The differences in emotional responses, neurological responses, and coping styles between creative individuals and a baseline group.

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Abstract

Creativity is a complicated human capability, and interestingly, some are better at being creative than others. Research suggests that creative individuals with a high absorption levels respond differently to stress than average individuals with low absorption level do. Here, it is hypothesized that creative individuals are affected differently by stress, based on neuropsychological findings, differences in absorption level / coping strategies, and neurological response. The current experiment makes use of a case intending to support the notion that creative individuals are affected by stress differently than more logical individuals are. While in stress, on average, the creatives have a higher absorption level, they make use of a specific coping style in comparison to the norm group, and the creatives show relatively more right brain activity in contrast with non-creatives.

I Introduction

Creativity is a sophisticated human capability that has been studied for decades. There are plenty of anecdotal stories to be found on the internet concerning the - seemingly magical - creative brain. In order to unravel its mysteries, (neuro)science attempts to study the creative brain, through, for example, (f)MRI ((functional) magnetic resonance imaging), EEG (electroencephalogram) and DTI (diffusion tensor imaging). One exciting aspect of the creative brain is how it copes with stress. The effects of stress on creativity appear to be - based on anecdotal information - quite large, and research suggests that this might indeed be the case (Van Dyne, Jehn & Cummings, 2002; He & Wong, 2015). However, the workings of these effects are, as of yet, still under investigation. In order to illustrate the functioning of a creative brain versus a "logical" brain ("logical" here is used to denominate the brain of an individual who does not see themselves, or is seen by the general public as, creative), a series of EEG experiments will be conducted with the aim to expose differences between creatives and logicals on a neuronal basis, a coping basis, and a conscious emotional basis.

To clarify the effects of stress on creative individuals versus logical individuals, previous studies on neuropsychological findings, differences in absorption levels / coping strategies, and conscious emotional response will be consulted. Firstly, the neurological response to stressful stimuli will be taken into consideration.

Generally, stress has a severe impact on the functioning of the brain (for examples of this research, see: Yang, Qi, Guan, Hou & Yang, 2012; Dedovic, Duchesne, Andrews, Engert, Pruessner, 2009; Dedovic, Renwick, Mahani, Engert, Lupien, Pruessner, 2005). Since the creative brain is likely to show different baseline activity than a "logical" brain does (Beaty, Benedek, Wilkins, Jauk, Fink, Silvia, & Neubauer, 2014; Fink, Graif, & Neuenbauer, 2009), it is hypothesized that the creative brain also responds differently to stress than does the "logical" brain does.

Besides the sheer neurological effects, there is also behavior to consider. One type of behavior that is strongly related to stress is coping. Coping behavior is undoubtedly related to stress and thus could prove to be an exciting indicator of the psychological differences between creative and non-creative individuals (e.g., Folkman, Lazarus, Gruen, & DeLongis, 1986; Folkman & Lazarus, 1988; Snow, Swan, Raghavan, Connell, & Klein, 2003). Since stress might affect creative individuals in a different way than it affects "logical" individuals on a neurological level, it can be argued that this would also be visible in coping style. It is hypothesized that creative individuals use different coping styles than "logical" individuals do.

Finally, besides coping and neurological response, one final aspect that will be taken into account in the research design is a conscious emotional response. Both coping and neurological response take place subconsciously. In order to analyze both conscious and subconscious processes, the emotional response to stress can be an indicator of differences between creative and logical individuals on a more conscious level, while still staying relatively close to the subconscious experience. Since differences in neurological response between the two groups are expected, it is currently hypothesized that there will also exist a difference in conscious experience between creative individuals and logical individuals.

The first section of the current article is the theoretical background that employs the results of previously conducted research to clarify and elaborate on firstly the possible neurological differences, secondly the differences in coping strategies, and lastly, the differences in conscious emotional response. The second section is the method section, followed by the results as the third section, and finished with the conclusion as the fourth section.

