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The dual pathway to creativity model: Creative ideation as a function of flexibility and persistence

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The dual pathway to creativity model argues that creativity—the generation of original and appropriate ideas—is a function of cognitive flexibility and cognitive persistence, and that dispositional or situational variables may influence creativity either through their effects on flexibility, on persistence, or both. This model is tested in a number of studies in which participants performed creative ideation tasks. We review work showing that cognitive flexibility, operationalised as the number of content categories surveyed, directly relates to idea originality, but that originality can also be achieved by exploring a few content categories in great depth (i.e., persistence). We also show that a global processing mode is associated with cognitive flexibility, but only leads to high originality in tasks that capitalise on cognitive flexibility. We finally show that activating positive mood states enhance creativity because they stimulate flexibility, while activating negative mood states can enhance creativity because they stimulate persistence. Implications for theory and practice are discussed.

Keywords: Creativity; Cognitive flexibility; Cognitive persistence; Ideation.

Humans have an amazing capacity for creativity. While other species use artefacts and sometimes manipulate objects to better fit their needs, our

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capacity for creativity allows us to fly to the moon, develop DVD recorders, create art and write poems, and generate research hypotheses. Because of its importance to human culture, our survival, well-being, and prosperity, creativity has long been studied (Simonton, 2003a). For example, quite some work has been devoted to understanding the characteristics, development, and career trajectories of creative geniuses (e.g., Csikszentmihalyi, 1996; Galton, 1869; Mumford & Gustafson, 1988; Simonton, 2003b). Indeed, when we think of creativity, the creative achievements of brilliant scientists (e.g., Marie Curie, Albert Einstein), of great inventors (e.g., Thomas Edison), or of famous artists (e.g., Emily Dickinson, Pablo Picasso, The Beatles) readily come to mind.

Although creativity is sometimes treated as an attribute of a few brilliant minds, it is in fact inherent to human cognitive functioning. This is expressed in our flexible use of language, our ability to create and use new mental categories to organise our experiences, and our ability to mentally manipulate objects (Ward, Smith, & Finke, 1999). A distinction is sometimes made between "little c" and "big C" creativity (Gardner, 1993). While "little c" creativity refers to relatively mundane contributions and everyday creativity, "big C" Creativity refers to genuinely important discoveries and works of art. This paper is concerned mainly with "little c" creativity. The study of this type of creativity is important for at least two reasons. First, it is important in day-to-day life: it helps us to adapt to changing circumstances, to solve everyday problems, and to create new opportunities (Runco, 2004). Second, the same processes that lead to "little c" creativity may also operate in cases of "big C" creativity (Ward et al., 1999; see also Guilford, 1950), and the study of "little c" creativity may therefore contribute to a better understanding of creative genius.

Creativity is commonly defined as the production of ideas, problem solutions, and products that are both novel (original) and appropriate (feasible, potentially useful) (e.g., Amabile, 1983; Paulus & Nijstad, 2003; Sternberg & Lubart, 1999). Originality is considered the hallmark of creativity, and indeed one cannot be creative without being original. However, ideas or products that are original but not appropriate would be considered crazy and irrelevant. One problem is that original ideas that are considered inappropriate at some point in time may be seen as appropriate (and therefore highly creative) later on (or vice versa). The work of Vincent van Gogh is a good illustration: Van Gogh died a poor man, but his work now sells for millions. Creativity therefore cannot readily be established in an objective way, and several researchers have suggested that a product or idea is creative when relevant experts agree that it is creative (e.g., Amabile, 1982; Csikszentmihalyi, 1999).

Although humans in general are a creative species, levels of creativity may vary from person to person (trait-based variation) and from situation to situation (state-based variation). For example, social psychological research has shown that creative performance is influenced by a broad variety of dispositional and situationally induced mood states (see Baas,

De Dreu, & Nijstad, 2008, for a review), by external evaluations and rewards (e.g., Amabile, 1979; Eisenberger & Rhoades, 2001), by situationally induced motivational orientation (i.e., approach versus avoidance; Friedman & Förster, 2000), and by the activation of romantic motives (Förster, Epstude, & Özelsel, 2009; Griskevicius, Cialdini, & Kenrick, 2006). This article seeks to further our understanding of these trait- and state-based variations in creativity (also see Amabile, 1983, 1996). We present our dual pathway to creativity model (also De Dreu, Baas, & Nijstad, 2008) and examine supportive evidence derived from a number of studies in which participants engaged in creative ideation tasks.

The dual pathway model assumes that there are two pathways to creative performance, the *flexibility* pathway and the *persistence* pathway, and that psychological states and traits influence creativity through their impact on either of these pathways, or both. The dual pathway model builds on and is an integration of previous theorising. After discussing some of the previous theories of creativity, we present the dual pathway model in more detail. We then discuss how ideation tasks (e.g., brainstorming and divergent-thinking tasks) may be used to test our model, and how various measures of creativity derived from ideation tasks relate empirically to each other. We next focus on the persistence pathway, and show that persistence may lead to creativity even in the absence of flexibility. Focusing on the flexibility pathway, we also show that global (as opposed to local) processing modes are associated with cognitive flexibility, but only lead to original ideas when task performance benefits from cognitive flexibility. We subsequently use the dual pathway model to discuss the effects of mood states on creative performance. We close with a discussion, in which we consider the applicability of the model to other types of creativity tasks, propose a general hypothesis and discuss avenues for future research.

THEORIES OF CREATIVITY

The dual pathway model builds on and expands several theories of creativity. These theories come from various sub-disciplines within psychology, including cognitive, personality, and social psychology. In this section we present those theories that have been most important for the development of the dual pathway model. These theories are mainly about the cognitive processes that underlie creative performance.

Creativity as a stochastic process

Several authors have argued that creativity, similarly to biological evolution, involves a process of random (or blind) variation and selective retention (e.g., Campbell, 1960; Simonton, 1999). In this view, the human brain

produces variations to known ideas in an essentially random or quasi-random way, for example by making new connections among existing ideas. Some of these new combinations are promising and are retained, and others appear useless and are discarded. This process of selective retention may occur both within the mind of the inventor and within the society that adopts useful ideas and disregards those that seemingly have no value at that time (e.g., Csikszentmihalyi, 1999).

In line with this view, Simonton (1999, 2003b) has argued that creativity involves a constrained stochastic process, involving "the intrusion of a restricted amount of chance, randomness, or unpredictability" (Simonton, 2003b, p. 476). His theory was developed in the context of "big C" creativity, and has (among others) been used to explain the creative productivity of scientists and artists. The theory assumes that creators work within a specific domain (e.g., painting or mathematics), and that during education and training they acquire a sample of the larger set of ideas that make up a particular domain (e.g., ideas about number theory within mathematics). The size of this ideational sample varies among creators, and this sample is subjected to relatively unconstrained (quasi-random) recombination with the aim of finding useful permutations. When these new ideas are found to be useful by the field (the individuals who work within a domain), they are retained and passed on to later generations of inventors.

This theory of creativity can be used to explain a number of findings with regard to the creative output of inventors. For example, a robust finding is that the best predictor of creative eminence is sheer productivity (e.g., Simonton, 1997, 2003b). Because the creative process is (to some degree) random, most new ideas will be useless, but occasionally an idea will be generated that is truly creative (i.e., both novel and appropriate). The chance that this happens is small, but the chance of generating a truly creative idea increases when more ideas are generated. Furthermore, if the creative process is truly random, the chance that any specific idea is creative should not change with creative output: generating more ideas should lead to more ideas that are creative, but also to more ideas that are useless. This has indeed been observed and has been called the equal-odds rule: the ratio of creative ideas to total output (i.e., the "hit-ratio") is uncorrelated with total output (Simonton, 1997, 2003b).

Creativity as normal cognition: Problem solving and memory retrieval

While the work of Simonton has developed out of an interest in creative genius and creative productivity across the lifespan, another tradition studies creative processes in time-constrained laboratory experiments. This

research tradition started with experiments on insight problem solving by the early Gestalt psychologists (e.g., Köhler, 1925). Much of this work assumes that creativity is an inherent property of human cognitive functioning, and that creativity can be seen as a case of problem solving. Newell and Simon (1972), for example, have argued that problems consist of an initial state, a goal state, and a set of operators. Problem solving is the process of finding a path through "problem space" (consisting of states, operators, goals, and constraints) that links the initial state to the goal state. Finding such a path can be highly systematic, involving the application of known procedures or operators. However, when problems are "ill-defined", meaning that the initial state, the goal state, the operators or the constraints are not well specified, less-systematic procedures (e.g., heuristics) need to be applied, including use of analogies or simple trial and error (Klahr, 2000). This is often the case for insight problems, for which the obvious paths through problem space do not lead to the correct solution.

More recently, Finke, Smith, and Ward (e.g., Finke, Ward, & Smith, 1992; Smith, Ward, & Finke, 1995; Ward, 1994; Ward et al., 1999) have developed what they called the "creative cognition approach". The assumptions of this approach are: (1) creativity is a hallmark of normal human cognitive functioning (i.e., people are inherently creative); (2) the processes leading to creativity are open to rigorous experimental investigation; and (3) creativity results from ordinary mental processes that are in principle observable (Ward et al., 1999, p. 189). Furthermore, these authors argue that many non-cognitive factors have their impact on creativity through their influence on human cognition.

Finke et al. (1992) have proposed the "geneplore" (generate–explore) model of creativity, arguing that creativity involves both generative and exploratory processes. Typical generative processes involve the retrieval of existing structures from memory, the formation of simple associations among these structures, and the mental synthesis and transformation of existing structures. The new ideas resulting from these processes are explored for new or desired attributes (Finke et al., 1992). For example, a social psychologist might retrieve the concept of cognitive dissonance, and apply this to small groups. Exploring this further, the social psychologist comes up with the idea that within-group disagreement can be a source of cognitive dissonance, and explores whether specific findings within the dissonance literature might also be observed in small groups (e.g., effects of lack of choice and opportunities to self-affirm) (see Matz & Wood, 2005).

It is important to note that creative products, even if tasks are ill-defined, often have properties that are quite predictable. For example, when asked to draw an animal that lives on a planet different from earth, most people come up with drawings that include features of typical of earth mammals, such as bilateral symmetry, sensory organs, and arms and legs (Ward, 1994).

