

# ANXIETY RESTRICTS THE ANALOGICAL SEARCH IN AN ANALOGY GENERATION TASK

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## ABSTRACT

This paper further explores the influence that anxiety has on the analogy-making process. A psychological experiment is described that requires participants to generate analogies to a certain case. In the experimental group state anxiety is induced by a simulated public speech procedure. The results show that the participants in both the control and experimental group generated roughly the same number of analogies, the quality of these analogies is also indistinguishable according to the independent judges, however, the participants in the anxiety group were more rigid and generated a significantly smaller amount of drastically different analogies, i.e. most of their analogies belonged to one and the same domain close to the target, while the participants in the control group were more flexible and generated a greater variety of analogies belonging to two or three different domains, and the domains were more remote from the target.

## INTRODUCTION

Anxiety has become central for psychology at least since Freud. He considered anxiety as “uniquely unpleasant feeling state, accompanied by certain specific efferent phenomena and the perception thereof” (Freud, 1936, p.70). Thus according to him anxiety combines a strongly negative emotional state (such as fear, worry, uneasiness) with somatic symptoms (such as heart palpitations, fatigue, nausea, chest pain, shortness of breath, stomach aches, or headaches), and cognitive representa-

tions of that state, involving the perception of the emotional and somatic state and experiencing it consciously. He has been distinguishing various types of anxiety: “real anxiety” – the automatic reaction of fear from an external object or danger (the prototype being the traumatic experience of helplessness at birth); “neurotic anxiety” – experiencing fear without a specific real danger in the external environment, fear arising from excessive stimulation originating from the Id and the anticipation of possible danger (he distinguishes three types of neurotic anxiety: “free floating anxiety”, “phobic anxiety”, “panic reactions”); and finally “moral anxiety” – the fear from punishment arising from the Superego (Freud, 1933). According to him anxiety is the response of the Ego to stimulation that it is unable to control when someone is confronted with or imagines a dangerous or harmful situation. Evolutionary the fear response, elicited by a perceived threat to the Ego, mobilizes the Ego defenses to protect the individual from the anticipated harmful or painful stimulation.

Sullivan (1949) differentiates fear from anxiety, fear having a clearly represented source or danger in the environment which is more or less identical for all people, while the source of anxiety is being infinitely varied and obscure since it depends on the imagination and anticipations people generate. To simplify, fear is about a present real danger, while anxiety is about a future anticipated danger.

Mowrer (1939) developed his avoidance theory of anxiety based on the behaviorist idea of associative learning. He has described the anxiety reaction as being a result of learning to

anticipate a dangerous situation when perceiving certain stimulus. Anxiety is a reaction of fear from this anticipation based on previous experience and the mismatch between the individual learning history (and the specific frequency of happening of dangerous events in this history) and the objective probability of these events. Thus sometimes people anticipate events to be more harmful than they actually are and react with fear where there is no need for fear and mobilization.

Kelly (1955) put forward his Psychology of Personal Constructs which basically claims that we construct the reality using our own personal constructs which nowadays might be described as schemas. Based on this theory Beck and his colleagues (Beck, 1975, Beck et al., 2005) developed a cognitive approach to anxiety describing it as result of distorted construction of the reality as result of the inability to see the alternatives, or as result of applying an individually developed schema. Miceli and Castelfranchi (2005) suggested to look at anxiety as an “epistemic emotion” which results from the need for uncertainty reduction and epistemic control over the situation.

Researchers further differentiate state anxiety (as described above) and trait-anxiety – the predisposition of a person to experience anxiety in a variety of situations. We will be concerned with state anxiety only in this paper.

Whatever the reasons for developing and experiencing of anxiety in certain situations, an interesting question is what the consequences of this experience are and more specifically, whether it further influences the cognitive processes. In fact, the main argument of many of the above theories is that the state of anxiety changes the cognitive processes and mobilizes the resources of the cognitive system preparing it to act adequately to the situation of danger. Of course, in case of inadequately generated fear, these consequences are negative since no defense is actually necessary.

There are many studies demonstrating that anxiety changes the cognitive processes. Researchers found out that anxiety impedes free recall and memory span (Hodges & Spielberger, 1969, Mueller, 1977, MacLeod, &

Donnellan, 1993), learning and memory (Eysenck, 1979, 1985), deductive reasoning (Blanchette & Campbell, 2005, Blanchette & Richards, 2004, Blanchette, Richards, Melnyk, Lavda, 2007, Darke, 1988, Oaksford, Morris, Grainger, & Williams, 1996), decision-making (Keinan, G. (1987), problem solving (Klein & Barnes, 1994). It was also shown that interference is observed mostly on complex tasks that require a lot of attention and representational capacity in working memory.