II Theoretical Background

Neurological response to stressful stimuli

Research suggests that the creative brain and the lesser creative brain are, in fact, neurologically slightly different. Although it remains uncertain which precise differences are essential in order to distinguish a creative from a non-creative brain as the literature suggests that creativity does not appear to critically depend on only one brain region or a single mental process as sometimes hypothesized (Dietrich & Kanso, 2010), some results have repeatedly been found. One of these results concerns the α (alpha) wave. Studies suggest that the alpha wave synchronizes when creative individuals come up with a creative idea. A study by Fink and colleagues (2009) found that professional dancers show stronger alpha synchronization compared to novice dancers when coming up with alternative uses. Additionally, they found that during improvisation dance, professional dancers displayed more right-hemispheric alpha synchronization than the group of novices did. This is particularly prevalent in the period directly before the production of an idea:

"As evident in Fig. 2, these differences were most pronounced in frontal, frontocentral, and centrotemporal regions of the brain. Particularly performance of the AU [Alternative Uses] task exhibited a comparatively strong alpha synchronization in frontal brain areas, while the performance of the waltz task, which involves the lowest creative demands, elicited the lowest frontal alpha synchronization. […] While generating alternative uses of conventional objects (i.e. AU task), dancers show stronger alpha synchronization in posterior (i.e. centroparietal, parietotemporal, and parietooccipital) brain regions than novice dancers did." (Fink, Graif & Neubauer, 2009, p. 860).

These results suggest that alpha synchronization is one of the central premises of the difference between creative and non-creative individuals.

Simultaneously, researchers have looked into the effects of emotional imagery on the alpha wave. In 2003, Simons, Detenber, Cuthber, Schwartz, and Reiss looked into the effects of emotion-provoking imagery. Their results revealed that subjective reports of stress-inducing stimuli were directly related to cortical activation, hence reduced alpha power. Both positive and negative images were associated with more robust cortical activation relative to neutral images:

"The analysis revealed that subjective reports of emotional arousal were directly related to cortical activation (i.e., reduced alpha power), and this was particularly true at the parietal recording site. The relationship between alpha power and ratings of valence was curvilinear; cortical activation was associated with both positive and negative images relative to neutral images. Alpha power was also reduced during the viewing of moving compared with still images, and this effect occurred independently of stimulus valence." (Simons, Detenber, Cuthber, Schwartz & Reiss, 2003, p. 284)

Together with the evidence for the neurological difference between creative and non-creative individuals, hints toward the hypothesis that creative individuals do respond differently to stress-inducing stimuli. Because their relatively high levels of alpha synchronization -compared to logical individuals - are inhibited while stress is induced, specifically when it is induced using emotional arousing imagery.

Coping strategies

A possible consequence that may follow from a difference in neurological response between creative individuals and logical individuals is a difference in coping strategy. As emotional arousal (stress-inducing stimuli) inhibits alpha synchronization - which is essential for creativity - due to its cortical activation (Fink et al., 2009), creatives might cope differently with stress compared to logical individuals. To examine possible differences between the two groups with relation to behavioral responses to stress, the PARCS (predictive and reactive control systems) framework can give us a frame of reference. Recent research by Tops, Quirin, Boksem & Koole suggests that the way mammals (and thus humans) cope with novel stimuli can be divided into two distinct categories: predictive response or reactive response. These two categories can be distinguished both on a neurological level, as well as on a behavioral level. The reactive control system responds quickly to novel stimuli and specializes in processing biological salience, whereas the predictive control system predicts future outcomes through simulation, and updates those simulated models slowly.

The PARCS framework suggests that the natural left-right hemispherical distinction in our brain is in agreement with the coping styles humans will apply in order to deal with novel stimuli. The left hemisphere, known to play a role in anticipating future scenarios and choosing between them (Dien, 2008), is related to a predictive control system, while the right hemisphere (engaged in integrating ongoing information and detecting and immediately responding to novel stimuli) is related to reactive control systems.

