.g., Derryberry, 1988; Mikulincer et al., 1990), it may be that activating moods produce reduced category inclusiveness when tone is negative. In other words, we expected greater category inclusiveness among activating moods than among deactivating moods when tone is positive rather than negative. We included a mood-neutral control condition in which participants did not do the self-generated imagery and only performed the category inclusion task. This permitted us to explore whether (de)activation and positive (negative) tone promote (inhibit) category inclusiveness.

Method

Design and participants. Undergraduate students (N = 179, 73% women, 27% men) participated for €5 (approximately U.S. $6.50), and they were randomly assigned to one of eight different mood conditions (anger, fear, sadness, depression, happiness, elation, relaxation, calm) or to the mood-neutral control condition. Gender had no effects, and it is not discussed further. Dependent variables were self-reported activation, hedonic tone, and category inclusiveness.

Procedure and manipulation of discrete moods. Participants were seated in individual cubicles and told that they would participate in two independent studies: one about autobiographical memory (the task used to manipulate discrete moods) and one about object recognition (the task used to assess cognitive flexibility). Participants were then given a booklet with instructions about the autobiographical memory study. Discrete moods were manipulated as before, except that participants wrote their essays in separate booklets. In the control condition, the self-generated imagery task was not included, and participants immediately went on with the study about object perception.

Upon completion of the mood manipulation task, participants handed in their booklet, and they were asked to turn to their computer to continue with the next experiment about object perception. First, they once again filled in their gender and age (to increase the suggestion that indeed a new and independent experiment had started), and participants were given the category inclusion task to assess their cognitive flexibility (see below). Thereafter, they completed several manipulation checks, and participants were fully debriefed, paid for participation, and dismissed.

Dependent variables. To assess cognitive inclusiveness, participants were asked to rate how prototypical exemplars were of a particular category (1 = *not at all* to 10 = *very prototypical*). For each of the four categories we used, three exemplars were presented, one being strongly, one being moderately, and one being weakly prototypical (see Rosch, 1975). Specifically, the four categories (with strong, intermediate, and weak exemplars) were vehicle (bus, airplane, camel), vegetable (carrot, potato, garlic), clothes (skirt, shoes, handbag), and furniture (couch, lamp, telephone). Inclusion ratings across the four categories were aggregated into separate indices for strong, moderate, and weak exemplars (α = .78, .82, and .74, respectively). Cognitive flexibility usually shows up in prototypicality ratings for the weak exemplars more than in ratings for the moderate or strong exemplars (Isen, Daubman, & Nowicki, 1987; Rosch, 1975).

Upon completion of the category inclusion task (and because of an administrative error in the mood conditions, only), we measured hedonic tone by asking participants to rate their affective state on three items (how do you feel: *very positive–very negative; very pleasant–very unpleasant; very nice–not at all nice*). Ratings were aggregated (α = .89) and coded so that higher scores indicated more positive (and less negative) tone. In addition, we included a measure of activation level. Specifically, we asked participants to rate the following: (a) how energetic do you feel, (b) how engaged are you, and (c) how active are you presently? (1 = *not at all* to 5 = *very much*). Ratings were averaged into one activation level index (α = .79).

Results

Manipulation checks. Ratings for the activation level measure were tested in two planned comparisons, one testing all four negative mood states (anger, fear, sadness, depression) against all four positive mood states (happiness, elation, relaxation, calm) and one testing all four deactivating mood states (sadness, depression, relaxation, calm) against all four activating mood states (anger, fear, happiness, elation). Results were as expected: Whereas the hedonic tone contrast was not significant, $t(155) < 1$, *ns*, the activation contrast was, $t(155) = 1.97$, $p < .05$. Participants reported more activation when activating moods had been induced ($M = 4.73$) than when deactivating moods had been induced ($M = 4.53$).

Ratings for the tone measure were tested in the same two planned comparisons. Results were as expected: Whereas the activation contrast was not significant, $t(155) < 1$, *ns*, hedonic tone contrast was, $t(155) = 4.03$, $p < .01$. Participants reported more positive tone when positive moods had been induced ($M = 4.23$) than when negative moods had been induced ($M = 2.53$). We conclude that our manipulations were successful.

Cognitive flexibility. Table 2 gives the mean prototypicality of strong, intermediate, and weak exemplars per condition. Hypothesis 1 was tested in a planned contrast grouping all activating moods versus all deactivating moods. This contrast was not significant for the strong and intermediate exemplars, $ts(170) < 1$, *ns,* but was significant for weak exemplars, $t(170) = 2.10$, $p < .037$, $\eta^2 = .03$. Prototypicality ratings for weak exemplars were higher in activating mood conditions ($M = 6.43$) than in deactivating mood conditions ($M = 5.98$).

Hypothesis 2 predicted that activating mood states lead to greater inclusiveness, especially when tone is positive. A directional contrast showed that positive activating moods produced higher inclusiveness ($M = 6.51$) than did all of the negative mood states and the two deactivating positive mood states ($M = 6.10$), $t(170) = 1.82$, $p < .035$, $\eta^2 = .025$. Furthermore, among the positive moods, the two activating moods produced greater category inclusiveness than did the two deactivating conditions and the control condition, $t(170) = 1.98$, $p < .05$, $\eta^2 = .033$, whereas both of the negative activating moods did not produce greater category inclusiveness than did the two deactivating moods and the control condition, $t(170) = 1.48$, $p < .14$, $\eta^2 = .016$. However, these patterns notwithstanding, the Tone × Activation contrast was not significant, and Hypothesis 2 received no support; the trend for negative activating moods to produce greater inclusiveness is weaker but is otherwise in the same direction as the trend for positive activating moods.

