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de Rooij, Alwin; Vromans, Ruben

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ALWIN DE ROOIJ
RUBEN D. VROMANS

The (Dis)Pleasures of Creativity: Spontaneous Eye Blink Rate during Divergent and Convergent Thinking Depends on Individual Differences in Positive and Negative Affect

ABSTRACT

Previous research has demonstrated that individual differences in affect and motivation predict divergent and convergent thinking performance, two thinking processes involved in creative idea generation. Individual differences in affect and motivation also predict spontaneous eye blink rate (sEBR) during divergent and convergent thinking; and sEBR predicts divergent and convergent thinking performance. This study investigates experimentally whether the relationship between sEBR and divergent and convergent thinking depends on individual differences in affect and motivation. Eighty-two participants completed the Emotion/motivation-related Divergent and Convergent thinking styles Scale (EDICOS; G. Soroa et al., 2015), performed the alternative uses task (AUT; divergent thinking) or the remote associates task (RAT; convergent thinking), while their sEBR was captured with an eye-tracker. The results showed that individual differences in positive affect positively correlated with sEBR for the AUT, whereas individual differences in negative affect positively correlated with sEBR for the RAT. Furthermore, the interaction between individual differences in positive and negative affect and sEBR predicted divergent and convergent thinking performance. The contribution of our study is therefore that individual differences in positive and negative affect can both positively correlate with sEBR during divergent and convergent thinking; and that this predicts divergent and convergent thinking performance.

Keywords: affect, convergent thinking, divergent thinking, eye blink rate, individual difference, motivation.

In recent years, there has been an increasing interest in using eye movement patterns, fixations and eye blink rate to study divergent and convergent thinking—two thinking processes that are involved in creative idea generation (for a recent review, see Salvi & Bowden, 2016). One major finding is that spontaneous eye blink rate (sEBR)—the average number of blinks per minute under normal resting state (Cruz, Garcia, Pinto, & Cechetti, 2011)—predicts divergent and convergent thinking performance (e.g., Akbari Chermahini & Hommel, 2010, 2012a). However, sEBR also associates with multiple affective and motivational constructs, and therefore associates with a wider variety of predictors of divergent and convergent thinking performance. In this study, we studied experimentally whether the relationship of sEBR with divergent and convergent thinking depends on individual differences in affect and motivation.

DIVERGENT AND CONVERGENT THINKING

Divergent and convergent thinking refer to two orthogonal modes of thinking that can be involved in the generation of creative ideas (Cropley, 2006; Guilford, 1967), that is, the creation of ideas that are both original and effective (Runco & Jaeger, 2012). *Divergent thinking* has originally been defined by Guilford (1957) as "*the nature of tests where items are going off in multiple directions*", and was rephrased later by Cropley (1999, p. 254) as the "*production of variation*". During creative idea generation, for example, divergent thinking can facilitate the production of sufficiently diverse and original material from which a single solution can be developed (Cropley, 2006). *Convergent thinking* was originally defined by Guilford (1957) as "*the nature of tests where items are converging toward one right answer*", and later rephrased by Cropley (1999, p. 254) as the "*production of singularity*". Convergent thinking can be seen as the opposite and the complement of divergent thinking (Cropley, 2006; Guilford, 1967). During creative idea generation, for example, the diverse set of material that is generated through divergent thinking can form the basis for deriving a single best solution through convergent thinking. Divergent and convergent thinking can therefore support the generation of ideas that are both original and effective (Cropley, 2006).[1] Tests of divergent (e.g., Guilford, 1967) and convergent thinking (e.g., Mednick & Mednick, 1971) can be used as indicators of creative potential (Cropley, 2000).[2]

Divergent and convergent thinking *performance* depends on the degree to which *cognitive control* adapts during a divergent or convergent thinking task, so that this favours the emergence of original and effective solutions (de Rooij & Jones, 2013). Experimental studies have shown that greater cognitive flexibility predicts divergent thinking performance (Zabelina & Robinson, 2010). This can be explained by an increase in the likelihood that a person engages with remotely associated information, which in turn can increase the likelihood that more original responses are generated (Zabelina, Colzato, Beeman, & Hommel, 2016). Cognitive stability predicts convergent thinking performance (Razumnikova, 2007). This can be explained by an increase in working memory capacity, which in turn increases the maintenance of task-relevant information, that is focus; and can possibly benefit convergent thinking via persistence (de Dreu, Baas, & Nijstad, 2012; Nijstad, De Dreu, Rietzschel, & Baas, 2010). However, convergent thinking may also benefit from cognitive flexibility when it is achieved via sudden insight (cf. Salvi, Bricolo, Franconeri, Kounios, & Beeman, 2015; Subramaniam, Kounios, Parrish, & Jung-Beeman, 2009).

INDIVIDUAL DIFFERENCES IN AFFECT AND MOTIVATION

Affective and *motivational* processes predict cognitive flexibility and cognitive stability. Empirical studies show that most types of positive affect positively correlate with cognitive flexibility, or that this relationship can be described with an inverted U-shaped function (Goschke & Bolte, 2014). Most negative affects (in particular those that associate with uncertainty (de Rooij & Jones, 2013; Tiedens & Linton, 2001)) positively correlate with cognitive stability (de Dreu, Baas, & Nijstad, 2008; Goschke & Bolte, 2014). Relatedly, empirical studies suggest that the (proactive) motivation to achieve a positive outcome also positively correlates with cognitive flexibility (Goschke & Bolte, 2014), whereas the motivation to prevent achieving a negative outcome positively correlates with cognitive stability, and relatedly focus and persistence (Koch, Holland, & van Knippenberg, 2008; Miron-Spektor, Efrat-Treister, Rafaeli, & Schwarz-Cohen, 2011). It follows that individual differences in affect and motivation (i.e., a disposition to experience positive or negative affect, or engage in proactive or preventive motivation) during tasks that require divergent or convergent thinking, can predict performance on these tasks.

Individual differences that predict *divergent thinking* performance positively correlate with a disposition to experience *positive affect* and with the motivation to achieve positive outcomes in a *proactive* manner during tasks that require divergent thinking (Soroa, Balluerka, Hommel, & Aritzeta, 2015). These individual differences increase the likelihood that (a) cognitive flexibility is increased through positive affect (Goschke & Bolte, 2014), which (b) increases the likelihood that an individual performs well on a divergent thinking task (Baas, de Dreu, & Nijstad, 2008), (c) which signals an increase in the likelihood that a positive outcome is (being) achieved (de Rooij, Corr, & Jones, 2015, 2017), (d) eliciting more positive affect (cf. Kappas, 2011), and (e) thus further favouring task performance (de Rooij et al., 2015, 2017). For instance, recent studies by de Rooij and colleagues have shown that providing performance feedback during the alternative uses task (henceforth AUT), on the originality of a person's ideas, in a manner that is slightly more positive that one would typically expect, also increases the likelihood that that person will generate even more original ideas. Thus, when individual differences comprise of a disposition to experience positive affect and proactive motivation during a divergent thinking task, such as the AUT, these can predict divergent thinking performance.