Furthermore, when asked to draw a species with feathers, participants are likely to also include wings and a beak. Based on these results, Ward (1994) argued that, when developing new ideas, most people retrieve a specific instance of a known concept from memory (e.g., a bird), and then use its features in the subsequent creative product. Ward further argued that when trying to be creative most people follow the "path of least resistance": they will generate a few highly accessible ideas with the least effort possible and then stop.

Following the path of least resistance will inevitably lead to low levels of originality, but if people can be induced to exert more effort, they may be more creative. For example, when people were asked to think a bit more about their creatures (by instructing them to consider the environment of the imagined planet) participants made more creative drawings (Ward, 1993). This logic also underlies specific procedures, such as brainstorming (Osborn, 1953), that ask people to generate as many ideas as possible (rather than stopping after having generated a few). It has been suggested that more original ideas will primarily be generated later in the process, because early on people tend to rely on habitual thought and easily accessible ideas (e.g., Perkins, 1981; Stein, 1975). Note that this results in the prediction that there is, in fact, a correlation between the ratio of creative to total ideas (the hit-ratio) and total output: because later products are more creative, not only do those who generate more ideas generate more original ideas, but the ratio between original ideas and total ideas will also increase with total output.

The general idea that creative processes involve memory retrieval (i.e., ideas cannot be generated *ex nihilo* but build on existing knowledge) also underlies models of creative ideation, such as the matrix model (Brown, Tumeo, Larey, & Paulus, 1998) and Search for Ideas in Associative Memory (SIAM; Nijstad & Stroebe, 2006). According to these models, the production of ideas is to some extent predictable. For example, both models predict that, because of the associative nature of long-term memory from which previous concepts are retrieved, successively generated ideas will often be semantically related (e.g., fall within the same semantic category). SIAM (but not the matrix model) also predicts that such semantic clustering is very efficient: semantically related ideas can be generated more quickly than semantically unrelated ideas. These and other predictions have been confirmed in experimental research (see Nijstad & Stroebe, 2006, for an overview).

Creativity as special cognition: Remote associations

While most researchers would agree that creativity involves cognitive processes such as retrieval and the formation of new associations, some argue that creative thinking is qualitatively different from "ordinary"

problem solving (e.g., Friedman & Förster, 2005; Martindale, 1995; Schooler & Melcher, 1995). While problem solving requires focused attention, effort, and systematic, analytical processing, creativity benefits from defocused attention and unsystematic (random) processes (e.g., spreading of activation). Analytical thinking, in this view, would primarily lead to ideas that are highly accessible and closely related to existing concepts and ideas (and thus not to originality). Defocused, random processes would result in the generation of associations that are more remotely related to existing ideas (and thus more original).

One prediction is that creativity benefits from an intellectual and dispositional capacity to generate and use remote associations (e.g., Eysenck, 1993, 1995; Guilford, 1967; Mednick, 1962; Simonton, 1997, 2003b). According to this viewpoint, people differ in the steepness of association hierarchies. Whereas for less-creative individuals stimuli are generally strongly associated with a few responses, and much less strongly associated with other responses (i.e., a steep association hierarchy), for creative individuals the differences in the strengths of associations are smaller (a flatter association hierarchy). Thus creative individuals are more likely to come up with an unusual (and therefore original) response to a stimulus, whereas less-creative individuals are more likely to come up with habitual, uncreative responses. For example, for most people the concept "cat" is strongly associated with the concept "dog", but for creative people this association may be less strong, whereas associations with other more remote concepts may be stronger (e.g., "eye"). Indeed, research indicates that creative scientists give more original word associations than uncreative scientists (Gough, 1976).

One (brain) mechanism through which this might work is latent inhibition. Latent inhibition refers to the capability of the brain to filter out from current attentional focus those stimuli previously experienced as irrelevant, which in general is highly adaptive (Lubow, 1989). However, creative individuals, according to this reasoning, have attenuated levels of latent inhibition. As a result, more seemingly irrelevant stimuli are allowed to enter attention, which in turn increases the availability of elements to work with during a creative task, leading to more original responses (e.g., Carson, Peterson, & Higgins, 2003; Eysenck, 1993, 1995). Evidence does indeed indicate that an attenuated level of latent inhibition is predictive of creative performance (e.g., Carson et al., 2003; Dykes & McGhie, 1976; Martindale, Anderson, Moore, & West, 1996), and this seems to be the case especially for people with high general mental ability (i.e., high IQ; Carson et al., 2003).

The hypothesis that attenuated levels of latent inhibition are associated with flat association hierarchies and creativity can explain some findings regarding the relation between individual differences and creativity.

For example, reductions in latent inhibition are associated with the Big Five personality trait Openness to Experience (Peterson & Carson, 2000; Peterson, Smith & Carson, 2002) and Openness to Experience is positively related to creativity (McCrae, 1987). Furthermore, attenuated latent inhibition is also associated with susceptibility to, for example, schizophrenia (e.g., Baruch, Hemsley, & Gray, 1988), and schizophrenia (or more generally, psychoticism) has in turn been linked to higher levels of creativity (e.g., Eysenck, 1993, for an overview).

Interestingly, this mechanism might also account for some findings within social psychology. For example, although negative moods may also sometimes lead to creativity (see our later discussion), it is beyond doubt that situationally induced positive moods stimulate creativity (for reviews: Ashby, Isen, & Turken, 1999; Baas et al., 2008; Lyubomirsky, King & Diener, 2005). One of the theories to account for this effect is Ashby et al.' s (1999) dopaminergic theory of positive affect. This theory argues that positive moods are associated with the release of the neurotransmitter dopamine in certain brain areas (e.g., the basal ganglia and the anterior cingulate cortex), and that dopamine increases cognitive flexibility (also see Dreisbach & Goschke, 2004). Interestingly, latent inhibition also seems connected to the dopaminergic system (e.g., Eysenck, 1993), and it is possible (although speculative) that positive moods lead to dopamine release, which in turn causes a reduction in latent inhibition and an increase in cognitive flexibility and creativity.

Other authors within social psychology have also suggested that creativity benefits from a flat association hierarchy and from global, holistic processing rather than from local and detailed processing. For example, Friedman and Förster (2000, 2001, 2002) have shown that situationally induced motivational orientation (approach vs avoidance) and regulatory focus (promotion vs prevention) are associated with creativity. These authors assume that approach motivation and a promotion focus (relative to avoidance motivation and prevention focus) lead to a more global and holistic processing mode, promoting higher levels of creativity. These ideas resemble the idea of a flat association hierarchy, and one (speculative) hypothesis may be that approach and promotion states have similar effects to positive moods: they lead to the release of dopamine, a reduction in latent inhibition, and therefore to more creativity (also see Baas et al., 2008).

THE DUAL PATHWAY TO CREATIVITY MODEL

The dual pathway to creativity model builds on and integrates the theories discussed in the previous section. The model was first proposed by De Dreu et al. (2008) to account for the effects of positive and negative moods on creative performance (see our later discussion of this issue). The model was

developed after previous findings that suggested systematic and focused thinking can and does result in high levels of creativity under some circumstances (Rietzschel, De Dreu, & Nijstad, 2007a; Rietzschel, Nijstad, & Stroebe, 2007b). These findings ran counter to the viewpoint that focused, systematic, or analytical thinking is incompatible with creativity (e.g., Friedman & Förster, 2005; Martindale, 1995). At the same time, there was little doubt that defocused, holistic thinking also positively relates to creativity, which led to the idea that there are two different ways to be creative.

The dual pathway model adds to previous theorising in two important ways. First, as indicated in the name, it assumes that there are two qualitatively different processes that may result in creativity (defined as the generation of original and useful ideas): the flexibility pathway and the persistence pathway. Second, it is a social psychological model, in the sense that it assumes different states or traits may associate with creativity because they influence cognitive flexibility, or because they influence cognitive persistence, or both. That is, the model aims to explain the effects of situational and dispositional variables on creative performance (cf. Amabile, 1983), rather than only illuminate which cognitive processes are related to creativity.

The dual pathway model is schematically presented in Figure 1. At the core of the figure are the two pathways through which creativity might be achieved: the flexibility pathway and the persistence pathway. We define cognitive flexibility as the ease with which people can switch to a different approach or consider a different perspective, and cognitive persistence as the degree of sustained and focused task-directed cognitive effort. The pathways are influenced by situational (denoted with X_i) as well as dispositional (denoted with P_i) variables. However, some situational and dispositional variables affect the flexibility pathway more strongly than the persistence pathway, and vice versa. The arrows are therefore drawn in solid (stronger relation) or dotted (weaker relation, or even a negative relation) lines. For example, it is possible that a variable is positively related to persistence and thereby positively affects creativity, whereas it is also negatively related to

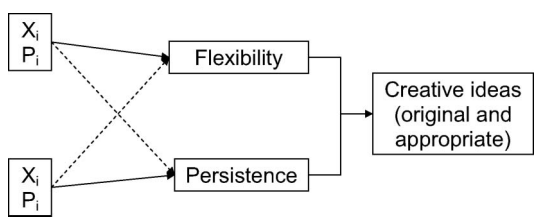

Figure 1. The dual pathway to creativity model.

flexibility and therefore negatively affects creativity (in which case the relation between that variable and creativity becomes difficult to predict, or will depend on other factors; as we will discuss later, this seems to be the case for fearful or anxious states).

The model applies to situations in which at least some (conscious) attention is directed at a task that requires creativity (i.e., it applies to deliberative rather than automatic processes). Some authors have argued that creativity may occur during daydreaming (e.g., Dietrich, 2004; Martindale, 1999) or can occur during distraction (e.g., Dijksterhuis & Meurs, 2006), but our model is not applicable to situations in which creativity occurs "spontaneously" without intentional effort. Rather, the model assumes that task-related cognitive activities are, at least to some degree, regulated by attention and involve parts of the prefrontal cortex that are needed for "executive control", most notably the dorsolateral prefrontal cortex (e.g., Dietrich, 2004; Fuster, 2000; Posner, 1994). These structures are implied in working memory (Baddeley, 1996; Fuster, 2000), sustained and directed attention (Posner, 1994; Sarter, Givens, & Bruno, 2001), and are recruited in long-term memory retrieval (Cabeza & Nyberg, 2000). However, the degree of executive control is different for the flexibility and persistence pathways.