Comparisons involving the mood-neutral baseline. The conclusions emerging from the above analyses are further supported by specific contrasts involving the mood-neutral control condition (for cell means, see Table 2). First, activating moods (positive and negatives together) produced higher inclusiveness ratings for weak exemplars than did mood-neutral control condition ($M = 6.43$ vs. $M = 5.71$), $t(170) = 1.98$, $p < .05$, $\eta^2 = .04$. It is interesting to note that deactivating moods (positives and negatives together) did not produce lower inclusiveness ratings for weak exemplars than did mood-neutral control condition ($M = 5.98$ vs. $M = 5.71$), $t(170) < 1$, ns.

Second, consistent with past work (e.g., Isen & Daubman, 1984), we found that happy participants had higher prototypicality ratings for weak exemplars than did control participants, $t(170) = 2.03$, $p < .044$, $\eta^2 = .051$. Positive activating moods (happy and elated) produced higher inclusiveness ratings than did the mood-neutral control condition, $t(170) = 1.96$, $p < .05$, $\eta^2 = .031$, whereas positive deactivating moods did not produce higher or lower inclusiveness ratings, $t(170) < 1$, *ns*. This supports the idea that activating moods promote cognitive flexibility and inclusiveness when tone is positive. However, as mentioned, because the same (nonsignificant) trend emerged for negative activating moods versus deactivating moods, we cannot conclude that Hypothesis 2 received support.

Discussion and Introduction to Study 3

Study 2 shows that activating moods increase category inclusiveness. Together with Study 1, we thus have reasonable support for the dual pathway model, which indicates that activating mood states promote creative fluency and originality more than do deactivating mood states and that perseverance is higher among activating moods that are negative in tone (cf. Study 1). Although trends in the data suggested that cognitive flexibility was higher among activating moods that are positive in tone (cf. Study 2), these tendencies for cognitive flexibility were fairly weak—in Study 1, means were as predicted but were not statistically reliable; in Study 2, the critical Activation × Tone interaction was not significant.

At present, it cannot be excluded that category diversity (Study 1) and category breadth and inclusiveness (Study 2) reflect not only cognitive flexibility but also persistence and perseverance. Those in an activating positive mood may be cognitively flexible and may, therefore, include peripheral exemplars (e.g., camel) in a particular category (e.g., vehicle). Those in an activating negative mood may persevere and systematically explore possibilities, ultimately concluding that peripheral exemplars fit into a particular category. This possibility implies that those in an activating positive mood are faster than those in an activating negative mood, which indeed fits the results of Isen et al. (1987). In Study 2, we did not track time-on-task and cannot examine this possibility. In Study 3, however, we included time-on-task as a key variable.

The evidence for our model thus far pertains to cognitive and conceptual material (idea generation, cognitive category inclusiveness), and an issue is whether our dual pathway model also predicts perceptual insights and creativity. Creative insight problems differ from the tasks used thus far in that they are soluble, are likely to produce an impasse and a state of high uncertainty as to how to proceed, and are likely to produce a kind of "aha" experience when the impasse is suddenly overcome and the solution is discovered after prolonged efforts at solution (Förster et al., 2004; Schooler et al., 1993). Such tasks can be solved heuristically, through loose and detached processing, which is relatively effortless and fast (Brand et al., 2007). Alternatively, they can also be solved through persevering and analytical probing of a series of

Table 2
Mean Prototypicality Ratings as a Function of Experimental Manipulations (Study 2)

	Experimental condition								
Exemplars	Angry	Fearful	Depressed	Sad	Happy	Elated	Relaxed	Calm	Control
Strong	9.64	9.42	9.57	9.68	9.48	9.56	9.56	9.75	9.62
Intermediate	7.53	7.71	7.86	7.76	7.36	6.93	6.90	7.17	7.25
Weak	6.51	6.22	5.95	5.88	6.63	6.38	6.13	5.88	5.71

Note. Higher numbers indicate greater category inclusiveness.

hypotheses. This is a relatively effortful and time-consuming process.

From our dual pathway model it follows that activating moods, more than deactivating moods, lead to greater creative fluency and, accordingly, that individuals in activating moods perform better on creative insight tasks—they close more gestalts (see below) – than do those in deactivating moods (cf. Hypothesis 1). Because positive affective tone increases cognitive flexibility and restructuring and pairs with a broader visual field, we further expected that individuals in positive activating moods would be able to perform creative insight tasks in relatively short time and would not benefit from longer time-on-task. But, because negative affective tone increases persistence and more effortful processing and pairs with attentional focus, we expected that individuals in negative activating moods benefit from longer time-on-task when performing creative insight tasks. Put differently, whereas we did not expect differences in creative fluency between positive and negative mood states, we did expect longer time-on-task to associate with creative fluency among (activating) negative mood states more than among (activating) positive mood states.

Method

Design and participants. Undergraduate students ($N = 90$, 66% women, 34% men) participated for €5 (approximately U.S. $6.50) and were randomly assigned to one of eight different mood conditions (anger, fear, sadness, depression, happiness, elation, relaxation, calm) or to the mood-neutral control condition. Gender had no effects, and it is not discussed further. Dependent variables were manipulations checks, number of correctly closed Gestalts, and time-on-task.