Individual differences that predict *convergent thinking* performance positively correlate with the disposition to experience *negative affect* (anxiety and stress in particular) and the motivation to *prevent* negative outcomes during tasks that require convergent thinking (Soroa et al., 2015). These individual differences

[1] Note that there is some debate about the necessity of divergent and convergent thinking during different steps in the creative process. We refer to Isaksen, Dorval, and Treffinger (2010) and to Mumford, Medeiros, and Partlow (2012) for reviews.

[2] Note that there is an ongoing debate about the degree to which divergent and convergent thinking tests such as the alternative uses task and the remote associates test measure creativity, creative potential, and related constructs. Relevant discussions on the alternative uses task can be found, for example, in Zheng, Proctor, and Salvendy (2011) and Runco and Acar (2012). Discussions on the remote associates task can be found in, for example, Mednick and Mednick (1971) and Worthen and Clark (1971).

increase the likelihood that (a) cognitive stability and persistence are enhanced through negative affect (Baas et al., 2008), which (b) increases performance on convergent thinking tasks (Baas et al., 2008), but also (c) functions as a form of self-regulation that repairs negative affect when it is elicited (Kappas, 2011), while (d) maintaining cognitive stability to achieve self-regulation (Kappas, 2011), and (e) further favouring task performance during convergent thinking (cf. Bledow, Rosing, & Frese, 2013; Roskes, De Dreu, & Nijstad, 2012). For instance, studies by Roskes and colleagues suggest that a motivation to prevent negative outcomes enhances performance through persistence (which can be a feature of cognitive stability), but only when people feel that increased performance on the task can be used to prevent the possibility of negative outcomes that they are confronted with. Thus, when individual differences favour the emergence of negative affect and preventive motivation during a convergent thinking task, these can predict convergent thinking performance.

On the basis of such findings, Soroa et al. (2015) recently developed a taxonomy of *individual differences* in affect and motivation that predict divergent and convergent thinking performance. These individual differences are grouped as follows:

1 *Convergent unpleasant*. People who experience negative affect (in particular anxiety and stress) when they engage in a convergent thinking task.
2 *Convergent preventive*. People who have a disposition to engage in convergent thinking because of a tendency to focus on the prevention of negative outcomes.
3 *Divergent pleasant*. People who experience positive affect when they engage in a divergent thinking task.
4 *Divergent proactive*. People who have a disposition to proactively seek out to achieve novelty through divergent thinking as a way to achieve positive outcomes.

SPONTANEOUS EYE BLINK RATE ASSOCIATES WITH DIVERGENT AND CONVERGENT THINKING

Spontaneous eye blink rate (sEBR)—the average number of blinks per minute under normal resting state (Cruz et al., 2011)—also predicts divergent and convergent thinking performance. Studies suggest that there exists a curvilinear relationship of sEBR with the amount of different concepts people use to generate responses (a measure of cognitive flexibility) on the AUT, which is best described with an inverted U-shape function (Akbari Chermahini & Hommel, 2010, 2012a). Relatedly, Ueda and colleagues found that sEBR positively correlates with the amount of ideas (a measure of fluency) that people generate during a cued version of the AUT. These findings suggest that sEBR predicts divergent thinking performance, either via a positive correlation or via a curvilinear relationship.

The same studies suggest that sEBR may negatively correlate with convergent thinking (measured with the remote associates task (henceforth RAT); Akbari Chermahini & Hommel, 2010, 2012a; Ueda, Tominaga, Kajimura, & Nomura, 2016). Akbari Chermahini & Hommel found a negative correlation between sEBR and the amount of correctly answered items in the RAT. However, Ueda and colleagues found no significant correlation between sEBR and the amount of correctly answered items during the RAT. However, sEBR did positively correlate with response rates during the RAT (i.e., larger sEBR associated with larger response times). Taken together, there is some evidence to suggest that there might be a negative correlation between sEBR and convergent thinking performance.

As such, the currently available literature suggests that sEBR predicts both divergent and convergent thinking performance, but in different ways.

SPONTANEOUS EYE BLINK RATE ASSOCIATES WITH CHANGES IN AFFECT AND MOTIVATION

Interestingly, recent studies also suggest that sEBR predicts seemingly opposing psychological phenomena such as proactive and preventive motivation (Braver et al., 2014); and positive and negative affect (Burgdorf & Panksepp, 2006; Lago, Davis, Grillon, & Ernst, 2017).

sEBR positively correlates with *proactive motivation*, that is, the motivation to (proactively) achieve a positive outcome. For example, research has shown that sEBR positively correlates with anticipation, reducing distance to obtaining, and achieving reward (Barkley-Levenson & Galván, 2016; Peckham & Johnson, 2016). However, other studies suggest that sEBR can also positively correlate with *preventive motivation*, that is, the motivation to prevent a negative outcome. For instance, sEBR increases when an impending negative outcome is prevented, such as loss aversion in the IOWA Gambling task (Byrne, Norris, & Worthy, 2016) and averting conflict-induced punishment (Cavanagh, Masters, Bath, & Frank, 2014).

Furthermore, sEBR positively correlates with *positive affect*, i.e. the extent to which a person feels pleasurably engaged (Burgdorf & Panksepp, 2006). For example, writing down events that make you happy, positively correlates with both sEBR and with self-reported positive affect (Akbari Chermahini & Hommel, 2012b). However, increases in sEBR can also positively correlate with *negative affect*, that is, the extent to which a person feels unpleasurably engaged (Badgaiyan, 2010; Lago et al., 2017). For example, Weiner and Concepcion (1975), who used visual and auditory threat inducing stimuli (e.g., a car accident) and the Multiple Affect Adjective Checklist as a subjective self-report measure for anxiety, found that threat inducing stimuli caused a higher sEBR and higher self-reported anxiety than control stimuli.

These findings suggest that increases in sEBR can predict seemingly opposing constructs, such as with positive and negative affect, and with proactive and preventive motivation. As these phenomena are at the basis of the individual differences in affect and motivation that are predictive of divergent and convergent thinking performance, as proposed by Soroa et al. (2015), they can be taken as indirect evidence for the existence of a relationship between these individual differences and sEBR.

PRESENT STUDY

On the basis of the reviewed studies, we conjecture that in the currently available literature there is both a *consistency* and a *discrepancy* about how individual differences in affect and motivation play a role in the relationship of sEBR with divergent and convergent thinking performance.

The *consistency* in the discussed literature suggests that there is evidence for the conjecture that a disposition to experience positive affect when engaging in a divergent thinking task (*divergent pleasant*), or to proactively seek to achieve novelty by divergent thinking as a way to achieve positive outcomes (*divergent proactive*), positively correlates with sEBR. Moreover, this can predict divergent thinking performance due to the relationship between sEBR and cognitive flexibility.

This is because the available literature consistently shows that (a) positive affect and proactive motivation (during divergent thinking) positively correlate with sEBR (Akbari Chermahini & Hommel, 2012a; Barkley-Levenson & Galván, 2016; Peckham & Johnson, 2016); (b) both such individual differences (Soroa et al., 2015) and sEBR predict divergent thinking performance, either via a positive correlation (Ueda et al., 2016), or via a relationship that is best described with an inverted U-shape function (Akbari Chermahini & Hommel, 2010); and (c) positive correlations between positive affect, proactive motivation, and cognitive flexibility (Baas et al., 2008; Goschke & Bolte, 2014), as well as a curvilinear relationship between sEBR and cognitive flexibility (Akbari Chermahini & Hommel, 2010, 2012a), predict divergent thinking performance.