The flexibility pathway

The flexibility pathway represents the possibility of achieving creative insights, problem solutions, or ideas through the use of broad and inclusive cognitive categories, through flexible switching among categories, approaches, and sets, and through the use of remote (rather than close) associations (e.g., Amabile, 1983; Eysenck, 1993; Mednick, 1962). Indeed, creativity is often associated with making new connections among distant ideas (e.g., Koestler, 1964; Simonton, 1999), and with "breaking set" or overcoming "functional fixedness" (e.g., Duncker, 1945; Smith & Blankenship, 1991; Wertheimer, 1945). In all these cases it is important that people do not rely on habitual thinking and fixed task strategies, but have a broad attentional focus and switch flexibly between approaches to the task (e.g., Ashby et al., 1999).

As described earlier, a number of authors associate cognitive flexibility with the availability of dopamine in certain brain areas (e.g., Ashby et al., 1999; Dreisbach & Goschke, 2004; also Leber, Turk-Brown, & Chun, 2008), and with reduced levels of latent inhibition (e.g., Carson et al., 2003; Cohen, Braver, & Brown, 2002; Dreisbach & Goschke, 2004). Reduced latent inhibition would allow more distant associates and ideas to enter working memory, leading to more original (rather than habitual and dominant) responses. However, a disadvantage of increased flexibility is that it will be

associated with reduced cognitive control and increased distractibility (Dreisbach & Goschke, 2004): when the threshold for ideas to enter working memory is lower, it is inevitable that irrelevant thoughts or poor solutions are also considered. Therefore, an evaluation mechanism (an "idea monitor") is needed to judge the appropriateness of generated responses (also Dietrich, 2004; Iyer et al., 2009), and cognitive processes need to be adjusted when "getting off track", which requires at least some control mechanisms that keep our behaviour in line with our internal goals and intentions (i.e., cognitive control; also Nijstad & Stroebe, 2006). Assuming that cognitive control is associated with general mental ability (e.g., working memory capacity; see McVay & Kane, 2009), this is in line with evidence showing that reduced levels of latent inhibition are only associated with creativity for people with high mental abilities (e.g., Carson et al., 2003).

The persistence pathway

The persistence pathway represents the possibility of achieving creative ideas, insights, and problem solutions through hard work, the systematic and effortful exploration of possibilities, and in-depth exploration of only a few categories or perspectives. Indeed, several authors have argued that creativity can be achieved through a systematic exploration of problem space and through incremental search processes (Boden, 1998; Dietrich, 2004; Finke, 1996; Newell & Simon, 1972; Simonton, 1997). Systematic thinking and incremental search are not normally associated with creativity, because these processes will initially often lead to obvious and readily available solutions. Rather, systematic search will only yield original ideas, insights, and solutions after more readily available ideas have been examined and discarded. To arrive at original responses therefore requires persistence.

The idea of the persistence pathway is consistent with Ward's (1994) path of least resistance model (see above), and with evidence that there is a strong relation between quantity and quality of ideas, both within short-term brainstorming sessions (e.g., Diehl & Stroebe, 1987; Parnes & Meadow, 1959; Rietzschel, Nijstad, & Stroebe, 2006), and for cases of "big C" creativity (e.g., Simonton, 1997, 2003b). The systematic search processes employed in the persistence pathway require more executive control than the associative search processes employed in the flexibility pathway. Systematic thinking requires that distracting and irrelevant thoughts are blocked out of working memory and that attention is fully focused on the task at hand (e.g., Dreisbach & Goschke, 2004; Koch, Holland, & Van Knippenberg, 2008). This may imply that more distant associates are not readily considered, because they are filtered out before they reach the threshold of activation needed to enter working memory (also see Harkins, 2006). Thus, when the

persistence pathway is employed, people will be less distractible, but also generally less flexible (i.e., more distant associations are not readily or immediately considered).

The relation between the pathways

From the foregoing, it follows that cognitive flexibility and systematic search processes are negatively related. Within cognitive psychology this has been described as a trade-off between flexibility and stability (e.g., Cools, 2008; Dreisbach & Goschke, 2004; Dreisbach et al., 2005; Müller et al., 2007). One function of attention is to stay focused on a task (e.g., keep one's goals active in working memory) and ignore distraction; this is achieved through inhibition of irrelevant material. However, while inhibition of seemingly irrelevant ideas will lead to stability in terms of goal pursuit, it will also reduce the breadth of attentional focus and thus prevents more distant ideas from entering working memory, which may harm cognitive flexibility (also see Harkins, 2006). Some authors associate the flexibility–stability trade-off with the dopaminergic system, and argue that the balance of dopamine in different (frontal) brain areas determines whether a flexible or systematic processing mode is used (e.g., Braver & Cohen, 2000; Cools, 2008).

The trade-off between flexibility and stability may lead to the hypothesis that the flexibility and persistence pathways are negatively related. However, this need not be the case, because people can switch from more flexible to more systematic processing modes (e.g., Finke, 1996; Leber et al., 2008). In the course of creative problem solving or ideation people may therefore use both the flexible and systematic processing modes, although perhaps to different degrees. For example, a person might employ the flexibility pathway to discover new and promising approaches to a task, and then switch to a more systematic approach to further explore these approaches. Thus, over time, the use of the flexibility pathway does not exclude the use of the persistence pathway or vice versa.

CREATIVE IDEATION AND THE DUAL PATHWAY MODEL

Indicators of creativity in ideation

Guilford (1950) proposed that creativity could be studied using paper-and-pencil tests, such as the unusual uses test (e.g., think of uses for a common object such as a brick) and other divergent-thinking tasks. Building on this insight, Torrance (1966) developed his Torrance Test of Creative Thinking, which includes a number of these divergent-thinking tasks: open-ended tasks in which respondents are asked to generate as many responses as possible.

The well-known brainstorming procedure (Osborn, 1953) also emphasises the quantity of ideas (with the assumption that quantity breeds quality), and in the remainder of this article we use the terms ideation, divergent thinking, and brainstorming interchangeably. Responses on divergent-thinking (ideation, brainstorming) tasks can be scored on different indicators of creativity: fluency (total number of responses), flexibility (number of different categories of responses), originality (the statistical infrequency of a response), and elaboration (amount of detail). A person is considered to be more creative when generating many responses (fluency), when generating responses in many different conceptual categories (flexibility; e.g., not only use a brick to build something, but also as a weapon, a weight, or a musical instrument), when generating unusual responses (i.e., infrequently generated responses), and when ideas are more elaborated.

Nijstad, Stroebe, and Lodewijkx (2002, 2003) proposed that, when ideas are categorised in conceptual categories, one can not only establish flexibility (i.e., count the number of categories that are used), but also see how many ideas have been generated in each of the categories. Their measure of *within-category fluency* consists of the average number of ideas per category and is computed by dividing the total number of ideas generated (fluency) by the number of categories used (flexibility). Flexibility can be viewed as an operationalisation of the flexibility pathway, whereas within-category fluency can be viewed as an operationalisation of the persistence pathway. Thus cognitive flexibility is reflected in the use of many categories and frequent switching among categories.[1] Persistence is reflected in the generation of many ideas within a few categories, and with examining categories more fully and systematically.

According to the dual pathway model, both flexibility and persistence will eventually lead to creativity, defined as the generation of original and useful responses. It is therefore necessary to score ideas on these quality dimensions. In keeping with the brainstorming literature (see e.g., Diehl & Stroebe, 1987; Rietzschel, et al., 2006) we therefore also examine both originality (“is the idea new, unusual, infrequent?”) and feasibility (“can the idea be realised and implemented?”). After all, ideas may be very original but useless if they cannot be realised; these ideas are bizarre rather than creative. However, in most of our studies we considered originality rather than feasibility as the outcome variable of interest; first, because originality

[1]Flexibility may also manifest itself in the use of broader mental categories. For example, one task to assess cognitive flexibility is Rosch’s (1975) category inclusion task. In this task participants are asked to what degree specific exemplars (e.g., bus) fall into certain categories (e.g., vehicles). Higher flexibility manifests itself in higher ratings of less-prototypical exemplars (e.g., camel in the category *vehicles*), because they indicate the use of broad mental categories (see e.g., Isen & Daubman, 1984).

is the more "rare" (and sought after) attribute of creative ideas; and second, because our hypotheses pertain to originality more than to feasibility (see below). However, we will initially also analyse feasibility, to confirm that effects on originality do not come about at the expense of feasibility. Hence, in the studies we discuss, we examined fluency (number of ideas), flexibility (number of categories), within-category fluency (number of ideas per category), and the average originality and feasibility of ideas.

Hypotheses

There are two basic hypotheses that we examine in this section. First, we hypothesise that flexibility (the use of many categories) is positively related to the average originality of ideas. The reason is that considering many categories also leads to the generation of ideas in categories that are not habitually considered. For example, one topic we have used is the health topic ("what can one do to improve or maintain one's health?"). A dominant and relatively unoriginal category in the health topic is improving physical fitness through exercise (e.g., sports). A less-dominant (and more original) category is preventing injuries. Ideas in that category (e.g., repairing one's ill-functioning bike brakes) tend to be more original (less frequently generated). Note that we predict a positive association between flexibility and originality, but we do not predict a relation (either positive or negative) between flexibility and feasibility of ideas (e.g., exercise and repairing one's brakes are both feasible ideas).

The second basic hypothesis is that within-category fluency is also associated with average originality of ideas. This is not because more original categories of ideas are considered, but rather because ideas within a particular category become more original as time proceeds and more ideas have been generated within that category. Thus an important implication is that the relationship between within-category fluency and originality depends on time-on-task (staying longer within a category): Only after unoriginal ideas have been generated, will more original ideas be examined. This higher originality is not necessarily attained at the expense of feasibility of ideas. For example, a relatively unoriginal idea within the "physical exercise" category is to take the stairs rather than the elevator, but a more original idea within that category would be to stand rather than sit when working at one's computer (perhaps unpleasant, but certainly feasible).