In order to relate these coping styles to the creative/non-creative brains, it is necessary to dive deeper into the related neural correlates. The functional hemispheric asymmetry, as described in PARCS theory, is consistent with much of the literature published on EEG alpha synchronization, as mentioned previously in this paper. According to Tops, Quirin, Boksem & Koole: "In [EEG] literature, left frontal activity has been associated with approach motivation, power, anger, dominance and drive forward, while right frontal activity had been associated with avoidance or withdrawal motivation, submission, social anxiety, inhibition or high arousal." As suggested by Fink et al. (2009), the right hemispherical alpha activity might be central to producing creative responses,

suggesting that creative individuals, more so than non-creative individuals make use of their right hemisphere when responding to stressful stimuli. In turn, it relates to the concept of Absorption, which is a term In PARCS theory, Absorption "…reflects the orienting responses, appraisal, salience detection, and immediate concerns function of the right hemisphere reactive system (Tops & Boksem, 2010; Tops et al., 2014). Absorption is the tendency to get absorbed in the full appraisal of sensory or emotional (positive and negative) experiences and one's internal state (Gohm & Clore, 2002). Absorption measures "absorption at the moment," emergence into sensory experiences, a unifying focus on limited stimuli, to the exclusion of other stimuli, and attentional resource allocation (Carleton et al., 2010), and as such reflects its association with the right-lateralized ventral novelty/saliency attentional system." (Tops, Montero-Marin & Quirin, 2016).

Taking both PARCS and the concept of Absorption into consideration, it can be hypothesized that creative individuals cope differently with stressful, novel stimuli than do non-creatives. These differences in coping arise through neurological underpinnings and show in behavior such as Absorption.

Conscious emotional response to stressful stimuli

The difference, as mentioned above between creative individuals in neurological response together with the difference in coping strategies, may consequently affect the conscious emotional response of creatives towards stress-inducing stimuli. As highly creative individuals rely on a system and a structure of cognitive processes that enable and stimulate their creative thinking (Amabile, 1983, 1988, 1996), stress may block the functioning of this system. Problem-solving and decision-making literature has provided evidence that people working under time pressure employ a strategy of filtering (processing only some parts of the information), and omission (ignoring specific parts of the information) (Edland & Svenson, 1993). Also, Ben Zur and Breznitz (1981) found that under high time pressure, individuals focused almost exclusively on negative information. Hypervigilance is the term coined by Janis (1982) that is the state of excessive alertness to signs of threat that is triggered by stressful situations. Summed up, this suggests that stressful situations result in conservative and narrow thinking, the exact opposite of creative thinking.

Two additional findings that hint towards a difference in conscious emotional response to stressful stimuli between creative and logical individuals is firstly the often found association between neuroticism and creativity (Perkins, Arnone, & Smallwood, 2015), and secondly the association between (manic) depression and creativity (Weisberg, 1994). The main processes relating creativity to neuroticism and depression are rumination-related processes, such as worrying. Worrying within creatives may partially be the result of wrongful coping and not being able to adapt to stressful situations. Whereas logical individuals would, for instance suppress thinking about aversive aspects of the situation to be able to come up with a solution, creative individuals may enter a negative loop feeding their rumination with the possibility of a depression.

Aims present case study

Above mentioned literature provides evidence that supports the notion that stress is detrimental for creatives as they cannot rely on the creative cognitive processes they usually employ which is due to the cortical activation inhibiting their alpha synchronization when feeling stressed. Furthermore, the stress mentally forces them towards a state of hypervigilance that strengthens their inability to handle the stressful situation. In turn, it leads to a conscious emotional response of

worry and depression. In other words, the set of components that make up the creative cognitive processing seems to be adversely affected by stress.