The *discrepancy* in the literature, however, suggests that there is uncertainty about whether a disposition to experience negative affect when engaging in a convergent thinking task (*convergent unpleasant*), or to engage in convergent thinking because of a tendency to focus on the prevention of negative outcomes (*convergent preventive*), positively or negatively correlates with sEBR during tasks that require convergent thinking. Moreover, there is uncertainty about whether the relationship between these individual differences and sEBR relates to convergent thinking performance in a positive or negative way.

On the one hand, individual differences grouped under convergent unpleasant and convergent preventive positively correlate with convergent thinking performance (Soroa et al., 2015); this can be explained by a relationship between a disposition to have some negative affects, with cognitive stability, and relatedly enhanced focus and persistence, which is conducive to convergent thinking (Baas et al., 2008). On the other hand, elicited negative affect and preventive motivation, which is likely to happen in individuals characterised by these differences, can positively correlate with sEBR (Byrne et al., 2016; Cavanagh et al., 2014; Weiner & Concepcion, 1975). However, other studies suggest that sEBR negatively correlates with convergent thinking performance (Akbari Chermahini & Hommel, 2010; Ueda et al., 2016); and this can be explained by a relationship between sEBR and cognitive flexibility, which may negatively correlate with convergent thinking performance (Akbari Chermahini & Hommel, 2010, 2012a). Therefore, there is uncertainty about what sEBR represents during tasks that require divergent and convergent thinking, when taking into account individual differences in affect and motivation.

As such, the discussed literature raises questions about the relationship between individual differences in affect and motivation, sEBR, and divergent and convergent thinking performance. With this study, we aim to explore this—by testing experimentally whether individual differences in positive and negative affect, and in proactive and preventive motivation, can further help explain the relationship of sEBR with divergent and convergent thinking.

METHOD

PARTICIPANTS

A group of 82 (under)graduate students of Tilburg University participated in our experiment in exchange for course credit or candy. Two participants were excluded from the analysis, one due to missing data (that resulted from a technical error), and one due to extreme blink rate (which we suspect is the result of measurement error). As a result, 80 participants were included in the analysis (51 female, 29 male, $M_{age} = 22.8$, $SD_{age} = 2.86$, $Range_{age} = 18–30$ years). All participants had normal or corrected-to-normal vision. The participants were randomly assigned to either the divergent thinking condition ($N = 41$) or the convergent thinking condition ($N = 39$). All participants signed informed consent and were debriefed after the session. The study was approved by the Review Board of Communication and Information Sciences of Tilburg University.

MATERIALS AND MEASUREMENTS

The Emotion/motivation-related Divergent and Convergent thinking styles Scale (EDICOS)

To measure individual differences in affect and motivation during divergent and convergent thinking, participants completed the emotion and motivation related divergent and convergent thinking styles scale (EDICOS; Soroa et al., 2015). This questionnaire assesses situational individual differences in the way people respond emotionally to and are motivated by tasks that require divergent or convergent thinking. The EDICOS consists of four dimensions: (a) Convergent unpleasant (eight items, e.g., "While working on a complex problem I feel a certain level of anxiety"), (b) Convergent preventive (eight items, e.g., "I like to think about a difficult decision"), (c) Divergent pleasant (five items, "When I get involved in projects that require creativity I feel joy"), and (d) Divergent proactive (nine items, e.g., "I am motivated to suggest new solutions for an existing problem"). All items were rated on a 6-point Likert scale (1 = strongly disagree, 6 = strongly agree). Table 1 provides an overview of the four dimensions measured by the EDICOS including Cronbach's alpha. EDICOS was translated from Spanish into Dutch by the joint efforts of a bilingual Spanish-Dutch speaker and a Dutch-Spanish language professional. The distributions of the four EDICOS factors obtained in this study are presented in Appendix A.

Assessment of divergent and convergent thinking

We used the AUT to measure divergent thinking performance and the RAT to measure convergent thinking performance. For both tasks, we used a cued adaptation. We assumed that cueing each item in the same manner would remove other differences that may exist between these tasks other than the differences in divergent and convergent thinking. Therefore, we assumed that the adapted versions of the AUT and RAT benefit the validity of a comparison between divergent and convergent thinking (see Ueda et al., 2016; for similar reasoning). During the AUT, participants were asked to generate a total of 21 uses for three common items, that is, seven trials for each item (cf. Guilford, 1967; Ueda et al., 2016). The selected items were taken from Ueda et al. (2016) and translated to Dutch. The three items were *baksteen* (*brick), paperclip (paperclip),* and *krant (newspaper)*.

On the basis of the generated ideas, we composed three variables to assess divergent thinking performance (Guilford, 1967): *fluency*, the amount of non-redundant ideas, *flexibility*, the amount of different concepts used in the generated ideas, and *originality*, the amount of ideas for each participant that were unique

TABLE 1. Overview of Individual Differences Factors Measured by the EDICOS

Number	Dimension	Cronbach's alpha	Number of items	Score range
1	Convergent-unpleasant	.80	8	8–48
2	Convergent-preventive	.75	8	8–48
3	Divergent-pleasant	.88	9	9–54
4	Divergent-proactive	.81	5	5–30

given the ideas produced by all the participants, that is, statistical infrequency, which amounted to 13.4% of the ideas produced in this study.

Although these ratings are often considered to be objective (Silvia et al., 2008), we also believe that there is a subjective component to assessing redundancy when counting ideas (fluency), determining what constitutes different concepts (flexibility), and what constitutes a unique idea (originality). Therefore, two raters assessed these variables independently of each other. Cronbach alphas suggested high consistency between the raters for fluency, $\alpha = 1.00$, flexibility, $\alpha = 0.87$, and originality, $\alpha = 0.96$. For further analysis, the arithmetic means of the raters' results were used.

Note that the cued version of the AUT may penalise slowing response times in a manner that differs from Guilford's original version, with possible implications for how fluency, flexibility, and originality are achieved. Generating alternative uses often takes more time later in the AUT, as common uses are already generated early in the AUT. Setting a time limit for each item does not provide sufficient time to generate alternative uses later in the AUT, thereby biasing the fluency measure to people who are able to generate many uses early in the AUT. To provide insight into this, the probability of generating an alternative use for the cues over time are presented in Appendix B.

During the RAT participants were asked to find the word that, when combined with each of the three stimulus words, would result in a word pair that is a common compound word or phrase (Mednick & Mednick, 1971). At each trial, they were presented with a different triad to solve. During two practice trials, the triads *bell-back-mat* (answer: *door*) and *door-work-room* (answer: *house*) were presented and the answers were given. During the experimental trials, 20 triads were presented in random order. The triads used were taken from the recently validated Dutch version of the RAT (Akbari Chermahini, Hickendorff, & Hommel, 2012). More specifically, 10 easy and 10 difficult triads were selected on the basis of the probability of valid solutions provided by the authors. A comparison of the probability of valid solutions for the used items in this study, with these same items in Akbari Chermahini and colleagues, is presented in Appendix B. On the basis of the responses to the presented word triads, we counted the amount of correctly solved triads to assess convergent thinking performance.