We should note two things regarding these hypotheses. First, because flexibility and within-category fluency are both necessarily correlated with overall fluency (i.e., total number of ideas), the hypotheses imply that fluency is correlated with originality. As the relation between quantity and quality of ideas has been found before, these hypotheses may not appear

new. However, previous work has found the strongest evidence for a relation between fluency and the *number* of good ideas (e.g., the number of ideas that are rated to be highly original), because generating more ideas implies generating more good ideas as well as generating more bad ideas (e.g., Diehl & Stroebe, 1987; see our earlier discussion of creativity as a stochastic process). We predict a correlation between flexibility and within-category fluency on the one hand and *average* originality of ideas on the other, which is less well established. Second, in our conceptualisation flexibility and within-category fluency are process measures that mediate effects of situational and dispositional variables on creativity (see Figure 1). A prerequisite for mediation is that the proposed mediators are associated with the outcome variable, and we want to demonstrate that this basic assumption underlying our model is, in fact, true.

RELATIONS AMONG CREATIVITY INDICATORS: A META-ANALYTIC INVESTIGATION

According to the model, both flexibility and within-category fluency should be related to idea quality, and especially to idea originality. We have conducted a number of experiments in which some or all of the mentioned creativity indicators have been assessed and these studies can be used to examine meta-analytically the correlations among the different indicators of creativity (the relevant studies are marked with an asterisk in the reference section). In these studies we have used ideation tasks with four different topics: "How can one improve or maintain one's own health?" (health), "What can people do to protect the environment?" (environment), "What can one do with a brick?" (brick), and "What can be done to improve teaching at the psychology department?" (education). For these four topics we have used category-coding schemes developed by Diehl (1991) for the health and environment topic, and we have developed coding schemes for the brick and education topic. Additionally, we have developed coding schemes to reliably score ideas on originality and feasibility on 5-point scales (from 1 = "not original/feasible" to 5 = "highly original/feasible"; e.g., De Dreu et al., 2008; Rietzschel et al., 2006).

We should note that this meta-analysis is not based on an exhaustive search of the literature, but only on studies that have been performed by one or more of the present authors. While this does not give an unbiased estimate of the true correlations among variables, the analyses have sufficient statistical power to detect relatively small effects, and can be used as a first test of our hypotheses.

Table 1 reports the results of the meta-analysis in which we analysed the 20 different studies (total $N = 2118$) in which different indicators of creativity have been assessed. Figure 2 summarises the results in a more convenient

TABLE 1
Meta-analytic correlations among creativity indicators

				95% CI			
	k	*N*	*r*	*Lower*	*Upper*	Q_w	*p*
Fluency–flexibility	17	1858	.72*	.66	.76	67.99	.000
Fluency–wcf	17	1858	.64*	.59	.69	43.15	.000
Fluency–originality	13	1699	.22*	.07	.37	112.70	.000
Fluency–feasibility	8	610	−.04	−.16	.07	13.53	.06
Flexibility–wcf	17	1858	.01	−.11	.12	82.51	.000
Flexibility–originality	10	1439	.34*	.07	.56	224.32	.000
Flexibility–feasibility	5	350	−.02	−.22	.18	12.39	.02
Wcf–originality	10	1439	.12*	.06	.19	11.53	*ns*
Wcf–feasibility	5	350	−.09	−.22	.05	6.13	*ns*
Originality–feasibility	8	610	−.42*	−.60	−.21	57.85	.000

k = number of independent studies; *N* = total number of participants; *CI* = confidence interval; Q_w = heterogeneity statistic; wcf = within-category fluency; * = confidence interval excludes zero.

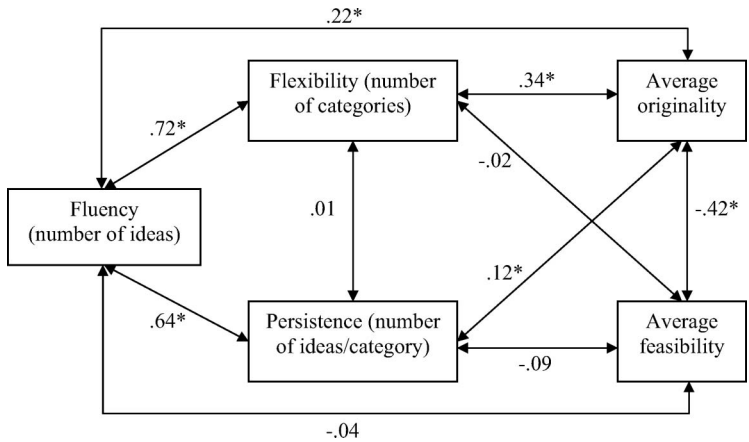

Figure 2. Meta-analytic correlations among the various measures of creative production.

way. Not every indicator was assessed in every study, and Table 1 reports the meta-analytic correlations among the various creativity indicators and the number of studies (*k*) and sample sizes (*N*) on which the correlations are based. We report the 95% confidence interval (*CI*) for each correlation, and the heterogeneity statistic Q_w. A significant Q_w indicates that correlations vary among studies. Note that correlations may vary due to, for example, the different topics used in the different studies, manipulations used in

different studies, and the duration of the ideation task (this varied between 4 and 20 minutes).[2]

A number of observations derive from Table 1. Not surprisingly, fluency correlates strongly with both flexibility and within-category fluency. To some extent this correlation reflects a measurement issue: because of the way flexibility and within-category fluency are assessed and computed, multiplying the two yields overall fluency. Theoretically more interesting is that fluency is also positively correlated with originality ($r = .22$; confidence intervals are reported in Table 1) but not with feasibility ($r = -.04$), and that originality and feasibility are negatively correlated ($r = -.42$). Thus original ideas tend to be less feasible, which is perhaps unsurprising given that original ideas have often not been implemented before. Consistent with our dual pathway model, Table 1 highlights that flexibility and within-category fluency do not correlate ($r = .01$). As such, there does not appear to be a trade-off between flexibility and within-category fluency (i.e., that using many categories implies that categories are explored less fully). Rather the two pathways are, across studies, independent.

Of most interest are the correlations among flexibility and within-category fluency on the one hand and originality and feasibility on the other. Consistent with the dual pathway model, there is a correlation of moderate size between flexibility and originality ($r = .34$). This correlation indicates that participants who use many categories also generate ideas in categories that are used less frequently, and these ideas tend to be more original. There is no correlation between flexibility and feasibility ($r = -.02$): using many categories does not lead to ideas that are more or less feasible (despite the negative correlation between originality and feasibility). Within-category fluency is also positively correlated with originality, but—although significant—this correlation is much weaker ($r = .12$). Within-category fluency is not significantly related to feasibility ($r = -.09$).

To conclude, these results support the idea that originality can be achieved through cognitive flexibility (using many categories) as well as through persistence (exploring categories in greater depth). However, the correlation between within-category fluency and originality is much weaker than the correlation between flexibility and originality, an issue we address in the next section. Further, potential positive effects of flexibility and persistence on originality do not seem to occur at the expense of feasibility, even though originality and feasibility are negatively correlated. Finally, flexibility and within-category fluency are uncorrelated, and in divergent-thinking tasks the two pathways seem to be relatively independent.

[2]These studies were meant to examine different hypotheses, and therefore differed on these dimensions. For the present purposes we do not report the effects of these across-study differences, but they may be obtained from the first author.

Exploring the persistence pathway

The meta-analysis showed a relatively weak correlation between within-category fluency and originality, and therefore the evidence for the persistence pathway is not strong. However, within-category fluency in the meta-analysis was operationalised as the average number of ideas per category across all categories; similarly, originality in the meta-analysis referred to average originality across all ideas. This is a rather imprecise way to examine the persistence pathway, especially because the dual pathway model predicts that generating many ideas *within* a specific category leads to greater originality of ideas *within* that specific category. We have tested this hypothesis in several studies.

Topic breadth and idea originality. Rietzschel (2005; Study 4.3) used a manipulation of topic breadth. He asked participants to generate ideas on a broad topic (the education topic mentioned above) or a narrow topic. Participants in the narrow topic condition were asked to generate ideas about how to improve the *lectures* at the department of psychology, which is a subtopic of the (more general) education topic. In the narrow topic condition people are forced to generate ideas systematically within a more limited domain. According to our reasoning, after the more dominant (and least original) ideas within these categories have been generated, this will lead to higher levels of originality. In the "broad topic" condition, participants are not forced to stay in a category, and the lack of persistence within categories will lead to ideas of lower average originality: they will follow the path of least resistance and superficially generate the most accessible ideas across different categories. Furthermore, fluency (i.e., the total number of ideas generated) should correlate positively with average originality in the narrow topic condition, but should be unrelated to originality in the broad topic condition.[3]

A total of 102 undergraduate students participated in the study and generated ideas for 20 minutes. Independent judges counted the number of ideas and reliably scored each idea on originality and feasibility using 5-point scales (from 1 = "not original/feasible" to 5 = "highly original/feasible"). The manipulation of topic breadth did not influence the total number of ideas generated (fluency), and it did not affect the average feasibility of ideas. However, originality of ideas was significantly higher in the narrow topic condition ($M = 2.33$) than in the broad topic

[3]There was a second manipulation in this study, which was "instruction" (generate ideas that are relevant to you as a student vs generate original ideas). This manipulation also had a main effect on originality, with higher average originality with originality instructions than with relevance instructions. However, this manipulation is less relevant to the current paper. It should be noted, however, that in the correlations we report, instruction was partialled out.

condition ($M = 2.18$). Further, the correlation between fluency and originality was significant ($r = .28$, $p < .05$) in the narrow topic condition, and higher than in the broad topic condition ($r = -.06$, *ns*). Thus this study shows that persistence within a few categories eventually leads to original ideas.

Inducing people to stay in a category. While the study by Rietzschel (2005) provides good evidence that persistence within a category leads to original ideas, this evidence was obtained by comparing participants who essentially generated ideas on different topics. It would be advisable to conceptually replicate the results in a situation in which participants generate ideas on the same topic and in which a different manipulation is used to induce participants to stay within a limited number of categories. Rietzschel et al. (2007b) accomplished this through a priming procedure.