Procedures, mood manipulations, and creativity task. These were the same as in Study 2, except that all materials were provided through computers, and responses had to be given using a keyboard and a computer mouse. Furthermore, to enhance comparability between mood conditions, we also asked participants in the mood-neutral control condition to perform a task about autobiographical memory. Participants were asked to write a short essay about the route they took to the psychology department. They were specifically asked to pay attention to the buildings they passed and to write their essay in such a way that another person could imagine the route they took. After finishing their autobiographical story, they were asked to report the major building that they passed. Third and finally, we replaced the category inclusion task with the gestalt completion task, adapted from Förster et al. (2004), which involves recognizing fragmented pictures of familiar objects. After the gestalt completion task, participants answered a short questionnaire, were debriefed, and were paid for participation.

Dependent variables. The hedonic tone and activation manipulations were checked, as in Study 2. We coded the number of closed gestalts as correct, incorrect, or missed. Although we had 10 gestalts, initial analyses revealed one picture to be unsolvable (less than 30% correctly closed, and over 50% missed). We decided to base analyses on the remaining 9 pictures (including the tenth gestalt produced similar results and identical conclusions). For each gestalt, we tracked the time in seconds between the appearance of the gestalt on the computer screen and the response (either a word or a hard return indicating a miss). The total time across the nine gestalts served as our second dependent measure.

Results

Manipulation checks. Ratings for the activation level measure were tested in two directional comparisons. The first tested all four negative mood states (anger, fear, sadness, depression) against all four positive mood states (happiness, elation, relaxation, calm), and the second tested all four deactivating mood states (sadness, depression, relaxation, calm) against all four activating mood states (anger, fear, happiness, elation). Results were as expected: Whereas the hedonic tone contrast was not significant, $t(81) < 1$, *ns*, the activation contrast showed a trend in the predicted direction: Participants reported more activation when activating moods had been induced ($M = 3.35$) than when deactivating moods had been induced ($M = 2.69$), $t(81) = 1.53$, $p < .06$. The control condition fell in between ($M = 3.11$) and did not differ from the activating or deactivating mood conditions, $ts(81) < 1$, *ns*.

For the tone measure, results were also as expected: Whereas the activation contrast was not significant, $t(81) < 1$, *ns*, the hedonic tone contrast was, $t(81) = 2.04$, $p < .025$. Participants reported more positive tone when positive moods had been induced ($M = 2.89$) than when negative moods had been induced ($M = 2.53$). The control condition fell in between ($M = 2.69$) and did not differ from both the positive and the negative mood conditions, both $t(81) < 1.20$, *ns*.

Creative fluency. The number of correctly closed gestalts was analyzed using the same set of a priori contrasts as used in Study 2. Means and standard deviations, broken down for experimental condition, are given in Table 3.

The planned comparison grouping all positive mood states versus all negative mood states was not significant, $t(81) < 1$, *ns*. However, consistent with Hypothesis 1, a planned contrast grouping all activating moods versus all deactivating moods was significant, $t(81) = 2.13$, $p < .036$. Participants in activating mood conditions had more correctly closed gestalts ($M = 7.02$) than did those in deactivating mood conditions ($M = 6.25$). Directional tests within the negative mood states showed that activating moods produced more correct responses than did deactivating moods, $t(81) = 1.85$, $p < .05$. Likewise, within the positive mood states, activating moods produced more correct responses than did deactivating moods, $t(81) = 1.75$, $p < .05$.[2]

Cognitive flexibility and persistence. The time participants needed to correctly close the gestalts was log-transformed to deal with skewness. A 2 × 2 (Tone × Activation) ANOVA on log-transformed time revealed the expected interaction between tone

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[2] Differences in correctly closed gestalts may be due to differences in incorrectly closed gestalts, and/or differences in number of nonresponses. For incorrect responses, no a priori contrasts were significant, $ts(81) < 1$, but participants in the activating mood conditions tended to miss fewer than did those in the deactivating mood conditions ($M = 1.10$ vs. $M = 1.73$), $t(81) = -1.84$, $p < .07$. This suggests that the lower number of correct closures in the deactivating mood conditions is due to a higher number of missed responses. Furthermore, inspection of Table 3 may suggest that anger and fear differ in terms of correctly closed gestalts and in number of misses. Statistically, however, this is not the case, $ts(81) = 0.92$ and $–1.32$, $ps > .22$, respectively.

Table 3

Means and Standard Deviations for Creative Performance and Time-on-Task as a Function of Experimental Manipulations (Study 3)

	Experimental condition																	
	Angry		Fearful		Depressed		Sad		Happy		Elated		Relaxed		Calm		Control	
Dependent variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Correct	7.36	1.20	6.70	0.94	6.11	1.73	6.37	1.19	7.00	1.00	7.00	1.41	6.00	2.01	6.55	1.58	6.67	0.89
Missed	0.90	0.90	1.40	0.69	1.67	1.50	2.00	1.85	1.34	1.13	1.25	1.04	1.90	1.37	1.58	1.48	1.53	0.99
Time-on-task	1.80	0.13	1.79	0.12	1.74	0.16	1.78	0.08	1.73	0.12	1.78	0.18	1.79	0.18	1.76	0.14	1.80	0.17
Time for correctly closed gestalts	1.68	0.21	1.64	0.15	1.54	0.17	1.53	0.21	1.57	0.12	1.58	0.13	1.58	0.14	1.57	0.15	1.57	0.15

Note. Data for time-on-task and time on correctly closed gestalts are log-transformations of seconds across nine trials.

and activation, $F(1, 71) = 2.69$, $p < .10$ (marginal).[3] Participants spent a significantly longer time on the task in the negative activating mood conditions than in the negative deactivating mood conditions ($M = 4.01$ min vs. $M = 3.11$ min), $F(1, 71) = 3.98$, $p < .05$, and a nonsignificantly shorter time in the positive activating mood conditions than in the positive deactivating mood conditions ($M = 3.01$ vs. $M = 3.22$, $F < 1$). It thus appears that longer time-on-task benefits participants in activating negative moods, who tend to persist, but not those in activating positive moods (see Table 3 for log-transformed overall time-on-task, and time needed to correctly close).