In the current case study, a comparison will be made in brain activity between creative individuals and "average non-creative" individuals when induced with stress by making use of an EEG headset. The participants will be instructed to carry out several stress-inducing tasks while brain activity will be measured. The following hypotheses are developed based on previous research:

H1: *"Creative individuals have a high absorption level."*

H2: *"Creative individuals with high absorption levels make use of specific coping strategies."*

H3: *"There is a difference between creative individuals with a high absorption level and average individuals (non-creatives) in their neurological response towards stress-inducing stimuli."*

III Method

Participants

For this experiment, to investigate the effects of stress on the functioning of the brain, nine participants are selected and recruited based on the criteria that they are regarded as creative by the public (winners of the Cannes Lions), and eight "non-creatives" (representative of the average Dutch society) are recruited.

Measuring methods

The convenient measuring method in the research design is the electroencephalogram (EEG). This is a tried and tested method that has been used in scientific research for nearly a hundred years (Teplan, 2002), and is recently being applied to commercial research. EEG is the method that uses the naturally occurring electric charges in the brain to deduct what happens in the brain when exposed to certain stimuli. By analyzing brain activity in relation to the presented stimulus, information can be obtained concerning the subconscious experience. EEG is a painless and non-invasive method.

In this research design, the Emotiv Epoc + will be used: a 14-channel headset, based on the 10-20 system. Software, in the form of Emotiv mental tension or stress, is accompanied. It often rises when participants somehow cannot obtain specific goals/ Brain Map software will be used to visualize the EEG data.

Procedure

In order to bring to light differences in brain activity and coping style between creative individuals and average "non-creative" individuals, eight creatives and eight non-creative individuals are recruited and invited to a clinical lab environment. Before entering the experiment, all the creatives who are recruited, have to fill in the the Perceived Stress Scale (PSS; Schlotz et al., 2011) to measure their Perceived stress within a period of a month. Interpersonal Reactivity Index (IRI; Davis,1980). With this questionnaire, one is able to measure the theoretical involvement aspect of absorption. After they finished this questionnaire, they had to conduct the Coping-questionnaire to test for specific coping strategies. The non-creative individuals did not have to fill in any questionnaire.

Upon arrival, the participant is seated in front of a computer screen and is asked to fill out an informed consent. Subsequently, the test starts. After having briefed the participant, the EEG headset will be calibrated and adjusted to the individual that is partaking.

The groups are primed with 40 stress-inducing images. The pictures that are used for both the experimental and control group are taken from the standard GAPED database (Dan-Glauser, & Scherer, 2010). After the EEG-section of this

Table 1

Questionnaire scores

Questionnaires		Score (Mean±SD)	N	Norm qualification
PSS	Total	10±1.15	9	Moderate Stress
IRI	Total	2.55±0.69	7	Medium / High
	Perspective-taking	2.92±0.91		High
	Fantasy	2.78±0.80		High
	Empathic concern	3.20±0.49		High
	Personal distress	1.31±0.51		Low
COPING	Total		9	
	Problem solving	4.19±0.8		High
	Social support	3.50±0.65		High
	Avoidance	2.36±0.56		Low
	Blaming others	2.89±0.71		Average

The average scores, standard deviations and sample sizes are shown.

experiment, Subsequently, the participants are debriefed, and the experiment is over.

IV Results

Questionnaire scores analysis

Perceived stress is measured with the Perceived Stress Scale (PSS). The average PSS score within creatives is 10±1.15 (mean±SD). This score means that the creatives perceive themselves as low to moderate stressful in the past month.

The Interpersonal Reactivity Index (IRI) questionnaire has been conducted to measure the imaginary involvement aspect of absorption within the creatives. The IRI has four sub-scales; the perspective-taking scale (PTS), the fantasy scale (FS), the empathic concern scale (ECS), and the personal distress scale (PDS). The average scores within the PTS, FS, and ECS are high within the creatives (PTS: 2.92±0.91; FS: 2.78±0.80; ECS: 3.20±0.49 (mean±SD)). The score within PDS is low (1.31±0.51 (mean±SD)).