Eysenck & Calvo (1992) put forward the processing efficiency theory and then further developed it as the attentional control theory (Eysenck, Deraksan, Santos & Calvo, 2007) which claims that anxiety diverts attention to “danger-related” stimuli and thus restricts the working memory capacity left to the target task and that is why there is a decrement in performance. However, this decreased attention can be compensated by increased efforts to maintain the target task active and this could compensate for a better performance. Still, in this case the processing efficiency will be decreased as the same performance will be achieved by more efforts.

There are also a few more specific studies on the relation between anxiety and analogical reasoning. Thus Leon and Revelle (1985) manipulated the time pressure on the participants thus increasing or decreasing the anxiety of the subjects, and found people to be more accurate in low time-pressure condition. However, the time pressure itself is a factor influencing accuracy and the data could also be interpreted as speed/accuracy trade off. They found also correlation between anxiety as measured by the State-Trait Anxiety Inventory and accuracy. Keinan (1987) also run an experiment manipulating the anxiety, but this could be potentially interpreted as changing the target task.

Tohill and Holyoak (2000) performed two experiments by which they demonstrated that when the anxiety was manipulated prior to the task (by a serial subtraction task with negative feedback) the high-anxiety group has made less frequently relation-based mappings than the low anxiety group. Thus in a state of

anxiety people are less likely to make analogies.

Rickert, Whitehouse, and Stewart (2005) were interested in the role of analogies in generating religious ideas and they were particularly interested in generating analogies in states of high anxiety as in some specific rituals which are related with high arousal states (like for example of male initiation rituals in Papua, New Guinea, where the teenage boys are terrified during their sleep and brutally dragged to the ceremonial platform by adult males and tortured in various ways without explanation why this is being done). Their idea is the opposite to Tohill and Holyoak that people in this high arousal states will make more and better analogies than in non anxiety states and that is why these rituals are actually performed – to motivate people to search for more and better analogies. The results of the study seem to suggest that this is indeed the case. The problems with this experiment are that it is not well controlled (many differences in the target ritual itself which played both the role of a target task and of a source of anxiety) and that the scoring of the results is very coarse (they counted how many interpretations of actions were produced – 1 point for each, and in case of analogy use in the interpretation – 2 points were assigned). Thus it is not even clear whether the participants in the high-arousal condition produced more analogies or just more interpretations. Anyway, the idea was interesting and we are currently running a better controlled version of this experiment.

The main idea of the current study is to broaden up the exploration of the impact of anxiety on analogy-making by exploring not only the mapping phase, but the whole process of analogy-making. That is why we use an analogy generation task (Blanchette, I., and K. Dunbar. 2001). A target domain is presented to the participants and they have to generate as many as possible and as excellent as possible analogies to this target. This involves both the retrieval process to find appropriate potential bases for analogy, and the mapping and transfer processes in order to build and evaluate a mapping between the two and transfer infer-

ences and emotions to the target. Thus the total effect of anxiety on analogy making could be measured. We decided to use various measures some of which were borrowed from the Torrance Tests of Creative Thinking (TTCT) as proposed in (Torrance, 1974). This test involved generation of solutions, which were then scored on four scales:

- Fluency. The total number of interpretable, meaningful, and relevant ideas generated in response to the stimulus.
- Flexibility. The number of different categories of relevant responses.
- Originality. The statistical rarity of the responses among the test subjects.
- Elaboration. The amount of detail in the responses.

We excluded probably the most important Torrance scale – originality – since we tested a small group of subjects and we could not have a good statistics on the variety of ideas being proposed. However, we used equivalents to Fluency, Flexibility, and Elaboration, plus a number of other scales which are more specific for analogy-making (such as whether the analogy is from a remote domain or a close one, whether the analogy involves superficial similarities or not, whether it is based on sound structural correspondence, and whether it is a convincing excellent analogy.

Before outlining the experiment we would like to return on the theoretical issues discussed at the beginning. The main idea behind the attentional control theory of anxiety (Eysenck & Calvo, 1992; Eysenck, Deraksan, Santos & Calvo, 2007) is that in the state of anxiety people are actually in a situation of dual task processing: the official target task plus the self-generated task of thinking about the potential danger, i.e. part of the verbal Working Memory (WM) is devoted to the anxiety-related thoughts and thus is busy with processing threat-related stimuli, while the rest is used for the target task (Figure 1). As result of this decreased volume of available WM the more complex relational processing is impaired (Tohill & Holyoak, 2000). The problem with this explanation is that it assumes a spe-

cific fixed volume of WM (Miller, 1956) and no interaction between the thoughts generated by each of the two tasks. This approach has been implemented in the models of analogy-making STAR (Halford et al., 1994) and LISA (Hummel & Holyoak, 1997). It is also not obvious why a small decrease of the volume of WM (anxiety in a back subtracting task is definitely not so high as in the religious ritual described above) will destroy even single relation mapping as in the task of Tohill & Holyoak, while will make it possible in the experiment of Rickert et al. (2005).