Spontaneous eye blink rate

The participants' eye blinks were captured using the EyeLink II head-mounted eye-tracker (SR Research, Ltd.) at 250 Hz. Because eye-blink rate increases in the evening (Barbato et al., 2000), all experiments were performed before 18:00 (Akbari Chermahini & Hommel, 2010; Ueda et al., 2016). During these recordings, participants were seated in front of the computer screen (distance was 70 cm) and were asked to look at a black dot in the middle of the screen for 3.5 min (i.e., a fixation dot). Participants were explicitly instructed to stay relaxed during that time, and they were not told anything specific about blinking during resting state. Before we used the blinks captured by the EyeLink II software, we checked for measurement errors. We only used blinks that were between 50 and 400 ms in duration (Akbari Chermahini & Hommel, 2010). Eye-blinks were captured during a resting state before ($sEBR_1$) and after ($sEBR_2$) the tasks.

Apparatus

The instructions and stimuli during the tasks were shown as dark letters against a grey background displayed on a 22″ Dell P2210 monitor with a 1,680 × 1,050 resolution. Stimulus presentation was controlled with a custom built environment developed in OpenSesame (Mathôt, Schreij, & Theeuwes, 2012). Testing took place in a dimly lit room by placing two LED lighting strips behind the monitor. The eye-tracker was controlled in the OpenSesame environment using the PyGaze library (Dalmaijer, Mathôt, & Van der Stigchel, 2013).

PROCEDURE

Before entering the booth, the participants received a written explanation of the project, signed informed consent, and filled out the Dutch version of the EDICOS. After that, the experimenter made sure that the head-mounted eye tracker adjusted properly to the participants' head, and that their eyes were registered correctly. Then, written instructions followed on the computer screen. During the experimental session that followed, participants underwent three tasks or measurements in the following order: (a) participants' first eye blinks recording during a resting state ($sEBR_1$), (b) the task (either the AUT or the RAT), and (c) participants' second eye blinks recording during a resting state ($sEBR_2$). We used a five point calibration and validation only before $sEBR_1$. After $sEBR_1$, participants were randomly assigned to one of the two conditions (either the AUT or RAT).

During the AUT, each trial started with a fixation cross for 5 s, followed by the name of a household item. Participants were instructed to come up with a creative use for the presented item within 15 s. Participants could press the space bar when they had an idea in mind and orally report that idea within 5 s, after which the next trial started automatically (Figure 1, right). In cases participants could not come up with an idea, they were instructed to say "I don't know" during the answer screen. The practice phase consisted of two trials, and the experimental phase consisted of 21 trials. Trial order for the household items was randomized across participants.

During the RAT, each trial started with a fixation cross for 5 s, followed by a triad. Participants were instructed to find a fourth word within 15 s that could form a common compound word with each of the three stimulus words. Participants could press the space bar when they knew the solution and orally report that solution within 5 s, after which the next trial started automatically (Figure 1, left). When participants could not come up with a solution, they were asked to say "I don't know" during the answer screen. The practice phase consisted of two trials, and the experimental phase consisted of 20 trials. The triad presentation order was randomized across participants. After the task, participants' eye blink rate was measured for a second time ($sEBR_2$).

Finally, after the experimental session in the booth, participants were asked to fill out a questionnaire including evaluation related questions (i.e., the degree to which wearing the EyeLink II was bothersome, whether participants did their best, whether they liked the task or not, and whether they knew the goal of the experiment), followed by a debriefing. An experimental session lasted 40 min per participant.

RESULTS

MANIPULATION CHECKS

To check whether the results may be confounded we did several manipulation checks. We submitted each manipulation check as a dependent variable individually to a one-way ANOVA, with the tasks as the independent variable. The results showed no significant difference between the AUT and RAT task for $sEBR_1$, $F(1,78) = .32$, $p = .575$, task difficulty, $F(1,78) = .36$, $p = .550$, the degree to which participants did their best, $F(1,78) = 1.68$, $p = .199$, and the degree to which wearing the Eyelink II was bothersome, $F(1,78) = .644$, $p = .425$. There was a significant difference between the tasks for the degree to which participants found the task fun rather than boring, $F(1,78) = 9.06$, $p = .004$, $\eta_p^2 = .11$, where participants found the AUT more fun ($M = 3.47$, $SD = 1.48$) than the RAT ($M = 2.56$, $SD = 1.21$). However, the results showed no significant correlation between fun-boredom and the sEBR variables $sEBR_1$, $r = -.01$, $p = .901$ or $sEBR_2$, $r = .07$, $p = .537$. Therefore, these findings suggest that no clear confounding factors, with the possible exception of a difference in fun or boredom, were found that could provide an alternative explanation for the results of this study.

Furthermore, correlations show that convergent preventive was positively correlated with divergent pleasant, $r = .56$, $p < .001$, and divergent proactive, $r = .57$, $p < .001$, which in turn was positively correlated with divergent pleasant, $r = .72$, $p < .001$. This is in line with previous validation studies of the EDICOS questionnaire (Soroa et al., 2015). Similarly, there were positive correlations between the AUT measures fluency and flexibility, $r = .76$, $p < .001$, fluency and originality, $r = .48$, $p = .002$, and flexibility and originality, $r = .64$, $p < .001$, which is in line with previous studies of divergent thinking performance measured with the AUT (e.g., de Rooij & Jones, 2015; Silvia et al., 2008).

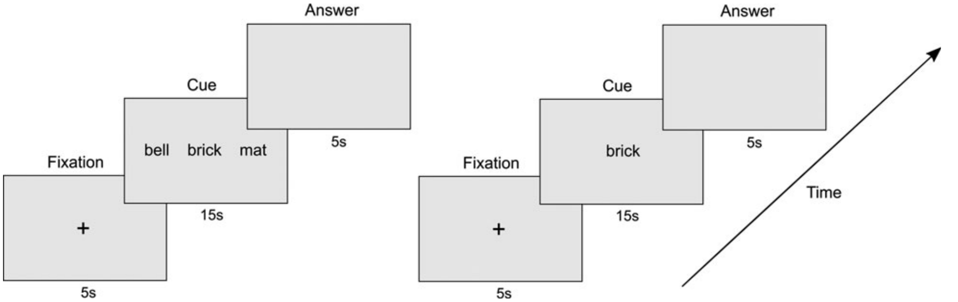

FIGURE 1. Trial structure in the remote associates task (left) and the alternative uses task (right).

Overall, the results of the manipulation checks support the validity of the results that follow from the tests below.

EXPLORATION OF THE RELATIONSHIP BETWEEN INDIVIDUAL DIFFERENCES AND sEBR DURING DIVERGENT AND CONVERGENT THINKING

To test whether there is a relationship between sEBR and individual differences in affect and motivation during divergent and convergent thinking, we submitted task type (AUT or RAT) and the two-way interactions between task type and the individual differences as the fixed factors to a linear mixed model, with sEBR as the dependent variable and the time at which sEBR was measured ($sEBR_1$ to $sEBR_2$) as the repeated measures. The descriptive statistics are presented in Table 2. The results of the linear mixed model analyses are presented in Table 3.