A complementary perspective is obtained by regressing creative fluency (number of correct responses) on level of activation, hedonic tone, time-on-task, and their interactions. This produced a significant regression model, $R^2 = .16$, $F(6, 68) = 2.23$, $p < .05$. Consistent with the contrast analyses reported before, the main effects for hedonic tone ($\beta = -.039$, $t < 1$) and for time-on-task ($\beta = -.11$, $t < 1$) were not significant, whereas the activation main effect was ($\beta = .21$, $t = 1.98$, $p < .05$). Furthermore, the interaction between hedonic tone and time-on-task was significant in the activating mood conditions ($\beta = -.52$, $t = -3.72$, $p < .001$) and not in the deactivating mood conditions ($\beta = -.15$, $t < 1$). Among activating negative mood states, longer time-on-task associated with more correct responses ($\beta = .32$, $p < .05$); among activating positive mood states, shorter time-on-task associated with more correct responses ($\beta = -.76$, $p < .01$). This pattern of results strongly suggests that cognitive processes underlying creative performance qualitatively differ between positive and negative activating mood states. This is consistent with our notion that positive tone impacts creative performance because it allows for cognitive flexibility and set-breaking (cf. Hypothesis 2), whereas negative tone impacts creative performance because it engenders cognitive persistence and perseverance (cf. Hypothesis 3). Furthermore, results suggest that participants in a negative activating mood profited from longer time-on-task, whereas those in a positive activating mood or those in a (positive or negative) deactivating mood did not.

Discussion and Introduction to Study 4

Across a variety of tasks, results showed that activating moods produce more creative fluency and originality than do deactivating moods. We also found that higher creativity associated with enhanced perseverance in the case of negative tone. However, with regard to the idea that cognitive flexibility is enhanced in the case of activating positive moods, evidence was less strong and, in Study 1, statistically not reliable. Furthermore, we did not test the idea that cognitive flexibility (persistence) mediates between positive (negative) activating moods on the one hand and creative fluency and originality on the other. In Study 4, we used the brainstorming task of Study 1 and, to enable formal tests of mediation, engaged a much larger number of participants. We expected higher creative fluency and originality among activating moods than among deactivating moods to be due to greater cognitive flexibility when mood states are positive in tone (Hypothesis 4) and to greater persistence when mood states are negative in tone (Hypothesis 5).

Another goal of Study 4 was to replicate results with a different assessment of mood states. Whereas the first three studies provided good evidence for the causal effects of discrete moods, we cannot exclude a monomethod/operation bias—the possibility that our findings are limited to the specific ways we manipulated mood states in Studies 1—3. In Study 4, we therefore used a different method: Participants rated their current mood state on a number of adjectives that were grouped according to their being positive in tone or negative in tone and, independently, activating or deactivating. These four dimensions were correlated with creativity indices.

Method

Design and participants. We used a correlational design with measures of discrete moods as predictor variables and brainstorming performance—creative fluency, originality, cognitive flexibility, and within-category fluency—as dependent variables. Participants were 546 first year psychology students (74% women, 26%

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[3] An alternative approach would be to compute planned comparisons and to use the overall error terms and degrees of freedom (i.e., those of the control condition as well). Doing so yields a highly significant contrast of negative activating moods against all others, $t(81) = 2.28$, $p < .025$, or against the negative deactivating moods, $t(81) = 2.27$, $p < .03$. No such effects were obtained when activating positive moods were contrasted against all others or against positive deactivating mood, $ts(81) < 1$, *ns*.

men) at the University of Amsterdam. They participated for partial fulfillment of a course requirement.

Procedure and independent variables. The study was included in mass testing sessions (approximately 50 participants per session). Participants were seated in large lecture halls behind personal computers, which displayed all materials. Responses to questions could be typed in using the computer keyboard. Participants were not allowed to talk and were required to work individually, at their own pace, and without consulting others. Experimenters supervised testing sessions and, when necessary, helped participants or enforced the above rules (this happened rarely).

Discrete moods were assessed by asking participants to complete a series of items that we derived from the PANAS (Watson et al., 1988) or generated for the specific purpose of this study. In total, participants indicated for each of 29 mood items how much of the mood they had experienced since they got up that morning (1 = *not at all* to 5 = *very much so*). Thereafter, supposedly as part of a new and unrelated testing session, we introduced the brainstorming task (for further detail, see the *Method* section of Study 1). When time was over, participants were informed that the test was completed, and they continued with another, unrelated test. At the end of the semester, all participants received a written debriefing along with a mailing address for further questions, and a complaint form to be submitted when they did not want their data to be used (no additional questions or complaints were received).