The DUAL cognitive architecture (Kokinov, 1994a, Petrov & Kokinov, 1999) and the analogy-making model based on it AMBR (Kokinov, 1994b, 1998, Kokinov & Petrov, 2001) have a different concept of WM. It is the active part of LTM and has graded membership based on the activation of the individual micro-agents. The idea is that the agents may be variably active and their speed of processing and degree of participation in the collective computational process and the emergent macro-level behavior will vary. Thus there is no fixed number of elements in WM (fixed volume of WM) but rather a fixed amount of energy in the system (which in fact can also vary but we will simplify it here) which can be distributed in different ways over the agents depending on the context and the internal state of the system. So, our suggestion within this architecture is that the emotional state could correspond to a specific profile of the distribution of activation in the system, the state of anxiety corresponding to a more focused and steep distribution (Figure 2) than the more neutral emotional state (Figure 3). This is an elaboration of the original Freud's idea that anxiety serves for higher mobilization of resources. In our case the result is that a smaller number of agents are active, but they are really very active and this will result in faster processing. In this way in the state of anxiety DUAL predicts that the memory search will be more focused, i.e. the individual would consider a smaller number of options, and may miss a potentially better but remote solution, but will ensure a faster and more effective re-

action (so that the individual can rapidly escape if necessary).

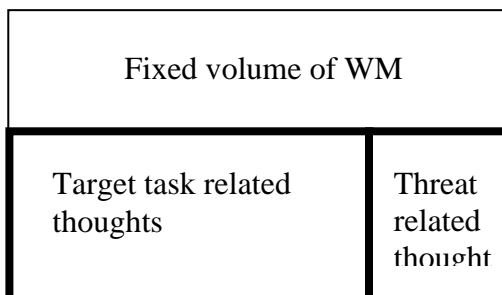


Figure 1. Attentional Control Theory of Anxiety view on WM in the state of anxiety.

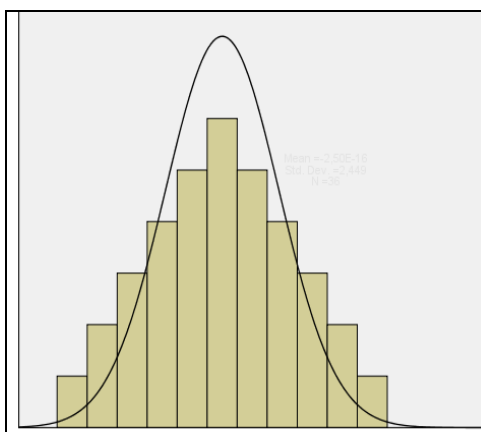


Figure 2. WM activation distribution in a state of anxiety.

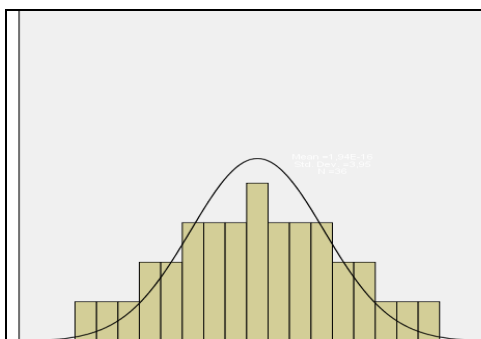


Figure 3. WM activation distribution in a neutral state.

Based on this theoretical view of the role of emotions (and specifically anxiety) in guiding the computational processing, our predictions will be the following. We expect indi-

viduals in higher state of anxiety to generate less remote analogies concentrated around one domain, while individuals at a state of lower anxiety to be able to produce a more divergent set of analogies some of which more remote. This is because the retrieval of knowledge from LTM is based on a spreading activation process that relies on activation of neighboring (semantically related or associatively linked) agents starting from the target agents. In the state of anxiety the activation could not travel too far away as Figure 2 shows, but this is compensated by higher activation in the neighboring nodes. On the other hand, at least when anxiety is kept moderate and far from extreme states, we do not expect that individuals will necessarily differ in the quality of the generated analogies, i.e. they will be relatively high on structural similarity and on excellence (or how convincing they are) and on how detailed they are described. Of course, if the analogies become complex and require too many elements to be mapped at the same time or if the anxiety level becomes too high, the quality of processing of the analogy (the relational representation and mapping) will begin to suffer as well.