Divergent pleasant significantly and positively correlated with sEBR for the AUT, $b = 1.42$, $t(79) = 2.08$, $p = .041$, but did not significantly correlate with sEBR for the RAT, $b = .82$, $t(79) = 1.43$, $p = .157$. *Divergent proactive* did not significantly correlate with sEBR for the AUT, $b = -.17$, $t(79) = .38$, $p = .710$, and not for the RAT, $b = -.31$, $t(79) = .89$, $p = .375$. *Convergent unpleasant* also did not significantly correlate with sEBR for the AUT, $b = .02$, $t(79) = .10$, $p = .921$. However, convergent unpleasant did significantly and positively correlate with sEBR for the RAT, $b = .67$, $t(79) = 2.05$, $p = .044$. *Convergent preventive* did not significantly correlate with sEBR for the AUT, $b = -.65$, $t(79) = 1.54$, $p = .128$, and not for the RAT, $b = .13$, $t(79) = .35$, $p = .731$. The results showed no significant difference between the AUT and RAT for sEBR, $b = 27.11$, $t(79) = 1.33$, $p = .188$. Taken together, these results suggest that the degree to which people self-report to experience positive affect when they engage in a divergent thinking task (divergent pleasant), positively correlates with sEBR, but only for the AUT; whereas the degree to which people self-report to experience negative affect when they engage in a convergent thinking task (convergent unpleasant), positively correlates with sEBR, but only for the RAT.

EXPLORATION OF THE RELATIONSHIP BETWEEN sEBR AND DIVERGENT AND CONVERGENT THINKING TASK PERFORMANCE

Since much of the discussed literature has found a relationship of sEBR with divergent and convergent thinking performance, we further explored the data. Previous studies suggest a curvilinear (inverted U-shape) relationship (Akbari Chermahini & Hommel, 2010, 2012a), whereas other's suggest a positive correlation (Ueda et al., 2016), between sEBR and divergent thinking performance. Therefore, we tested both a linear and a quadratic (curvilinear) model. For the linear model, we submitted sEBR and the two-way interactions between each individual difference and sEBR to a linear mixed model, with the performance variables of each task (AUT: fluency, flexibility, and originality; or RAT: correctly solved word triads) as the dependent variable. For the quadratic model, we added $sEBR^2$ (squared terms) to model 2. The models were computed for each of the task performance variables individually (AUT or RAT). The descriptive statistics are presented in Table 2. The results for the linear model are presented in Table 4, and for the quadratic model in Table 5.

TABLE 2. Means (M) and Standard Deviations (SD) for the EDICOS Individual Differences, Spontaneous Eye Blink Rate (sEBR), and Divergent (AUT) and Convergent Thinking (RAT) Performance Measures

Variable	*M*	*SD*
Convergent unpleasant	32.61	5.36
Convergent preventive	35.01	4.80
Divergent proactive	39.80	6.25
Divergent pleasant	23.98	3.68
$sEBR_1$	13.58	9.69
$sEBR_2$	13.14	11.10
RAT correct	10.21	3.05
AUT fluency	18.61	2.27
AUT flexibility	15.48	2.45
AUT originality	5.00	2.54

TABLE 3. Estimates of Fixed Effects of Model 1

Parameter	Task	sEBR
Intercept		−19.84 (14.74) [−49.17, 9.49]
Task	AUT	27.11 (20.40) [−13.48, 67.70]
	RAT	[a]
Task × convergent unpleasant	AUT	.02 (.25) [−.47, .52]
	RAT	**.67 (.33)*** **[.02, 1.32]**
Task × convergent preventive	AUT	−.65 (.42) [−1.49, .19]
	RAT	.13 (.37) [−.61, .87]
Task × divergent proactive	AUT	−.17 (.44) [−1.04, .71]
	RAT	−.31 (.35) [−1.00, .71]
Task × divergent pleasant	AUT	**1.42 (.68)*** **[.06, 2.8]**
	RAT	.82 (.58) [−.32, 1.97]

Notes. Fixed factors are task type and two-way interactions between sEBR (with pre and post measurement times as the repeated measures), task (Divergent thinking: AUT, Convergent thinking: RAT), and the individual differences (convergent unpleasant, convergent preventive, divergent proactive, and divergent pleasant). Data are parameter estimates, standard errors (between parentheses), and 95% confidence intervals (between square brackets). [a]Is the reference point for the fixed factor. Significant results are given in bold. *$p < .05$.

For the divergent thinking task, the results from the linear mixed model showed that sEBR in general does not significantly correlate with fluency, $b = -.134$, $t(40) = .74$, $p = .463$, flexibility, $b = -.168$, $t(40) = .85$, $p = .396$, or originality, $b = .179$, $t(40) = .85$, $p = .400$. Although divergent pleasant did positively correlate with sEBR (Table 3), it did not significantly correlate with fluency, $b = .009$, $t(40) = 1.24$, $p = .217$, flexibility, $b = -.008$, $t(40) = 1.44$, $p = .155$, or originality, $b = -.005$, $t(40) = .59$, $p = .558$. However, the results suggest that the convergent unpleasant × sEBR interaction significantly predicted originality, $b = .007$, $t(40) = 2.38$, $p = .020$. The quadratic model adds to this pattern. That is, it suggests that during divergent thinking, convergent unpleasant significantly but negatively interacted with sEBR to predict fluency, $b = -.018$, $t(40) = 2.55$, $p = .013$, and flexibility, $b = -.019$, $t(40) = 2.47$, $p = .015$. The squared terms were not significant for fluency, $b < .001$, $t(40) = 1.68$, $p = .096$, and flexibility, $b = .001$, $t(40) = 1.42$, $p = .158$. This suggests a linear relationship between the measured variables.

Furthermore, the results suggest that the convergent preventive × sEBR interaction significantly and positively correlated with fluency, $b = .012$, $t(40) = 2.45$, $p = .016$. However, a joint increase in sEBR and these individual differences does not typically happen because of divergent thinking (Table 3). Finally, for the convergent thinking task the results showed that sEBR in general does significantly but negatively correlate with RAT performance, $b = -.507$, $t(39) = 2.35$, $p = .021$, but not when increases in sEBR depend on convergent unpleasant. That is, the convergent unpleasant × sEBR interaction significantly and negatively correlated with the amount of correct answers on the RAT, $b = .012$, $t(39) = 2.27$, $p = .026$. Furthermore, the quadratic model suggested that the interaction between divergent pleasant and sEBR negatively correlated with correct amount of RAT items solved, $b = -.028$, $t(40) = 2.13$, $p = .037$. The squared term was significant and positive, but small, $b = .001$, $t(39) = 2.25$, $p = .028$, suggesting a negative and slightly convex relationship.