Rietzschel et al. (2007b, Study 1) asked participants ($N = 75$ undergraduates), prior to idea generation, to think about a particular sub-topic (nutrition or sports) within the broader (health) topic by asking them a number of questions (the priming manipulation).[4] Participants were asked to describe how much time they devoted to X [healthy nutrition vs sports], whether this was more or less time than others, whether they should devote more time to X, and how important X was. After answering these questions, they brainstormed for 10 minutes about ways to improve or maintain their own health. Two control conditions were used, one in which no priming procedure was employed and one in which participants were primed with an irrelevant topic (politics). The ideas were counted per participant, and all ideas were rated for originality and feasibility. Further, each idea was categorised as nutrition, sports, or other idea.

Rietzschel et al. (2007b) expected that participants who had been primed with nutrition would generate more nutrition ideas than the participants in the control conditions (as a percentage of the total number of ideas). More importantly, they expected that the nutrition ideas would be more original after nutrition priming. Finally, they expected positive correlations between the percentage of nutrition ideas and the originality of these ideas. Analogous findings were expected for the sports priming condition: more sports ideas, higher originality of sports ideas, and a positive correlation between the percentage of sports ideas and the originality of these ideas. This was exactly what was found (Figure 3). Thus participants who had

[4]There was a third priming condition in this study, in which the category of hygiene was primed. However, many of the participants who had not been primed with hygiene did not generate a single hygiene idea. This made it impossible to compare the originality of hygiene ideas across conditions. We therefore omitted this condition in the current chapter.

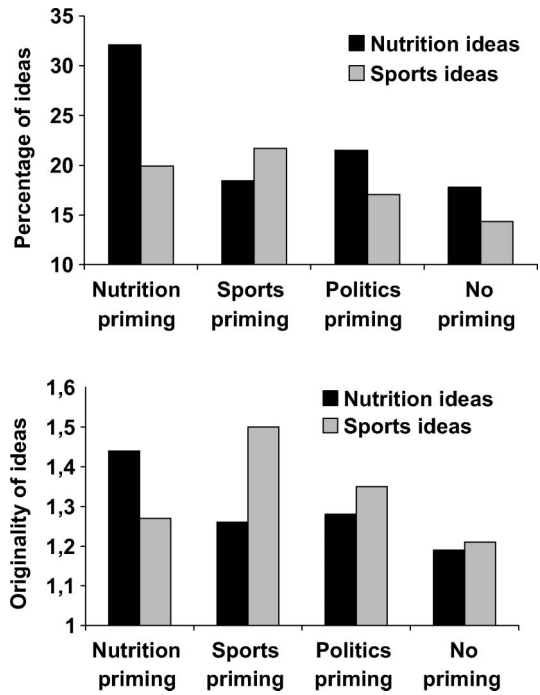

Figure 3. Percentage of nutrition and sports ideas in the different priming conditions (top panel), and originality of nutrition and sports ideas in the different priming conditions (bottom panel).

been primed with nutrition generated more nutrition ideas than participants in the control conditions (i.e., the no priming and politics priming conditions combined). Their nutrition ideas were also more original than in the control conditions, and the percentage of nutrition ideas was positively correlated with the originality of nutrition ideas ($r = .36$, $p < .01$). Similar findings were obtained for sports ideas: more sports ideas were generated in the sports priming condition than in the control conditions, the originality of sports ideas in the sports priming condition was higher than in the control conditions, and the correlation between percentage of sports ideas and originality of those ideas was significant ($r = .61$, $p < .001$). Thus making a particular category more accessible through priming increased the number of ideas generated within that category and, given persistence, this eventually led to more original ideas within the category.

Overall, these findings suggest that exploring one or a few cognitive categories systematically and in great depth can and will lead to original ideas. This suggests that even a lack of flexibility may not always be

detrimental to creativity. As long as categories are explored deeply, original ideas may result even for people low in cognitive flexibility. This is the issue we will now examine in more detail.

Need for structure, systematic exploration, and creativity. People differ in the degree to which they engage in flexible or systematic processing. One personality variable that captures these differences is Personal Need for Structure (PNS), a chronic aversion to ill-structured situations and a longing for certainty and predictability (Thompson, Naccarato, Parker, & Moskowitz, 2001). In terms of the trade-off between flexibility and stability, people high in PNS have a strong tendency towards stability. High PNS is also associated with a tendency to organise information in simple ways, with stereotyping, and with a strong tendency to form spontaneous trait inferences (Moskowitz, 1993; Neuberg & Newsom, 1993; Schaller, Boyd, Yohannes, & O'Brien, 1995). High PNS generally impedes flexibility of thought and might therefore be negatively related to creativity (Thompson et al., 2001). For example, PNS relates negatively to the big five factor Openness to Experience (Neuberg & Newsom, 1993), which in turn is positively related to creativity (e.g., McCrae, 1987). It also positively relates to authoritarianism (Thompson et al., 2001), which in turn is negatively related to creativity (e.g., Rubinstein, 2003).

However, Rietzschel et al. (2007a) argued that under some conditions PNS might actually relate positively to creative performance. People high in PNS will be inclined to take a structured approach to a creativity task, and to systematically explore conceptual categories. Such systematic exploration, as we have seen above, may eventually lead to original ideas, given a deep exploration of conceptual categories and sufficient time-on-task (also see Coskun, Paulus, Brown, & Sherwood, 2000).

Since there are reasons to believe that PNS can both positively or negatively relate to creativity, Rietzschel et al. (2007a) argued that the effects may depend on other factors. In particular, they considered the role of another personality variable, Personal Fear of Invalidity (PFI).[5] People high in PFI are very concerned with the consequences of their decisions, tend to be indecisive, and have a strong tendency to worry about the possibility that they give a wrong response (Thompson et al., 2001). PFI may undermine creativity because the "correctness" of original responses is harder to establish and harder to defend or justify to others than the "correctness" of

[5]PNS and PFI are both related to the construct of need for cognitive closure (Kruglanski & Webster, 1996; Webster & Kruglanski, 1994). High need for cognitive closure is associated with a tendency to reach quick conclusions ("seizing") and to stick to a conclusion that was reached earlier ("freezing"). In general, need for cognitive closure would positively associate with PNS and negatively with PFI (i.e., those high in PFI would tend to think more before reaching a conclusion).

habitual and well-established responses. In terms of our model, high levels of PFI will be associated with a stricter idea monitor, and more original ideas may not easily enter working memory, or may more readily be discarded as irrelevant. Rietzschel et al. therefore predicted that PNS will be positively related to creativity only when PFI is low—when PFI is high, a negative relation between PNS and creativity was predicted. Furthermore, this interaction between PNS and PFI should occur for originality and within-category fluency, but not for flexibility.

This hypothesis was tested in two studies that involved idea generation (Rietzschel et al., 2007a). In one study (Study 1c), participants ($N = 102$ undergraduates) first filled out scales to measure PNS and PFI (Dutch versions of the scales developed by Thompson et al., 2001) and then generated ideas on the education topic in a 7-minute session. The ideas were counted as a measure of fluency, and independent judges rated all ideas on originality on a 5-point scale. For both fluency and originality, interactions between PNS and PFI were obtained. Regarding fluency, moderated regression analyses showed that PNS was positively associated with fluency when PFI was low; PNS was negatively related to fluency when PFI was high. Similar results were obtained for originality: a positive association between PNS and originality under low PFI, and a negative relation between PNS and originality under high PFI.

This study thus showed that PNS can be positively associated with creativity (fluency and originality) when PFI is low. However, according to the dual pathway model, this should be the case because people high in PNS take a structured and systematic approach to the task (and this leads to many and original ideas when PFI is low). If this view is correct, one should obtain the PNS $\times$ PFI interaction especially on within-category fluency (i.e., reflecting the persistence pathway) but not on flexibility (i.e., number of categories explored, reflecting the flexibility pathway). In a replication study ($N = 240$; using identical procedures), Rietzschel et al. (2007a; study 2) therefore used not only fluency and originality as dependent variables, but also reliably coded all ideas into conceptual categories. Results replicated the findings of the previous experiment, and significant PNS $\times$ PFI interactions were obtained for fluency (total numbers of ideas) and originality: PNS was positively related to fluency and originality under low PFI, and negatively under high PFI. More importantly, similar findings were obtained for within-category fluency (a positive effect of PNS under low PFI, a negative effect under high PFI), but not for flexibility. Mediation analyses, following the Baron and Kenny (1986) method, established that the effects on originality were fully mediated by within-category fluency (Figure 4).

To conclude, a personality variable that might normally be associated with lack of creativity can actually be positively related to creativity. People

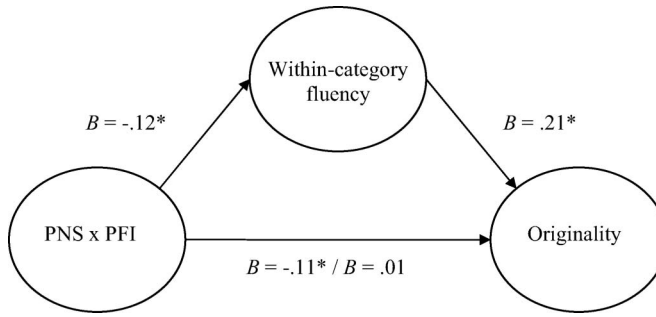

Figure 4. Mediation of within-category fluency between the interaction between Personal Need for Structure (PNS) and Personal Fear of Invalidity (PFI) on originality.

high in Personal Need for Structure take a systematic and structured approach to the ideation task, which leads them to explore conceptual categories in greater depth. This leads to high levels of within-category fluency, and eventually to high originality. However, these effects are only obtained when people are not hampered by a conservative idea monitor, and were only obtained for people low in Personal Fear of Invalidity. Furthermore, such systematic exploration of categories will only lead to original ideas after some time, because the more obvious and habitual ideas are likely to be considered first. This might be the reason why PNS is normally associated with low levels of creativity: only given persistence will people high in PNS be creative.

Conclusion. In a number of studies, using different approaches, we have explored the persistence pathway. From these studies it can be concluded that systematic exploration of conceptual categories can lead to original ideas. It should be noted, though, that these positive effects are likely to be found only when participants are given enough time, or are somehow induced to stay in conceptual categories longer. With more flexible processing modes, originality might be achieved sooner.