A coping questionnaire has been conducted (COPING) to measure the differences in coping styles. The COPING has four sub-scales; the Problem Solving scale (CPSS), the Social Support Scale (SSS), the Avoidance scale (AS), and the Blaming Others scale (BOS). The average scores within the CPSS and SSS are high within the creatives (PSS: 4.19±0.8; SSS:3.50±0.65 (mean±SD)). The score within AS is low, and the score within BOS is average (AS: 2.36±0.56; BOS: 2.89±0.71 (mean±SD)).

Stress-related EEG responses

The EEG responses to the stress-inducing stimuli were analyzed between the creatives and the non-creatives. When the power spectrum was quantified into power ratios according to the frequency intervals (4~7 Hz, θ signal; 8~15 Hz, α signal; 16~31 Hz, β signal; >32 Hz, γ signal) between

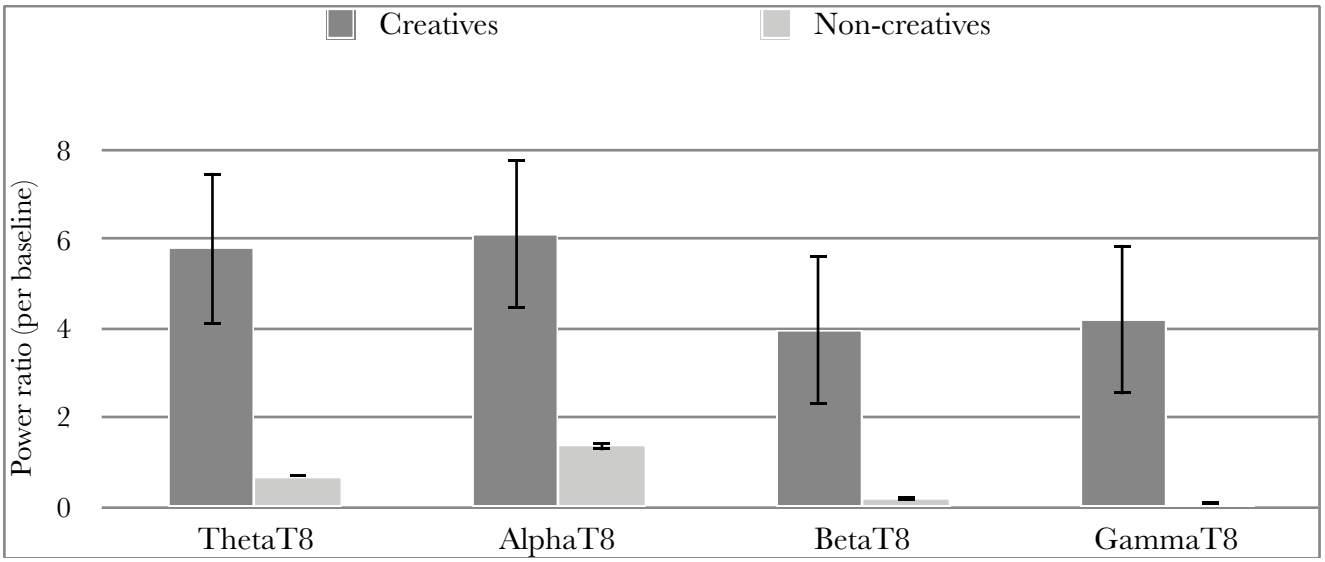

Fig. 1A

Represent the average power ratio of the θ, α, β, and γ signals in the T8 channel, respectively, in response to the stress stimuli between creatives and non-creatives. All values are represented as the mean±SEM. The sample size for EEG measurement was 16 individuals, of which 8 were creatives, and 8 were non-creatives.