Independent variables. Initial factor analysis of the mood ratings revealed a six-factor solution, with four factors being readily interpretable and two factors grouping 5 items that had high cross-loadings with other factors. These 5 items were dropped, and the remaining 24 items were submitted to a principal component analysis. Because, in theory, dimensions could be correlated, we applied oblimin rotation with Kaiser normalization. As expected, we found a four-factor solution, explaining a total of 62% of the variance. Table 4 summarizes the factor loadings and cross-loadings for all items on all four factors. The first factor groups negative activating moods (e.g., angry, guilty), the second factor groups positive activating moods (e.g., happy, elated), the third factor groups negative deactivating moods (e.g., depressed, discouraged), and the fourth factor groups positive deactivating moods (e.g., calm, relaxed). Ratings within each factor were averaged to form one index. Internal reliabilities (Cronbach's alphas) were acceptable to good (see the *Results* section).

Dependent variables. The ideas, problem solutions, and suggestions generated by the participants were coded and/or transformed into the same components of creativity as used in Study 1 (i.e., creative fluency, originality, cognitive flexibility, and perseverance; .76 < Cohen's K < .98). For originality, interrater agreement was satisfactory, ICC(1) = .67, and we used the aggregation across raters as an indicator of originality.

Results

Table 5 gives the descriptive statistics for all study variables. As can be seen, we found moderate to strong correlations between the four mood dimensions and strong correlation between our four indicators of creativity. Zero-order correlations between mood-dimensions and indicators of creativity were low and generally nonsignificant.

Table 4

Factor Solution and Loadings for Mood Items (Study 4)

Mood item	Factor I	Factor II	Factor III	Factor IV
Disgusted	**.76**	−.31	.29	−.22
Fearful	**.75**	−.31	.34	−.57
Ashamed	**.74**	−.22	.48	−.22
Disdainful	**.73**	−.26	.33	−.12
Worried	**.71**	−.20	.28	−.43
Afraid	**.71**	−.28	.33	−.59
Guilty	**.68**	−.21	.46	−.27
Angry	**.63**	−.17	.38	−.37
Upset	**.62**	−.28	.57	−.54
Happy	−.40	**.83**	−.39	.40
Elated	−.21	**.79**	−.17	.21
Excited	−.14	**.75**	−.18	.08
Drained	.36	−.30	**.85**	−.27
Lifeless	.27	−.40	**.79**	−.24
Fatigued	.26	−.14	**.78**	−.23
Depressed	.36	−.37	**.72**	−.37
Discouraged	.48	−.35	**.64**	−.35
Failed	.46	−.24	**.62**	−.53
Sad	.58	−.33	**.62**	−.51
Calm	−.37	.24	−.37	**.86**
Relaxed	−.34	.54	−.36	**.77**
At ease	−.51	.36	−.37	**.65**
Eigenvalue	9.59	1.97	1.57	1.10
% variance	41.68	8.59	6.77	4.76

Note. Numbers are factor loadings. Factor loadings in bold within one column are grouped together in subsequent analyses. Factor I = negative activating moods; Factor II = positive activating moods; Factor III = negative deactivating moods; Factor IV = positive deactivating moods.

Creative fluency and originality. To test Hypothesis 1, we regressed creative fluency and originality on the four mood dimensions. Results are summarized in Table 6 and showed that first of all, both negative and positive activating moods predicted creative fluency. Second, inspection of the regression weights further reveals that positive activating moods significantly predicted originality. Because neither positive nor negative deactivating mood states were related to creative fluency and originality, these results provide new support for the hypothesis (Hypothesis 1) that activating mood states associate with more fluency and originality than do deactivating mood states.

Cognitive flexibility and perseverance. For cognitive flexibility (i.e., category diversity), regression weights in Table 6 revealed that only positive activating moods predicted flexibility; no other predictor was significant. This supports the hypothesis (Hypothesis 2) that activating moods promote cognitive flexibility, especially when tone is positive. Regression weights in Table 6 also reveal that only negative activating moods predicted within-category fluency. This supports the hypothesis (Hypothesis 3) that activating moods lead to greater persistence, especially when tone is negative.

Mediation tests. To test for mediation (i.e., Hypothesis 4 and 5) we computed a series of regression along the criteria set forth by Kenny, Kashy, and Bolger (1998). We first tested whether cognitive flexibility mediates the effects of positive activating moods on creative fluency and originality (Hypothesis 4). When we regressed originality on positive activating moods after controlling for flexibility, the originally significant effect of positive activating

Table 5
Descriptive Statistics for Dependent and Independent Variables (Study 4)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1. Negative activating moods	2.03	0.69	.88	$-.45^{***}$	$.71^{***}$	$-.59^{***}$	.06	$.01^{***}$	$.11^{***}$	−.01
2. Positive activating moods	3.57	0.72		.80	$-.49^{***}$	$.61^{***}$	.07	$.09^{*}$	−.01	$.07^{\dagger}$
3. Negative deactivating moods	2.58	0.81			.88	$-.56^{***}$	.02	.01	.03	.01
4. Positive deactivating moods	3.67	0.78				.81	−.02	.02	−.06	.02
5. Creative fluency	5.06	3.66					—	$.75^{***}$	$.63^{***}$	$.56^{***}$
6. Flexibility	2.30	1.49						—	$.08^{\dagger}$	$.76^{***}$
7. Within-category fluency	1.80	0.97							—	.05
8. Originality	2.68	0.77								—

Note. $N = 546$. Scale reliabilities (Cronbach's α) are on the diagonal. Dashes indicate that there is no scale reliability to report.
$^{\dagger} p < .10$. $^{*} p < .05$. $^{**} p < .01$.

moods dropped to a nonsignificant level ($\beta = .01$, $t < 1$), whereas flexibility was highly significant ($\beta = .76$, $t = 26.90$, $p < .001$). A Sobel test confirmed that the mediation was significant, $z = 2.45$, $p < .015$. In other words, consistent with Hypothesis 4, flexibility fully mediated the effect of positive activating moods on originality (see also Figure 2a; We explored whether positive activating moods relate to higher fluency because of greater cognitive flexibility. This was not the case.)