TABLE 4. Estimates of Fixed Effects of Model 2 (Linear)

Parameter	Divergent thinking			Convergent thinking
	AUT fluency	AUT flexibility	AUT originality	RAT correct
Intercept	18.57 (.41)**	15.33 (.43)**	5.13 (4.58)**	10.77 (.59)**
	[17.79, 19.35]	[14.49, 16.18]	[4.22, 6.04]	[9.59, 11.94]
sEBR	−.134 (.182)	−.168 (.197)	.179 (.212)	**−.507 (.215)***
	[−.496, .228]	[−.561, .224]	[−.242, .601]	**[−.935, −.079]**
Convergent unpleasant × sEBR	−.003 (.003)	−.004 (.003)	**−.007 (.003)***	**.012 (.005)***
	[−.008, .002]	[−.009, .002]	**[−.013, −.001]**	**[.001, .023]**
Convergent preventive × sEBR	**.012 (.005)***	.010 (.005)	−.004 (.006)	.004 (.005)
	[.002, .022]	[−.001, .020]	[−.016, .007]	[−.005, .014]
Divergent proactive × sEBR	−.012 (.005)	−.008 (.006)	.008 (.006)	−.003 (.005)
	[−.020, .000]	[−.019, .003]	[−.004, .020]	[−.012, .006]
Divergent pleasant × sEBR	.009 (.007)	.011 (.008)	−.005 (.009)	.000 (.009)
	[−.005, .024]	[−.004, .027]	[−.022, .012]	[−.018, .019]

Notes. Fixed factors are sEBR and two-way interactions between sEBR (with pre and post measurement times as the repeated measures) and the individual differences (convergent unpleasant, convergent preventive, divergent proactive, and divergent pleasant). This model was computed for each of the performance variables of each task (Divergent thinking: Fluency, Flexibility, Originality; Convergent thinking: correct answers RAT). Data are parameter estimates, standard errors (between parentheses), and 95% confidence intervals (between square brackets). Significant results are given in bold. *$p < .05$. **$p < .01$.

Taken together, these results suggest that the degree to which people self-report to experience positive affect when they engage in a divergent thinking task (divergent pleasant) positively correlates with sEBR, but this relationship does not affect fluency, flexibility, or originality during the AUT in this study. sEBR does, however, negatively correlate with the amount of correctly solved word triads during the RAT. Most notably, the degree to which people self-report to experience negative affect when they engage in a convergent thinking task (convergent unpleasant) also positively correlates with sEBR, and this interaction positively correlates with the amount of correctly solved word triads during the RAT; but may also negatively correlate with fluency and flexibility during the AUT.

DISCUSSION

In this study, we explored whether sEBR during divergent and convergent thinking depends on individual differences in affect and motivation. The following results stand out.

SUMMARY AND IMPLICATIONS OF THE RESULTS

The results suggest that increases in sEBR during divergent and convergent thinking depend on individual differences in positive and negative affect, but may not depend on individual differences in proactive and preventive motivation. That is, self-reported individual differences in the degree to which people experience positive affect when they engage in a divergent thinking task (divergent pleasant) positively correlated with sEBR for the AUT (divergent thinking task); whereas a self-reported disposition to experience negative affect (in particular anxiety and stress) when they engage in a convergent thinking task (convergent unpleasant) positively correlated with sEBR for the RAT (convergent thinking task). Self-reported individual differences in the degree to which people engage in convergent thinking to prevent negative outcomes (convergent preventive), or proactively seek to achieve positive outcomes through divergent thinking, did not significantly correlate with sEBR during the AUT or RAT. These findings confirm our conjectures that individual differences in both positive (Akbari Chermahini & Hommel, 2012a; cf. Peckham & Johnson, 2016) and negative affect (cf. Weiner & Concepcion, 1975) can associate with increases in sEBR, depending on a person's engagement in tasks that require divergent or convergent thinking (Soroa et al., 2015).

Two main implications for theory emerge from these findings. First, the relationship of sEBR with divergent and convergent thinking cannot be explained without taking into account individual differences in positive *and* negative affect. This extends available research about the relationship between sEBR and positive

TABLE 5. Estimates of Fixed Effects of Model 3 (Quadratic)

Parameter	Divergent thinking			Convergent thinking
	AUT fluency	AUT flexibility	AUT originality	RAT correct
Intercept	18.84 (.60)**	15.04 (.65)**	4.48 (.71)**	11.71 (.88)**
	[17.66, 20.03]	[13.76, 16.32]	[3.01, 5.89]	[9.96, 13.46]
sEBR	.606 (.59)	.624 (.641)	.397 (.705)	**−1.23 (.611)***
	[−.572, 1.784]	[−.651, 1.899]	[−1.004, 1.799]	**[−2.45, −.012]**
sEBR^2	−.035 (.032)	−.032 (.035	>−.001 (.039)	.036 (.024)
	[−.100, .029]	[−.102, .038]	[−.077, .077]	[−.012, .083]
Convergent unpleasant × sEBR	**−.018 (.007)***	**−.019 (.008)***	−.013 (.009)	.015 (.015)
	[−.033, −.004]	**[−.035, −.004]**	[−.030, .004]	[−.015, .045]
Convergent unpleasant × sEBR^2	<.001 (<.001)	.001 (<.001)	<.001 (<.001)	>−.001 (.001)
	[−.0001, .001]	[>−.001, .001]	[−.001, .001]	[−.001, .001]
Convergent preventive × sEBR	.001 (.016)	.005 (.017)	.001 (.019)	.031 (.018)
	[−.030, .033]	[−.028, .039]	[−.036, .038]	[−.005, .067]
Convergent preventive × sEBR^2	.001 (.001)	<.001 (.001)	>−.001 (.001)	−.001 (.001)
	[−.001, .002]	[−.001, .002]	[−.002, .001]	[−.002, <.001]
Divergent proactive × sEBR	.004 (.027)	.015 (.029)	.016 (.032)	.021 (.021)
	[−.049, .057]	[−.042, .073]	[−.047, .079]	[−.021, .064]
Divergent proactive × sEBR^2	.001 (.001)	<.001 (.001)	>−.001 (.002)	−.001 (.001)
	[−.002, .003]	[−.003, .003]	[−.004, .003]	[−.003, .001]
Divergent pleasant × sEBR	−.005 (.017)	−.012 (.018)	−.007 (.020)	**−.028 (.013)***
	[−.037, .028]	[−.042, .073]	[−.046, .032]	**[−.054, −.002]**
Divergent pleasant × sEBR^2	−.001 (.001)	>−.001 (.001)	.001 (.001)	**.001 (.001)***
	[−.002, .001]	[−.003, .003]	[−.002, .003]	**[<.001, .002]**

Notes. Fixed factors are sEBR and two-way interactions of sEBR (with pre and post measurement times as the repeated measures) and sEBR^2 (squared), with the individual differences (convergent unpleasant, convergent preventive, divergent proactive, and divergent pleasant). This model was computed for each of the performance variables of each task (Divergent thinking: Fluency, Flexibility, Originality; Convergent thinking: correct answers RAT). Data are parameter estimates, standard errors (between parentheses), and 95% confidence intervals (between square brackets). Significant results are given in bold. $^*p < .05$. $^{**}p < .01$.

affect during divergent and convergent thinking (Akbari Chermahini & Hommel, 2010, 2012a; Ueda et al., 2016). Second, a disposition to seek to achieve positive outcomes through divergent thinking, or to prevent negative outcomes through convergent thinking did not correlate with sEBR in this study. Rather, the measureddispositions to experience positive and negative affect during divergent and convergent thinking positively correlate with sEBR. This confirms previous work on (individual differences in) affect (Akbari Chermahini & Hommel, 2012a; Weiner & Concepcion, 1975), but not previous work on individual differences in proactive and preventive motivation (Barkley-Levenson & Galván, 2016; Byrne et al., 2016; Cavanagh et al., 2014; Peckham & Johnson, 2016), within the context of divergent and convergent thinking.