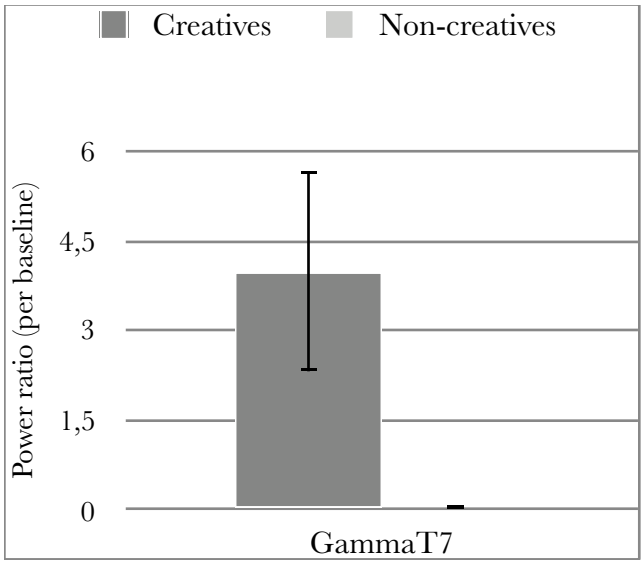

Fig. 1B

Represent the average power ratio of the γ signal in the T7 channel, respectively, in response to the stress stimuli between creatives and non-creatives. All values are represented as the mean±SEM. The sample size for EEG measurement was 16 individuals, of which 8 were creatives, and 8 were non-creatives.

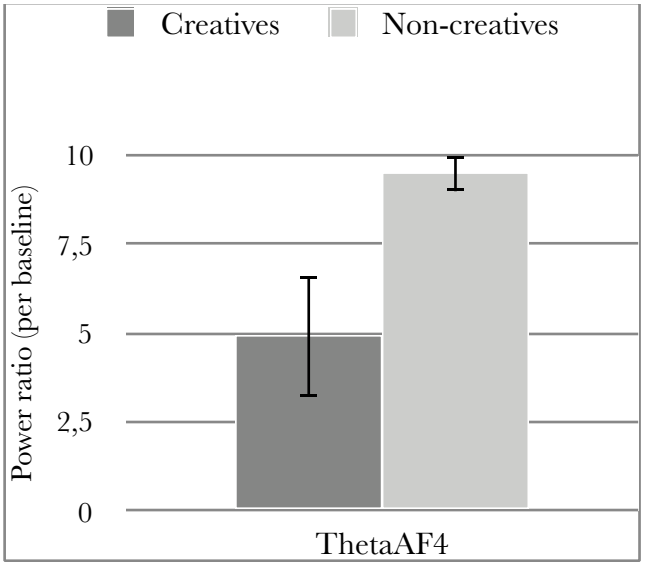

Fig. 1C

Represent the average power ratio of the θ signal in the AF4 channel, respectively, in response to the stress stimuli between creatives and non-creatives. All values are represented as the mean±SEM. The sample size for EEG measurement was 16 individuals, of which 8 were creatives, and 8 were non-creatives.

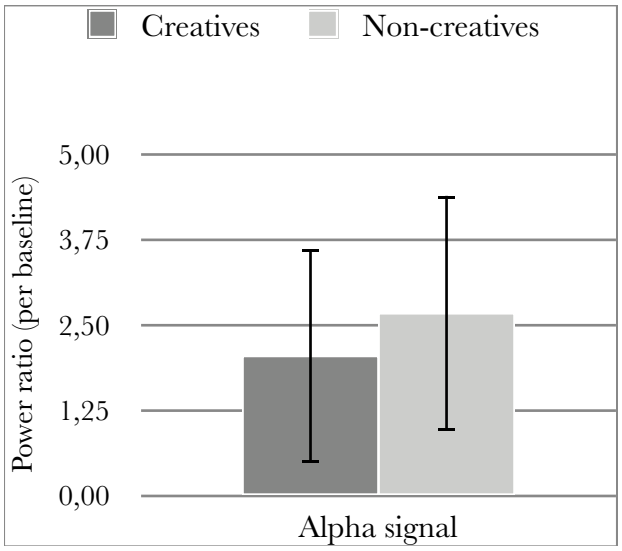

Fig. 1D

Represent the average power ratio of the α signal in the all channels, respectively, in response to the stress stimuli between creatives and non-creatives. All values are represented as the mean±SEM. The sample size for EEG measurement was 16 individuals, of which 8 were creatives, and 8 were non-creatives.