We also examined whether persistence (i.e., within-category fluency) mediated effects of negative activating moods on creative fluency. When we regressed creative fluency on negative activating moods after controlling for within-category fluency, the initially significant effect of negative activating moods dropped to a nonsignificant level ($\beta = .02$, $t < 1$), whereas the effect of within-category fluency was highly significant ($\beta = .63$, $t = 18.93$, $p < .001$). A Sobel test confirmed that the mediation was significant ($z = 2.46$, $p < .015$). In other words, consistent with Hypothesis 5, perseverance fully mediated the effect of negative activating moods on creative fluency (see also Figure 2b).

Discussion

Activating mood states related to a greater overall number of unique ideas and, when mood states were positive, to higher levels of originality. In the case of negative tone, results further showed that activating moods have their effects on creative performance (i.e., creative fluency) because they enhance within-category persistence. It should be noted though that fluency necessarily correlates with both within-category persistence and category diversity (i.e., multiplying these results in creative fluency). However, negative activating moods only affected creative fluency through increased within-category fluency, and neither effect of negative activating moods on category diversity nor mediation of category diversity was found. In the case of positive tone, results showed that activating moods have their effects on originality because of greater cognitive flexibility. These findings fit well with those of the previous studies and support our theoretical framework. Further, Study 4 showed that creativity was related to activating moods and not to deactivating moods. This suggests that activation stimulates creative performance rather than that deactivation undermines creative performance.

Conclusions and General Discussion

In their *Annual Review of Psychology* article, Brief and Weiss (2002, p. 297) stated,

> It is apparent that discrete emotions are important, frequently occurring elements of everyday experience. Even at work—perhaps especially at work—people feel angry, happy, guilty, jealous, proud, etcetera. Neither the experiences themselves, nor their consequences, can be subsumed easily under a simple structure of positive or negative states.

Quite consistent with this observation, the current study indeed showed that positive and negative mood states differentiate in terms of activating or deactivating nature (cf. Russell & Barrett,

Table 6
Regression of Cognitive Flexibility, Creative Fluency, Within-Category Fluency, and Originality on Positive Activating, Positive Deactivating, Negative Activating, and Negative Deactivating Moods (Study 4)

	Creative fluency			Flexibility			Within-category fluency			Originality		
Predictor variable	β	*t*	R^2	β	*t*	R^2	β	*t*	R^2	β	*t*	R^2
Negative activating moods	.12	2.00^{*}		.02	<1		.16	2.48^{**}		−.01	<1	
Positive activating moods	.13	2.29^{**}		.14	2.47^{**}		.04	<1		.11	1.98^{**}	
Negative deactivating moods	−.02	<1		.04	<1		−.08	−1.30		.06	<1	
Positive deactivating moods	−.03	<1	$.02^{*}$	−0.2	<1	.015	−.65	<1	$.02^{*}$	−.02	<1	.01

Note. $N = 545$.
$^{*} p < .05$. $^{**} p < .025$.

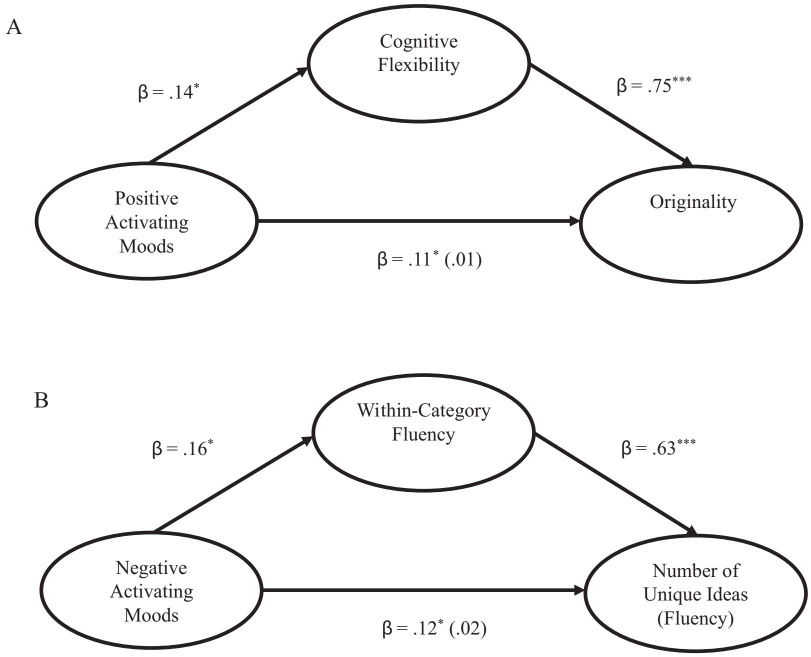

Figure 2. A: Path of positive activating mood states on originality mediated by cognitive flexibility (category diversity). B: Path of negative activating mood states on creative fluency mediated by cognitive perseverance (within-category fluency). Numbers in brackets are regressions weights after the mediator has been controlled for. $^{*}p < .05$; $^{***}p < .01$.