Two further results stood out from the exploration of the relationship between the individual differences in affect and motivation, sEBR, and divergent thinking and convergent thinking performance.

First, the results suggest that the interaction between individual differences in positive and negative affect and sEBR may predict divergent and convergent thinking performance, but in different ways. That is, the interaction between self-reported individual differences in the degree to which people experience positive affect when they engage in a divergent thinking task (divergent pleasant), and sEBR, did not correlate with fluency, flexibility, and originality during the AUT (divergent thinking task); but did have a curvilinear relationship with the amount of correctly solved word triads during the RAT in the quadratic model (convergent thinking task) that is best described as a negative but slightly convex relationship. Opposingly, the interaction between self-reported individual differences in the degree to which people experience negative affect when they engage in a convergent thinking task (convergent unpleasant), and sEBR, positively correlated with the amount of correctly solved word triads during the RAT (convergent thinking task); and also negatively correlated with fluency and flexibility during the AUT in the quadratic model (divergent thinking task). As such, this study did not replicate previous findings by Akbari Chermahini and Hommel (2010, 2012b). However, these individual differences did negatively correlate with task performance during convergent thinking, which is in line with previous findings (Akbari Chermahini & Hommel, 2010; Ueda et al., 2016). Importantly, the findings suggest that the relationship of sEBR with divergent and convergent thinking depends on individual differences in positive and negative affect.

Second, the conjectures about a possible relationship between individual differences in motivation with sEBR, and associated performance during divergent and convergent thinking, could not be confirmed. However, one unexpected finding emerged. The interaction between the self-reported degree to which people tend to engage in convergent thinking because of a tendency to focus on the prevention of negative outcomes (convergent preventive), and sEBR, positively correlated with the amount of uses generated (fluency) during the AUT, depending on an increase in sEBR. This despite the finding that this individual difference did not significantly correlate with sEBR for the AUT or RAT. As such, there may exist a relationship between sEBR, preventive motivation, and divergent thinking.

Speculatively, the implications of these findings are that sEBR can represent multiple relationships between (individual differences in) affect and cognitive control, where increases in sEBR associate with: (a) a relationship between positive affect and cognitive flexibility during divergent thinking, and (b) a relationship between negative affect and cognitive stability during convergent thinking. That is, the results showed that the interaction of individual differences in positive affect with sEBR negatively correlates with convergent thinking performance. In previous studies, this has been attributed to a negative effect of cognitive flexibility on convergent thinking; while previous studies have shown that the relationship between positive affect and sEBR predicts divergent thinking performance—also due to its relationship with cognitive flexibility (Akbari Chermahini & Hommel, 2010, 2012a). Opposingly, the result that the interaction between individual differences in negative affect and sEBR positively correlates with convergent thinking performance, and negatively correlates with divergent thinking performance, suggests that sEBR represents something else than cognitive flexibility as well. Previous studies have argued that convergent thinking can be enhanced by some negative affects (e.g., anxiety) and cognitive stability and persistence that associate with these affects (Baas et al., 2008). As such, sEBR could represent cognitive stability for individuals that have a disposition to experience negative affect when engaging in convergent thinking tasks. Thus, speculatively, sEBR may represent both a relationship between cognitive flexibility and positive affect, and cognitive stability and negative affect—depending on individual differences in positive and negative affect during divergent and convergent thinking.

LIMITATIONS AND ALTERNATIVE EXPLANATIONS

This study of course also has its limitations, which need to be taken into account when interpreting and building upon this study.

First, the results invite speculation about why individual differences in affect, but not in motivation, positively correlated with sEBR. This may be due to limited ecological validity of the AUT and RAT (Zheng et al., 2011). Generating new uses for a common object (AUT) or solving word triads (RAT) simply may not engage motivation sufficiently. For example, real-life creativity is often characterized by high investment, high reward, but a low chance of a positive outcome (Unsworth & Clegg, 2010). Such tasks would likely engage motivation more strongly than during the AUT or RAT due to the magnitude of the possible reward or loss that can be achieved.

Second, in four studies Akbari Chermahini and Hommel (2010) found a robust curvilinear relationship between cognitive flexibility and sEBR during the AUT, which was not replicated in this study. This could be explained by our use of a cued version of the AUT (more similar to Ueda et al., 2016), which, rather than allowing ideas to flow freely, may exaggerate time pressure effects and force pauses into the divergent thinking process. In addition, this non-replication could be explained by a skew in the sample toward a high self-reported disposition to experience negative affect (convergent unpleasant; see Appendix A). As the results suggest this individual difference interacts with sEBR in a manner that negatively predicts performance on the AUT, this skew may have cancelled out a potentially positive effect of sEBR on AUT performance measures.

Third, in this study, we observed an unexpected relationship between the self-reported disposition to prevent negative outcomes through convergent thinking (convergent preventive), sEBR, and the amount of uses produced during the AUT (fluency). There could be both a methodological and a theoretical explanation for this result. From a methodological perspective, the EDICOS questions that make up the convergent preventive factor may not clearly refer to behaviours that indicate preventive motivation specifically during tasks that require convergent thinking (cf. Soroa et al., 2015). Then, taking a theoretical perspective, convergent preventive, may, when the task enables actual prevention of a negative outcome (Bledow et al., 2013; Roskes et al., 2012), lead to positive affect (e.g., relief for preventing a negative outcome; Goschke & Bolte, 2014)—which positively correlates with both divergent thinking performance and sEBR (Baas et al., 2008; Bledow et al., 2013; de Rooij et al., 2017).

Fourth, there is uncertainty how the measured individual differences and sEBR interact during the RAT. There is increasing criticism on the validity of the RAT as a measure of convergent thinking (Bowden & Jung-Beeman, 2007; Salvi et al., 2015; Subramaniam et al., 2009). That is, the RAT can be solved via analytical thinking and via insight, which challenges its validity as a "pure" measure of convergent thinking. Since it was not measured how participants solved the RAT, this introduces uncertainty about the degree to which the results for the RAT can be generalised to the concept of convergent thinking.

Fifth, and finally, there are several more methodological limitations that need to be highlighted. That is, inferences about affect and motivation beyond the self-reported individual differences are highly speculative, as we did not measure elicited affect and motivation in this study—but only dispositions. The cued versions of the AUT and RAT differ from the original versions, including more time pressure and interruptions in the thinking processes to accommodate for an experimental set-up suitable for eye-tracking experiments. These differences need to be taken into account when making comparisons to previous work. Furthermore, the between-subject design limits the validity of any comparisons that can be made between the AUT and RAT.