creatives and non-creatives, creatives showed a higher θ, α, β and γ power ratio in the T8 channel compared to the non-creatives (Fig. 1A). There was also a greater increase in the γ power ratio in the T7 channel of the creatives than in non-creatives (Fig. 1B). Although all of the power ratios in the T8 channel in response to the stress stimuli and the γ power ratio in the T7 Channel are higher in the creatives, the θ power ratios in the AF4 is higher for the non-creatives compared with the creatives (Fig. 1C). When only the α signal is compared between the groups, there is a small difference between creatives in a comparison between the non-creatives. The creatives have a smaller power ratio than the non-creatives (creatives: 2.05±1.57; non-creatives: 2.66 ±1.72 (mean±SD) (Fig 1D))).

V Discussion

On average, the creatives have perceived moderate stress in the past month. So the effects that are measured are not a consequence of perceived stressful events of the creatives. Also, the creatives have a higher absorption level based on the results of the IRI. These results fit with the hypotheses that "*Creative individuals have a high absorption level.*" Based on the studies of Gohm & Clore (2002) and the results of this case study, it is plausible that the creatives of this study tend to get absorbed in the full appraisal of sensory or emotional (positive and negative) experiences and one's internal state.

Based on the COPED, on average, they make use of a specific coping style in comparison to the norm group. These findings fit with the hypothesis, "*Creative individuals with hight absorption levels make use of specific coping strategies.*" According to this test and going by the chart, they score high on problem-solving and social support, and they have a lower score on avoidance. Through this assessment, it has been revealed that stressful situations lead to the opportunity to use problem-solving skills, which is a strength of the creatives. They initiate a process of taking active steps to try to remove or circumvent the stressor or to ameliorate its effects. Also, when a stressful situation occurs, they tend to gather information about the problem and try to get assistance or advice from others. Avoidance they score the opposite (low). According to this test, they tend to put other projects aside, trying to avoid becoming distracted by other events, even letting other things slide, even if it is not necessary, in order to deal with the stressor. Sometimes this means that the over-valuate the impact of the stressor on their daily life. A consequence can be that other work will fall behind, which creates a new stressor.

The creatives show relatively more right brain activity in comparison with non-creatives. The power ratios are higher in different bands on channel T8. As suggested by Fink et al. (2009), the right hemispherical alpha activity might be central to producing creative responses, suggesting that

creative individuals, more so than non-creative individuals make use of their right hemisphere when responding to stressful stimuli. The findings of this case study support the study of Fink et al. and also fits with the hypothesis that "*there is a difference between creative individuals with a high absorption level and average individuals (non-creatives) in their neurological response towards stress-inducing stimuli.*"

In this case study, differences in power ratio are found between the creatives and the non-creatives in the γ signals in the T7 channel and the θ signals in the AF4 channel. These findings do not fit with the findings of earlier studies. This finding suggests that stress situations not only affect the right hemispherical alpha activity of creative individuals but also on other brain locations and signals. A repetition of this study is advised. In this repetition study, the effects of these signals and channels are taken into account to understand better the differences in creative individuals in comparison with non-creative individuals.

Despite the small N, this case study provides an indication supporting the functional differences in neurological activity and coping strategies between creatives and average individuals concerning stress and absorption levels. The results provide deeper insights into how stress affects cognitive and emotional neurobiological mechanisms that will improve predictions of behavior. Also, these insights enhance our objective understanding of the different emotional realms of creatives.

Stress is induced using emotional arousing imagery. There are tons of other stress-inducing techniques that have not been taken into account in this case study. The overall effect of stress between creatives and non-creative individuals will be more highly validated if more stress-inducing techniques are applied. However, a high level, tough to recruit, creative individuals are used in this case study. To let these individuals participate to do some tests alone is a real challenge. To let them participate even longer for the test would make it hard to conduct this study. Also, conducting more stress-inducing tests should go through the ethical board for approval. The mental harm that could be induced by conducting multiple stress-inducing tasks could become critical.

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