1999), and our results indicate that when it comes to creative performance, both activation and hedonic tone are important. Across four studies, findings were consistent with our dual pathway to creativity model, which indicates that only activating, and not deactivating, mood states lead to higher levels of creative fluency and originality, that activating positive mood states lead to creativity through higher levels of cognitive flexibility, and that activating negative mood states lead to higher creativity through increased perseverance within thought categories and longer time-on-task. Below, we discuss implications of these findings for research on mood and on creativity. We also discuss some limitations to our findings and highlight avenues for future research.

Summary of Results and Theoretical Implications

From our dual pathway to creativity model, we derived five hypotheses about the effects of mood states on particular facets of creativity. Hypothesis 1, predicting higher levels of creativity when moods are activating rather than deactivating, received strong support—with regard to creative fluency it was supported in all three tests (i.e., Study 1, 3, and 4), and with regard to originality, it was supported in two out of two tests (i.e., in Study 1 and 4). Hypothesis 3, that negative activating moods positively associate with cognitive persistence, also received good support; direct evidence was obtained in Study 1 and 4, and indirect evidence was obtained in Study 3. Hypothesis 2, that activating positive moods primarily associate with higher levels of cognitive flexibility, received less support; no evidence was obtained in Study 1 and 2, indirect evidence was obtained in Study 3, and only in Study 4 were statistical tests were supportive. This notwithstanding, Study 4 provided good evidence for mediation Hypotheses 4 and 5: Negative activating moods related to higher fluency because of increased persistence, whereas positive activating moods related to higher originality because of increased flexibility. We thus take these results as quite supportive of our dual pathway to creativity model and its specific application to the mood–creativity link.

All in all, results support four conclusions. First, activating moods lead to more creativity than do deactivating moods, most likely because activation stimulates creativity rather than because deactivation undermines it. Second, activating moods with positive tone lead to creative performance through enhanced cognitive flexibility and inclusiveness. Third, activating moods with negative tone lead to creative performance through enhanced cognitive perseverance and persistence. Fourth, and finally, the effects of mood on creativity cannot solely be understood in terms of activation or in terms of hedonic tone; both dimensions are needed to understand how mood states influence creative performance. As discussed below, these conclusions imply that different dimensions of creative performance, such as cognitive flexibility, inclusiveness, or perseverance, cannot and should not be used interchangeably. Further, these conclusions imply that the task used to study creativity may determine the likelihood that some traits or states do, and others do not, appear to successfully predict creativity.

Mood States and Creativity

We began this research with the observation that there seems to be general consensus that positive affect leads to more creativity. Contemporaries tend to explain this effect in terms of hedonic tone. For example, Ashby et al. (1999) noted,

> There is substantial reason to believe that affect and arousal are not synonymous . . . and that the increases in cognitive flexibility and creative problem solving reported in so many articles are indeed due to positive affect, not simply to increases in arousal. (p. 532)

Current findings qualify these conclusions. When it comes to discrete mood states, we noted that not only hedonic tone but also activation matters and that tone and activation may take on different roles in the creativity process—activation determines the likelihood of creative performance, and tone determines whether creative performance comes about because of enhanced cognitive flexibility (in the case of positive tone) or because of enhanced perseverance and persistence (in the case of negative tone).

As mentioned in footnote 2, this is not the first study to examine the role of activation in the mood–creativity link. Indeed, a number of other studies focused on the role of arousal, typically induced through some form of physical exercise. This past work produced inconsistent results, sometimes showing that physical exercise produces more creativity than no exercise and sometimes showing that it has no effects. Obviously, there are important differences between activation induced through physical exercise and activation associated with a particular mood state. This notwithstanding, it is important to note that past work on physical exercise and creativity did not differentiate between cognitive flexibility and persistence and did not examine possible interactions with hedonic tone—for some participants, physical exercise may have been a pleasant task, putting them in a good mood (happy, upbeat, relaxed) and thus, at best, facilitating cognitive flexibility. For some participants, however, physical exercise may have been an unpleasant task that put them in a negative mood (upset, frustrated, worried, depressed) and thus, at best, facilitating cognitive perseverance. Seen this way, it is not surprising that past work on physical exercise produced inconsistent results. Future work on (physical) activation needs to take into account the possible side effects that manipulations have on participants' mood as well as the dependent variables assessed (flexibility and/or persistence).

Related to this is that past work has revealed an inverted U-shape relationship between level of activation and arousal on the one hand and cognitive and motor performance on the other. Thus, at very low or extremely high levels of activation and arousal, working memory capacity is much lower and relevant brain regions function less effectively than at moderate levels of activation and arousal (cf., Yerkes & Dobson, 1908). An implicit assumption in our work thus far has been that the variation in activation related to particular mood states is in the lower range of this inverted U-shape relation; only intense emotions may temporarily produce the level of activation and arousal that shuts down the system and prohibits people from performing cognitive and motor tasks. Clearly, research is needed to further examine this issue. It would be particularly interesting to see whether exceedingly high levels of activation and arousal undermine cognitive flexibility and persistence to the same degree or to different degrees. Intuitively, it seems that flexibility is more vulnerable than persistence but, once again, research is needed to examine this further.