Processing mode, cognitive flexibility, and creativity

While Personal Need for Structure is associated with systematic processing and leads to creativity through persistence, other traits or states may be more strongly related to the flexibility pathway. For example, Friedman and Förster (2000, 2001, 2002) have shown in a number of studies that promotion focus and approach motivation (i.e., a focus on obtaining positive outcomes) lead to higher creativity than prevention focus and avoidance motivation (i.e., a focus on avoiding negative outcomes). These

authors explain their findings by arguing that promotion states engender a broad and global attentional scope and facilitate access to mental representations with lower a priori accessibility. Prevention states lead to a narrow attentional scope, a focus on perceptual details, and lower accessibility of distant associations. In terms of the dual pathway model, promotion-focused states enhance cognitive flexibility as compared to prevention-focused states. Furthermore, a global processing mode (a tendency to perceive global rather than local structures along with a focus on general rather than specific features and characteristics) stimulates cognitive flexibility more than a local processing mode (a tendency to perceive local structures and focus on details) (e.g., Förster, 2009; Förster, Friedman, & Liberman, 2004).

A relatively straightforward hypothesis would thus be that global processing modes stimulate creativity because they enhance cognitive flexibility (i.e., effects on creativity are fully mediated by flexibility). However, in some tasks creative performance may benefit more from cognitive flexibility than in other tasks. One factor within ideation tasks is, as we discussed above, topic breadth. When generating ideas on a broad topic, one can benefit from flexibility, and generate ideas in categories that are not commonly considered. With a narrow topic this is not possible, and global processing modes may not lead to creativity.

De Dreu, Nijstad, and Baas (2009) predicted that a global processing mode would lead to higher originality when working on a broad topic, but not when working on a narrow topic. Further, this interaction was predicted to be mediated by flexibility. Undergraduate students ($N = 74$) generated ideas on a broad topic (''how can education in the psychology department be improved?'') or a narrow topic (''how can the lectures in the psychology department be improved?'') for 7 minutes. Prior to the brainstorming session, the Navon (1977) task was used to manipulate processing mode (also see De Dreu & Nijstad, 2008; Förster et al., 2004). Participants saw eight large letters on their computer screens that were made up of small letters (e.g., a large A composed of small Cs). Participants were asked to read either the large letters (global processing mode) or the small letters (local processing mode).

Results revealed an interaction between processing mode and topic breadth for flexibility (i.e., number of categories) as well as for originality (i.e., average originality of ideas). A global processing mode increased flexibility relative to a local processing mode, but only with a broad topic. Similarly, originality of ideas was higher in the global processing mode condition, but only for people working on a broad topic. The interaction between processing mode and topic breadth on originality was fully mediated by flexibility. Thus the conclusion is that a global processing mode is associated with the flexibility pathway. Further, global processing is not

always related to creativity, but only on tasks that capitalise on cognitive flexibility (see Förster et al., 2004, for a similar point).

Mood states and the dual pathway model

Results so far indicate that creativity can be achieved through cognitive flexibility (e.g., surveying many conceptual categories, including ones not readily considered) as well as though persistence (e.g., surveying a few categories in greater depth). An interesting implication of the dual pathway to creativity model is that some states and traits may affect creativity primarily through their influence on cognitive flexibility, while other states and traits affect creativity primarily through their influence on cognitive persistence. In this section we apply this analysis to one of the most often studied factors that influence creativity: mood states.

Researchers began to analyse the effects of mood states on creative performance in the 1980s (e.g., Isen & Daubman, 1984; Isen, Daubman, & Nowicki, 1987; Strauss, Hadar, Shavit, & Itskowitz, 1981; Ziv, 1983), and since then over 100 studies have examined this relation (see Baas et al., 2008, for a recent meta-analysis). The popularity of the topic derives in part from the fact that mood states might mediate the effects of many variables on creative performance. For example, leadership, conflict, and previous task performance may influence mood states, and mood states may subsequently affect creativity (e.g., Carnevale & Probst, 1998; De Dreu & Nijstad, 2008; George & Zhou, 2002; Madjar & Oldham, 2002). And indeed, mood states affect cognitive functioning in various ways, including effects on creative functioning (e.g., Ashby et al., 1999; Bless & Fiedler, 2006; Dreisbach & Goschke, 2004).

The literature on mood and creativity breaks down into three interrelated lines of inquiry (see Baas et al., 2008). First, a huge body of research (over 60 studies) has examined the effects of positive mood states (as compared to neutral moods) on creative performance. In general, the evidence indicates that positive moods stimulate creativity: "It is now well recognized that positive affect leads to greater cognitive flexibility and facilitates creative problem solving across a broad range of settings" (Ashby et al., 1999, p. 530; also Baas et al., 2008; Lyubomirsky et al., 2005). However, there is also counter-evidence from studies showing a negative effect of positive moods on creativity (e.g., Anderson & Pratarelli, 1999; Kaufmann & Vosburg, 1997). A second line of research has examined the effects of negative mood states (as compared to neutral moods) on creativity, but here the evidence is quite mixed: some studies find that negative moods stimulate creativity (e.g., Adaman & Blaney, 1995; Clapham, 2001), others find that negative moods undermine creativity (e.g., Vosburg, 1998), and still others find no relation (e.g., Goritz & Moser, 2003; Isen et al., 1987). The third line of inquiry

directly compares positive and negative moods, and this has also yielded inconsistent results: some researchers find higher levels of creativity for negative than for positive moods (e.g., Gasper, 2003), others find the opposite (e.g., Grawitch, Munz, & Kramer, 2003).

Some of the inconsistencies could be resolved in the Baas et al. (2008) meta-analysis. First, Baas and colleagues found that positive moods were indeed associated with higher levels of creativity, but they found this effect only for activating positive mood states such as happiness and elation, and not for deactivating positive mood states, such as feeling calm and relaxed. Second, sadness overall did not correlate with creativity. Third, fear was associated with lower levels of creativity, but only if creativity was assessed with measures of flexibility. Yet this meta-analysis could not examine a number of issues, including why negative mood states sometimes enhanced creativity. In part, this question could not be addressed because most studies had focused on happiness, sadness, and anxiety, and very few had examined other mood states (e.g., anger, disappointment, disgust, etc.).

To explain some of the remaining issues, De Dreu and colleagues (2008) first of all applied the idea that mood states do not only vary according to hedonic tone (e.g., positive vs negative), but also according to level of activation (e.g., Barrett & Russell, 1998; Gray, 1982; Watson, Clark, & Tellegen, 1988). Some mood states are positive in tone and activating (e.g., happiness, elation), while others are positive in tone and deactivating (e.g., calm, relaxed). Similarly, some negatively toned mood states are activating (anger, fear), and others are deactivating (sadness, depression). De Dreu and colleagues argued that low levels of cognitive activation and arousal will primarily lead to inactivity, and these de-activating states are unlikely to be related to creativity (cf. Baas et al., 2008, results regarding the lack of effects of deactivating mood states such as feeling relaxed and sadness). Rather, moderate levels of activation and arousal (as associated with mood states rather than with intense emotions) stimulate cognitive performance, partly because of their association with the release of specific neurotransmitters such as dopamine and noradrenalin (see also, e.g., Ashby, Valentin, & Turken, 2002; Flaherty, 2005; Robbins, 1984). Thus activating moods will stimulate creativity more than deactivating moods.

Second, De Dreu et al. (2008) suggested that activating positive moods might enhance creativity because these mood states increase cognitive flexibility, while activating negative mood states might enhance creativity because they stimulate cognitive persistence. According to the cognitive tuning model (Clore, Schwarz, & Conway, 1994; Schwarz & Bless, 1991), a positive affective state leads people to experience the situation as safe and free of problems, which leads them to explore new possibilities in an unconstrained and flexible way (e.g., Fiedler, 2000; Schwarz & Clore, 1988).

Furthermore, positive affect is related to the release of dopamine in certain frontal brain areas, and this is hypothesised to enhance cognitive flexibility (e.g., Ashby et al., 1999; Dreisbach & Goschke, 2004). Negative mood states, on the other hand, lead people to experience the situation as problematic, and signal that specific action is needed to remedy the current situation, which calls for a systematic, constrained and analytical approach (e.g., Ambady & Gray, 2002; Schwarz & Bless, 1991). Activating negative moods also seem to stimulate persistence in cognitive activities (e.g., Derryberry & Reed, 1998; Strauss et al., 1981). To summarise, De Dreu et al. (2008) expected activating positive moods to enhance creativity because of greater cognitive flexibility (as compared to deactivating and neutral mood conditions), and they expected negative activating moods to enhance creativity because of greater persistence (as compared to deactivating and neutral moods).

In one study (De Dreu et al., 2008, Study 1), these hypotheses were tested among 58 participants who performed an ideation task (the education task discussed above). Four specific mood states were induced (anger, sadness, happiness, and relaxed) according to a 2×2 factorial between-participants design, crossing hedonic tone (negative: anger and sadness vs positive: happiness and relaxed) with activation (activating: anger and happiness, vs deactivating: sadness and relaxed). The mood induction was accomplished by asking the participants to write an autobiographical story about an event that made them feel really ... (depending on condition: angry, sad, happy, or relaxed). After the mood induction procedure (which manipulation checks showed to be successful), participants had 8 minutes to generate their ideas, and all ideas were counted (fluency) and rated on originality using a 5-point scale. Further, all ideas were categorised, and flexibility (number of categories used) and within-category fluency (number of ideas per category, as a measure of persistence) was established.

Results are presented in Table 2, and hypotheses were tested using planned contrasts. It was expected that creative fluency and originality would be higher for the activating mood states (anger and happiness) than for the de-activating mood states (sadness and relaxed), and this effect was indeed significant. Further, it was expected that flexibility would be especially high among happy participants (as compared to all other conditions). However, although the means were in the expected direction, this effect was not significant. Finally, persistence (i.e., within-category fluency) was expected to be highest among angry participants, and this prediction was confirmed. Thus this study gave considerable support for the dual pathway model predictions, but the results regarding flexibility were less strong than would be desirable, perhaps because of the relatively modest sample size (i.e., observed statistical power for this effect was smaller than .20).