SUGGESTIONS FOR FUTURE RESEARCH

The discussed limitations provide several interesting pointers for future work. First, future work could explore under what circumstances motivation predicts sEBR during tasks that require divergent and convergent thinking. Specifically, eliciting proactive and preventive motivation during an experiment can be done by proving rewards and punishments that depend on task performance in real-time, rather than by relying on questionnaires (cf. de Rooij et al., 2015, 2017; Roskes et al., 2012). For example, for such ends a computer-supported experimental paradigm was developed by de Rooij et al. (2015, 2017). There, an intelligent computer system automatically provided believable feedback on divergent thinking performance; the system can lower or raise performance feedback against people's typical expectations to vary the appraisal that positive outcomes are achieved or negative outcomes are prevented. This would then preferably be implemented in a task that carries some importance to an individual to ensure sufficient magnitude of the positive and negative outcomes so that proactive and preventive motivation can effectively be manipulated (cf. Zheng et al., 2011). Such a study could help to further explore whether (individual differences in) proactive and preventive motivation can correlate with sEBR during divergent and convergent thinking, as suggested by our theoretical background, or that these motivations do not correlate with sEBR, as suggested by the results of this study.

Second, we propose to further explore how individual differences characterised by a disposition to experience negative affect during convergent thinking tasks interact with sEBR to predict performance. As discussed, such individual differences may enable convergent thinking performance because of a positive correlation between anxiety and cognitive stability, and solving word triads via an analytic approach; but alternatively may also resolve the anxiety initially experienced, eliciting positive affect, and increasing the cognitive flexibility necessary to solve word triads via insight. We propose to partly replicate this study, while also testing explicitly whether people have solved word triads by means of insight, and test whether cognitive flexibility played a role in this, or by analytic thinking, and test whether cognitive stability played a role in this (cf. Salvi et al., 2015). In addition, testing of changes in affect and motivation during the task should complement these measurements. Such future work can help further our understanding of the relationships between individual differences in affect and motivation, and sEBR, during divergent and convergent thinking.

CONCLUSION

To summarise, the contribution of our study is novel evidence that suggests that individual differences in positive and negative affect can predict sEBR during divergent and convergent thinking in opposite ways.

Moreover, the interaction between these individual differences with sEBR differentially predicts performance during divergent and convergent thinking tasks. Given the function of divergent and convergent thinking in creative idea generation, this research sheds new light on the (dis)pleasures of creativity.

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Alwin de Rooij, Ruben D. Vromans, Tilburg University

Correspondence concerning this article should be addressed to Alwin de Rooij, Department of Communication and Cognition, Tilburg University, 5000 LE Tilburg, The Netherlands. E-mail: alwinderooij@tilburguniversity.edu

APPENDIX A

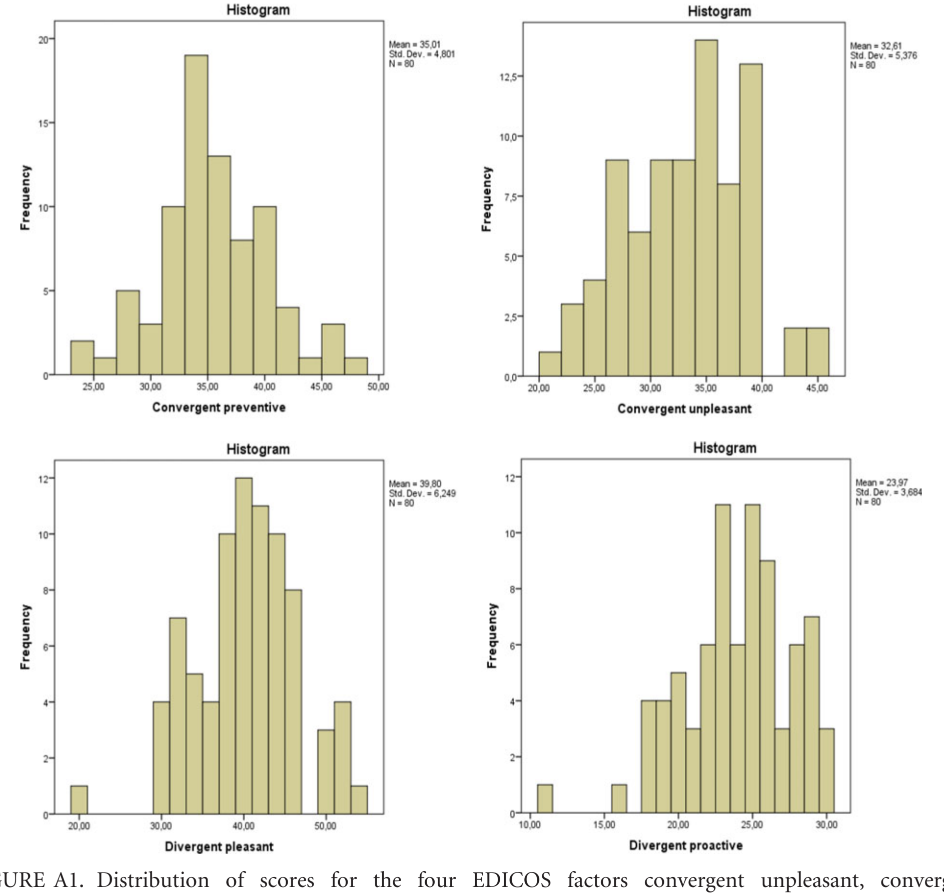

FIGURE A1. Distribution of scores for the four EDICOS factors convergent unpleasant, convergent preventive, divergent pleasant, and divergent proactive.

APPENDIX B

TABLE B1. Percentages of the Seven Alternative Responses for Each Item during the AUT, and of the Correctly Solved Triads during the RAT.

AUT Item	Attempt	Fluency	Triad	RAT Correct	Probability solution[a]
Paperclip (paperclip)	1	0.94	School/ontbijt/spel	0.18	0.04
	2	0.88	Kamer/masker/explosive	0.60	0.26
	3	0.90	Achter/kruk/mat	0.73	0.51
	4	0.83	Room/vloot/koek	0.68	0.59
	5	0.83	Nacht/vet/licht	0.20	0.17
	6	0.71	Water/schoorsteen/lucht	0.38	0.46
	7	0.78	Strijkijzer/schip/trein	0.40	0.02
Baksteen (brick)	1	0.98	Palm/familie/huis	0.80	0.04
	2	0.90	Val/meloen/lelie	0.90	0.58
	3	0.90	Lijm/man/ster	0.05	0.12
	4	0.78	Riet/klontje/hart	0.95	0.10
	5	0.88	Licht/dromen/maan	0.15	0.15
	6	0.80	Schommel/klap/rol	0.75	0.37
	7	0.78	Trommel/beleg/mes	0.88	0.37
Krant (newspaper)	1	1.00	Worm/kast/legger	0.68	0.48
	2	1.00	Kop/boon/pauze	0.43	0.11
	3	0.95	Grond/vis/geld	0.25	0.08
	4	0.93	Vlokken/ketting/pet	0.40	0.60
	5	0.90	Goot/kool/bak	0.63	0.35
	6	0.90	Olie/pak/meester	0.28	0.22
	7	0.90			

Note. [a] Probability of valid solutions provided by Akbari Chermahini et al. (2012).