That mood states impact creativity through different routes—cognitive flexibility or perseverance—has an important methodological implication. Some tasks used in creativity research, such as Rosch's category inclusion task, capitalize on cognitive flexibility, divergent thinking, and the use of broad and inclusive cognitive categories (cf., Murray et al., 1990). The present work shows that in such tasks positive moods have an advantage over negative moods in producing creative ideas, insights, and problem solutions. Other work has relied on tasks such as brainstorming that allow creativity through persistence and perseverance to come about. The present analysis shows that in such tasks negative moods have an equal or perhaps even better chance than positive moods of predicting creative performance. In short, an important insight that derives from our research is that the creativity task used may be a critical moderator of the relationship between mood (or any other trait or state for that matter) and creativity.

The currently proposed dual pathway to creativity model captures past and current findings on the effects of positive moods on creativity quite well. However, things are less clear cut when considering the effects of negative moods, most notably those for sadness. Although current findings are supportive of the idea that sadness—a negative and deactivating mood state—neither produces nor inhibits creative performance, past work has revealed that sadness can actually stimulate creativity. For example, when the task is being framed as serious, important, and extrinsically rewarding, sadness leads to more creativity than do mood-neutral control conditions (Gasper, 2003; Hirt et al., 1997; also see, Martin & Stoner, 1996). One could argue that such task framing is motivating and activating and, as such, is doing what sad people need—they need to be activated to perform because their mood state in and by itself will not drive them toward (creative) performance.

Although we believe that the dual pathway to creativity model has promise, we readily accept that invoking moderators may be needed to understand how particular (mood) states influence creative performance. Important moderators may include task framing and, as we elaborate on below, specific creativity task used. And although the current analysis focused on hedonic tone and activation as critical dimensions underlying discrete mood states, mood states differ on other dimensions as well, and these may meaningfully relate to creativity. For example, Higgins (2006) has argued that some mood states, such as happiness and anger, associate with approach motivation and promotion focus, whereas other moods, such as fear and feeling relaxed, associate with avoidance motivation and prevention focus (also see Amodio, Shah, Sigelman, Brazy, & Harmon Jones, 2004; Carver, 2004; Higgins, Shah, & Friedman, 1997). Promotion focus relates to more creativity than prevention focus (Friedman & Förster, 2001), and this together may suggest that mood states associated with promotion focus produce more creativity than do mood states associated with prevention focus. Future research may delve further into these possibilities, keeping in mind that a combination of hedonic tone, activation, and, perhaps also, regulatory focus better explains creative performance than do any of these dimensions alone.

Study Limitations and Avenues for Future Research

Before concluding, a few limitations of our study design need comment. First of all, our evidence for mediation is based on correlational designs, and future work is needed to unequivocally establish the causal links. Second, the support for our dual pathway model was stronger and more consistent for the negative activating mood–persistence–creativity pathway, than for the positive activating mood–flexibility–creativity pathway. To some, this may be surprising because quite some evidence has been gathered showing that positive tone relates to cognitive flexibility. Recent work by Hirt, Devers, and McCrea (2008) invoked hedonic contingency theory (Wegener & Petty, 1994), which posits that individuals in a positive mood use greater scrutiny in activity choice than do those in neutral or negative moods because fewer activities will be able to maintain or improve their current mood. Hirt, Devers, and McCrea showed that positive mood is indeed related to cognitive flexibility to the extent that it allowed mood maintenance, and their results thus suggest that positive mood effects may be limited to tasks that allow participants to maintain their positive feeling.

In a way, this work is consistent with the more general idea underlying the current work that specific tasks may facilitate or inhibit mood effects on creativity because some tasks provide more room for persistence and other tasks, for cognitive flexibility to come about. Future research could more systematically explore the role of task environment (also see Kaufmann, 2003). For example, some studies on visual perception and set-breaking tend to provide limited time (e.g., 3 min; e.g., Förster et al., 2004) to complete the task. Our Study 3 revealed that participants in an activating negative mood benefited from longer time-on-task (and spent, on average more than 3 min) whereas those in an activating positive mood did not. An implication of our work thus is that setting time limits may lead to misguided conclusions about the creative potential of particular states or traits.

A final avenue for future research is to analyze creative fluency and originality as a function of variables other than mood. We already discussed regulatory focus and global versus local information processing tendencies (cf., Förster et al., 2004; Friedman & Förster, 2001). Other candidates for such analyses are the role of intrinsic motivation versus extrinsic motivation (Amabile, 1983), achievement motivation, and traits such as openness to experience and conscientiousness (e.g., McCrae, 1987). It would be interesting to examine to what extent these and other variables known to affect creative fluency and originality do so because of enhanced flexibility, greater persistence, or some combination.

Concluding Thoughts

Creativity researchers have long argued that positive mood increases creative performance and have implicitly or explicitly assumed this to be due to enhanced cognitive flexibility and reliance on broad, inclusive cognitive categories. Our results supported this idea and provided first time evidence for the notion that effects of positive mood states are limited to activating moods. Creativity researchers have long struggled with the effects of negative moods on creativity, with some arguing and finding that negative moods undermine creativity and others arguing that it enhances creative performance. The present work clarified, first of all, that negative moods enhance creative performance when mood states are activating rather than deactivating. Second, our results permit the conclusion that negative activating moods lead to creative performance because of enhanced cognitive perseverance and persistence more than because of cognitive flexibility and inclusiveness. Thus, provided some activation, both positive and negative moods engender creative performance, but through cognitive flexibility and cognitive perseverance, respectively. As such, our work suggests that Edison's famous quote that creativity is 99% perspiration and 1% inspiration may reflect not only that Edison had apt intuition about the psychology of creativity but also that Edison resembled an angry young man more than a happy camper.

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