TABLE 2
Creative performance as a function of mood state

	Mood state			
Dependent variable	*Anger*	*Sadness*	*Happiness*	*Relaxed*
Fluency	13.32*	10.16	11.88*	10.42
Originality	2.73*	2.06	2.77*	2.26
Flexibility	3.65	3.56	4.01*	3.46
Persistence (within-category fluency)	3.64*	2.85	2.96	3.01

Means in the same row marked with an asterisk were hypothesised to be higher than means in the same row without an asterisk.

In another ideation study, De Dreu et al. (2008; Study 4) measured specific mood states rather than manipulating them. Participants ($N = 546$ undergraduate students) rated their current mood on a number of adjectives. Using factor analysis these were clustered into positive activating moods (e.g., happy, elated, excited), negative activating moods (e.g., fearful, angry, upset), positive de-activating moods (e.g., calm, relaxed, at ease), and negative de-activating moods (e.g., depressed, discouraged, sad). After the mood measurement, participants engaged in an 8-minute brainstorming task on the education topic. As in the previous study, fluency, originality, flexibility, and within-category fluency were reliably assessed.

Hypotheses were tested using multiple regressions. In each regression, one indicator of creativity (i.e., fluency, originality, flexibility, and within-category fluency) was the dependent variable, and all four measures of mood states (i.e., positive activating, positive deactivating, negative activating, and negative deactivating) were simultaneously used as predictors. We predicted that activating mood states (positive as well as negative) would enhance creativity and be positively related to fluency and originality. Indeed, both positive activating moods and negative activating moods significantly and positively predicted fluency and originality, but de-activating moods (positive or negative) had no effect. However, we predicted that these effects should be due to increased flexibility in the case of positive activating moods and due to within-category fluency in the case of negative activating moods. Consistent with these predictions, positive activating moods were positively related to flexibility, while negative activating mood states were positively related to within-category fluency. On these last two measures there were no further effects. Thus strong support was obtained for the prediction that positive activating mood states stimulate creativity through flexibility, and negative activating mood states stimulate creativity through persistence. In this study, however, only flexibility mediated the effects of positive activating mood states on originality, but no mediation of

within-category fluency between negative activating mood states and originality could be established (i.e., the path between within-category fluency and originality was not significant, see Figure 5). However, in previous sections we have shown that this path is stronger when fluency within a category is related to originality of ideas within that same category. That the overall path between within-category fluency and originality across all ideas was not significant is, therefore, not necessarily problematic for the model.

The results of De Dreu et al. (2008) fit the dual pathway model well. In addition, their findings are also largely consistent with the Baas et al. (2008) meta-analysis. Recall that Baas et al. also found that only activating mood states (e.g., happiness) were related to creativity, but deactivating states (e.g., feeling relaxed, sadness) were not. There seems to be one inconsistency: Baas et al. (2008) found that fear and anxiety negatively related to creativity, while De Dreu et al. (2008) found a positive effect. However, these findings may be reconciled, because the negative effects of fear in the meta-analysis were found only for measures of cognitive flexibility, while the positive effects found by De Dreu et al. were found for measures of persistence. Thus while fear may undermine flexibility, it enhances persistence, and positive effects of fearful moods on creative performance could perhaps be obtained when using tasks that capitalise more on persistence (as with ideational and divergent-thinking tasks) instead of only on flexibility. In any case, future studies should investigate the effects of negative activating moods (including fear and anger) more fully.

To conclude, there is quite strong evidence that deactivating mood states have no relation with creativity. Furthermore, positive activating moods are positively related to creativity, and this mainly seems to be the case because happiness and related states enhance cognitive flexibility. Negative activating mood states seem to be related to creativity because they enhance cognitive persistence. At the same time, however, some negative states such

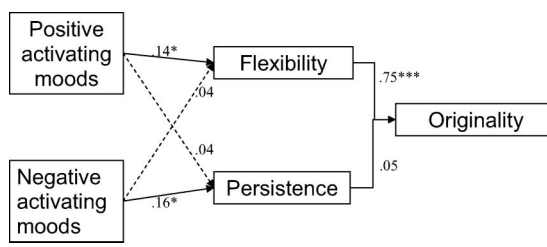

Figure 5. Path model linking positive activating and negative activating moods to originality through their effects on flexibility (number of categories surveyed) and persistence (within-category fluency). *$p < .05$; ***$p < .001$. Based on De Dreu et al., 2008, Study 4.

as fear and anxiety may undermine cognitive flexibility. Positive effects of fearful states on creative performance might therefore only be obtained when the creativity task capitalises (at least to some extent) on persistence.

DISCUSSION

The dual pathway to creativity model argues that creative performance is a function of cognitive flexibility, cognitive persistence, or some combination of the two. More importantly, it argues that some traits or states influence creativity because of their association with cognitive flexibility, while other states or traits influence creativity because they are associated with cognitive persistence. Here we will first discuss the evidence for the model. We then consider the applicability of the model to other types of creativity task (i.e., non-ideation tasks). Finally, we identify issues for future research.

Summary of the evidence

The dual pathway model was tested in a number of studies that all focused on ideation tasks. In these (brainstorming, divergent-thinking) tasks people are asked to generate as many ideas as possible, and several measures of creativity can be derived from these tasks, including fluency (number of ideas), flexibility (number of content categories), and within-category fluency (number of ideas per category). Further, ideas can be scored on quality dimensions, such as originality (e.g., infrequency of an idea) and feasibility (the degree to which an idea might be realised). We argued that studying the dual pathway model in the context of ideation tasks has the benefit that measures of flexibility versus persistence can be established: flexibility can be operationalised as the number of content categories used, and persistence can be established by looking at within-category fluency.

We have presented five types of evidence for the dual pathway model in the context of ideation tasks. First, correlational evidence from a meta-analysis indicated that flexibility relates directly to originality: the more categories are used, the higher the average originality of ideas. We suggest that the reason is that using many categories implies that less-frequently used categories are also sampled, and ideas in these categories are more original. Correlational evidence further indicated that within-category fluency is also positively related to idea originality: when more ideas from a category are generated and a category is explored in greater depth (i.e., higher persistence), these ideas are, on average, more original. However, the relation between flexibility and originality was much stronger than the relation between within-category fluency and originality.

A second piece of evidence indicated that when people focus more on a few content categories, rather than superficially examine many categories,

ideas tend to be more original. Thus when people generated ideas on a narrow rather than a broad topic, ideas were, on average, more original. In further support of the idea that persistence within a few categories can lead to originality, it was also found that the correlation between fluency and originality was higher and significant in the narrow topic condition, but was not significant in the broad topic condition. Using a priming procedure that focused people more on some categories than others, similar effects were obtained: when people (due to priming) focused more on a specific content category, their ideas sampled from this category were more original, and fluency within that category was positively associated with originality of ideas within that category. Thus, these results clearly show that persistence within categories leads to originality.

Third, we reported studies that assessed within-category fluency and the persistence pathway as a function of the personality variable Personal Need for Structure (PNS). Although PNS would normally be associated with rigidity and a lack of creativity, it was argued that PNS might be associated with persistence within categories. Indeed, we found that high-PNS participants were quite capable of producing original ideas, as long as they were not hampered by a high level of Personal Fear of Invalidity (PFI) and a tendency to worry too much about the correctness of their responses. Further, because the interactive effects of PNS and PFI on originality were mediated by within-category fluency, this effect could be attributed to persistence.

Fourth, we argued that a global processing mode (i.e., focusing on the broad picture rather than the details) would lead to higher flexibility. We further predicted that this increase in flexibility would only lead to original ideas when the task capitalises on flexibility. In a study in which both processing modes and task constraints (using a broad or narrow topic) were manipulated, we found that a global processing mode only led to higher flexibility and originality in the broad topic condition, but not in the narrow topic condition.

Finally we discussed the effects of mood states on creative performance. We presented evidence that positive activating mood states (happiness, elation) enhance creativity because they lead to higher flexibility. Negative activating mood states (anger, fear), on the other hand, lead to creativity because they stimulate persistence. These findings potentially explain the inconsistencies in the literature regarding the effects of mood states on creativity. Especially for negative moods, sometimes a positive effect is obtained, while at other times the effects are negative. The dual pathway model suggests that the size and direction of these effects may depend, first of all, on whether the mood state is activating (e.g., anger, fear) or deactivating (sadness, depression) and, second, on whether the task allows for creativity to emerge through persistence. For example, positive effects of

negative moods are more likely to be obtained when tasks are longer and when persistent search processes may eventually lead to new solutions.

The evidence is thus generally quite consistent with the idea that creativity can be obtained by flexible thinking, set breaking, and the use of broad categories and remote associations, but also by systematic and persistent search processes. We also presented evidence that some traits and states (e.g., positive activating moods, global processing styles) are mainly associated with cognitive flexibility, while others (negative activating moods, PNS) are mainly associated with cognitive persistence. In sum, the dual pathway to creativity model has by now received substantial support.

Generalisability to other tasks

While the use of ideational tasks has the advantage that measures of flexibility and persistence can be obtained, a critical issue is whether results generalise to other creativity tasks as well. For example, some work has studied performance on "eureka" or insight tasks (e.g., Duncker's candle task; Duncker, 1945; also see Schooler & Melcher, 1995) and other work has studied composite ratings of creativity of certain products (e.g., poems, stories, collages; e.g., Amabile, 1985; Griskevicius et al., 2006; Hovecar & Bachelor, 1989). We examine the evidence regarding these types of tasks now.

Insight performance. Insight tasks differ from ideation tasks in the sense that they have only one demonstrably correct solution (Simonton, 2003b). These tasks typically require a mental restructuring of problem information because one's initial solution is likely to be incorrect. Furthermore, a clear and sudden understanding of how the problem can be solved may arise (the "aha experience"; e.g., Schooler & Melcher, 1995). Because some mental restructuring is required to solve insight tasks, and people have to switch to a different approach, it seems that these types of tasks may profit more from cognitive flexibility than from cognitive persistence. However, might performance on insight tasks also benefit from cognitive persistence? Some evidence is available to address this question.

De Dreu et al. (2008) studied performance on the Gestalt Completion Task (GCT) as a function of mood state. The GCT involves recognising a number of fragmented pictures of familiar objects, and can be seen as a perceptual insight task (see also Förster et al., 2004). De Dreu and colleagues found that participants in activating mood states—negative (anger, fear) as well as positive (happiness, elation)—solved more gestalts than those in deactivating mood states (e.g., sadness, depression and relaxation, calmness). Further, they found that participants in an activating

negative mood state spent more time on the task (i.e., persistence) than those in a negative deactivating mood, while the difference between activating and deactivating positive moods was not significant. Finally, for activating negative mood states, time-on-task was positively related to performance on the GCT, while for activating positive mood states this relation was negative. Thus participants in negative activating moods were more persistent than those in deactivating moods, and their greater persistence led to better performance. However, to achieve a similar level of performance, participants in activating negative mood states needed more time than those in activating positive moods.

Another insight task that has been extensively studied is the Remote Associates Test (RAT; Mednick & Mednick, 1967). The RAT is a conceptual (rather than perceptual) insight task that asks participants to identify associations among words that are not normally connected. Participants are given three words (e.g., envy, golf, bean), and have to generate a word that associates with all of them (e.g., green). Because the solution is not strongly associated with the three stimulus words, a broad attentional focus is required to allow more distant associations to enter working memory. One might therefore assume that RAT performance is related more to cognitive flexibility than to cognitive persistence.

Harkins (2001, 2006) studied RAT performance as a function of evaluation. He argued that participants who can be evaluated will exert more effort than those who cannot be evaluated. Harkins found that participants in the evaluation condition solved more easy RAT items but fewer difficult RAT items than those in the no evaluation condition. The reason appeared to be that participants in the evaluation condition systematically generated associates of each stimulus word separately, which often led to the correct solution in the case of easy items. However, for more difficult items the correct answer was not strongly associated with any of the three stimulus words and using this (effortful and systematic) approach often did not lead to the correct solution (see Harkins, 2006). It thus appears that using an effortful strategy (similar to employing the persistence pathway) may actually harm cognitive flexibility, while cognitive flexibility is required to solve difficult RAT items.

It thus seems that difficult insight problems are more easily solved through cognitive flexibility and that systematic search processes are not very effective. However, the results of De Dreu et al. (2008) indicate that insight problems may also be solved through persistent search processes, although that takes more time. It may be the case that RAT performance also eventually benefits from persistence. For example, in the studies performed by Harkins (2001, 2006) participants were usually given a maximum of 30 seconds to solve each RAT item. When given more time, systematic search may also lead eventually to success.

Other creativity tasks. There is no direct evidence pertaining to the question of whether performance on other creativity tasks (e.g., writing a story, making a collage or drawing, etc.) benefits from flexibility and persistence. However, some indirect evidence exists. Rietzschel et al. (2007a) analysed the creativity of drawings as a function of Personal Need for Structure (PNS) and Personal Fear of Invalidity (PFI). Rietzschel et al. asked their participants, after filling out the PNS and PFI scales, to draw an alien. This drawing was scored on creativity by assessing whether the alien had a number of mammal-like features (e.g., a head separate from the body, symmetrical features, two or four feet), assuming that aliens with more of these features would be less creative. They found, analogous to the findings on idea generation tasks, that the creativity of the drawing was positively associated with PNS under low levels of PFI, but negatively under high levels of PFI. Thus some of the results that were found with respect to ideation tasks seem to generalise to these types of tasks. However, any direct evidence linking performance on these types of tasks to flexibility or persistence is missing. For example, no mediating processes (i.e., persistence or flexibility related) were assessed in the Rietzschel et al. study (or in any other study that we are aware of).

FUTURE RESEARCH

One clear avenue for future research, then, is to examine performance on other types of creativity tasks as a function of cognitive flexibility and persistence. For example, one could examine the relations between time-on-task and creativity, as was done by De Dreu et al. (2008), in tasks such as making a drawing, solving insight problems, or telling a story. However, the most important contribution of the dual pathway to creativity model is that it proposes that some traits and states influence cognitive flexibility while others influence cognitive persistence. Thus another direction for future research would be to identify traits and states that are associated with cognitive flexibility, cognitive persistence, or both.

Regarding cognitive flexibility, a general hypothesis would be that any state or trait that is associated with an approach orientation is positively related to cognitive flexibility and therefore to creativity. Examples for which positive effects on creativity have been found include intrinsic motivation (e.g., Amabile, 1983), positive moods (e.g., Ashby et al., 1999; Baas et al., 2008), approach motor actions and promotion focus (Friedman & Förster, 2000, 2001, 2002), romantic motives (Griskevicius et al., 2006), and individual differences in Openness to Experience (e.g., McCrae, 1987) and extraversion (e.g., Feist, 1998; Furnham & Bachtiar, 2008). These states and traits seem to have in common that they are associated with a broad attentional focus and a willingness to explore alternative courses of action to

reach some desired end-state. Future research may examine the hypothesis that approach-related states or traits are associated with creative performance particularly because they stimulate cognitive flexibility.

Avoidance-oriented states and traits, on the other hand, may be more related to cognitive stability and enhanced cognitive control (Koch et al., 2008), and perhaps to reduced cognitive flexibility (Derryberry & Reed, 1998). For example, the anticipation of conflict (Carnevale & Probst, 1998), fearful and anxious states (Baas et al., 2008), avoidance motor actions and prevention focus (Friedman & Förster, 2000, 2001, 2002), and neuroticism, seem to lead to a narrow focus of attention. However, as we have argued in this chapter, narrow and systematic processing may also eventually lead to creativity. Indeed, De Dreu and Nijstad (2008) showed that the anticipation of conflict leads to lower cognitive flexibility and creativity for tasks that are unrelated to the conflict. However, they also found that participants who anticipated a severe conflict were in fact quite original where conflict-related material was considered (e.g., in designing strategies to beat the opponent). Thus these participants focused their attention on the upcoming conflict (and were less creative in conflict-unrelated tasks), but within the conflict domain were capable of creative thinking. So, under some circumstances, avoidance-related states may be associated with creativity through persistent and focused processing, but future research would have to provide more conclusive evidence.

It would also be interesting to connect the dual pathway model to Big C creativity and genuinely important discoveries, inventions, and works of art. Earlier in this chapter we noted that the best predictor of creative eminence is sheer productivity (e.g., Simonton, 1997, 2003b). For example, Emily Dickinson wrote over 1700 poems, Thomas Edison by the end of his life held more than 1000 patents, and Pablo Picasso produced a staggering 147,800 works of art. Csikszentmihalyi (1996, 1997) has noted that many people who are considered creative geniuses simply love what they do. He introduced the notion of "flow": an almost automatic, effortless, yet highly focused state of consciousness (Csikszentmihalyi, 1996, p. 110). Flow is related to a perceived fit between individuals' skills and task demands, to longer time-on-task and greater fluency (Keller & Bless, 2008), as well as to external ratings of creativity in musical composition (MacDonald, Byrne, & Carlton, 2006). One hypothesis would be that the engaging experience of flow is associated positively with both cognitive flexibility and persistence: indeed, to become a great scientist, artist, or inventor one needs both flexibility and persistence.

Another interesting avenue for future research is to apply the dual pathway model to group creativity. The topic of group creativity has mainly been studied in the context of brainstorming groups (e.g., Paulus & Nijstad, 2003), and early work has focused on the finding that groups tend to

perform poorly as compared to individuals (Diehl & Stroebe, 1987; Mullen, Johnson, & Salas, 1991). Recently, research has focused more on the question of which factors make groups more versus less creative (as compared to other groups, rather than to individuals; see e.g., Mannix, Neale, & Goncalo, 2009). It would be interesting to link specific group-level factors to the flexibility and persistence pathways. For example, recent work suggests that a willingness to stand out from the group and take a divergent perspective is positively related to group-level creativity (e.g., Beersma & De Dreu, 2005; Goncalo & Staw, 2006), and other work suggests that minority dissent within a group enhances creativity of group members (e.g., De Dreu & West, 2001; Nemeth, Personnaz, Personnaz, & Goncalo, 2004; Van Dyne & Saavedra, 1996). Group cognitive diversity may, under certain conditions, also positively relate to group creativity (e.g., Milliken, Bartel, & Kurtzberg, 2003). Group norms that encourage members to take a different perspective, minority dissent, and group cognitive diversity most likely enhance creativity through increased levels of flexibility, because they lead group members to consider multiple perspectives and approaches. Future research might consider this hypothesis.

Other variables may affect group creativity through the persistence pathway. Nijstad, Stroebe, and Lodewijkx (1999) have found that groups tend to persist longer in brainstorming sessions than individuals, and that groups could thereby compensate for their usual poor performance as compared to individuals. However, the persistence pathway not only assumes longer time on task, but also a more systematic approach to creativity. Previous work on brainstorming groups suggests that group idea generation is less systematic than individual idea generation, because group interaction interferes with the ability of group members to think systematically (e.g., Diehl, 1991; Nijstad et al., 2003). This effect might be counteracted by structuring a brainstorming session more, for example by asking groups to sequentially generate ideas in different categories. Evidence indicates that this leads to higher productivity (i.e., more ideas) because categories are explored more fully (Coskun et al., 2000). We would propose that it probably also results in higher levels of originality, but that hypothesis has yet to be tested.

Finally, it would be interesting to connect the dual pathway model directly to neuropsychological work. The connections between certain states and traits, certain neurotransmitters, and cognitive performance have already received quite a bit of attention (see e.g., Ashby et al., 1999; Dreisbach & Goschke, 2004). It would be interesting to see whether the two pathways are associated with the activity of neurotransmitters in some brain areas, or with the activation of some brain areas rather than others. Further, connections with latent inhibition and working memory capacity could be explored. We would expect that reduced levels of latent inhibition will be

associated with the flexibility pathway, whereas higher working memory capacity will be associated with cognitive control and the persistence pathway.

CONCLUSION

Thomas Edison followed up his famous quote that "genius is one percent inspiration and 99 per cent perspiration" by saying "I never did anything worth doing by accident, nor did any of my inventions come by accident. They came by work" (quoted in *Harper's Monthly Magazine*, 1932). The dual pathway to creativity model, which we have laid out in this chapter, indeed suggests that creativity comes about not only by a spark of genius or while sitting in the bathtub. Creativity is a function of flexible thinking and taking different approaches to a task, but also of systematic search processes and hard work.

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