The role of anxiety as motivational factor for searching explanations of the ritual and constructing analogies, as described in Richert et al. (2005), could be explained in the model by postulating that episodes encoded during a high anxiety state and their elements become easily accessible, i.e. they are easier to be activated because of lower thresholds of the corresponding agents activation function. The result would be that such episodes will often be automatically re-activated and new and new analogies could be made.

The following experiment was designed to test some of these predictions about the diversity and quality of the analogies generated during a state of high anxiety. Specifically, we expect lower diversity and semantically closer analogies in such a state.

### **METHOD**

In this experiment the participants were asked to generate as many as possible convinc-

ing analogies in order to argue in favor of a specific political position. The amount, diversity, remoteness and quality of these analogies were measured. We used a generation task since our predictions are related to what kind of analogical domains will be retrieved (constructed) from Long Term Memory.

### *Design*

We used a between group design in this experiment. The independent variable was the induced emotional state of the participants and had two levels: anxiety and non-anxiety condition. The dependent variables were many: the number of generated analogies, the number of generated analogies which are rather different from each other (i.e. the number of clusters of similar analogies), the degree of details provided in the explication of the analogies, the degree of structural and superficial similarities between the target and the generated bases, and the degree of excellence of the analogies.

### *Procedure*

The participants were tested individually by an experienced experimenter in a sound proof booth. There was a computer and a camera on the desk in front of the participants but they were not used. The experiment was conducted by paper and pencil.

The participants received the following instruction: "Imagine you are a politician and you have to defend a thesis in front of an audience and convince them in your position. Remember that the use of good analogies make the argument more convincing. You will receive a specific topic and a specific thesis and you have to generate as many and as convincing analogies as possible in order to support the thesis. Develop them in details. The analogies can be from any domain; they do not need to come from politics or history." The participants had 20 minute to generate the analogies.

In the Experimental group the state anxiety was induced by a "public speech" procedure which was used successfully to induce state anxiety in a number of other studies

(Graeff1, Parente, Del-Ben, Guimarães, 2003; Pertaub, Slater & Barker, 2002). The participants in the Anxiety group were additionally instructed that “at some point you will be interrupted and you will be asked to make a presentation on a topic that you will not know in advance. The task will be similar to the current one and you will have to argue in favor of a specific claim. You will have to talk spontaneously and without interruption for 5 minutes. Your presentation will be video recorded and then later on your communication skills will be evaluated.” In that moment the experimenter installed the camera in front of the participant, but no recording was initiated. 10 minutes later the experimenter came into the booth again and tested the camera as if she would initiate the recording but went out of the booth without starting the camera. Thus the participants were never asked to make the public speech and were never recorded. However, they were constantly expecting that this might happen every moment.

### *Stimuli*

The participants received the following case:

“In the contemporary world there are many debates whether a specific territory has to become a separate state or it should stay within the bigger country as its constituent part.

The supporters of the independence idea claim that the citizens of these territories have the right to decide in what country they want to live. If they feel that there are obstacles in their personal or carrier development because of ethnic or religious differences, if they feel their rights are endangered, they have the right to decide to build their own country where they would feel free.

The supporters of the integral territory idea claim that independently of the possible ethnic or religious contradictions the territory of a country has to be kept intact. Their main argument is that even if the minority establishes its own country, it will again not be ethnically or religiously clean, i.e. there will again

be a minority there which can potentially aim at independence. And this process of fragmentation is endless until all countries in the world disappear.

You have now 20 minutes to support the independence position using as many analogies as possible, please, develop them in detail.”

### *Participants*

30 participants (13 male and 17 female) took part in the experiment. Part of them were enrolled in introductory psychology courses at the New Bulgarian University and participated for course credits. Another part consisted of students from different departments, which were paid for their participation. Their age varied from 19 to 26 years and the average was 21.2. The participants were randomly assigned in equal numbers to the two conditions, maintaining equal ratios between female and male participants in each group.

### **RESULTS**

The protocols from the generation task were used as the main data set. They were analyzed by three independent judges who evaluated the generated analogies over a set of criteria on 5 point scales. The evaluations of the three judges were compared and when a difference was found it was resolved by a forth judge. The encoding of the protocols was blind (i.e. the judges did not know which group the protocol came from).

First of all, our manipulation of anxiety seems to be successful. The two groups differed significantly on their self-evaluation of how nervous they had felt during the experiment on a 5 point scale ( $t(20)=3,459$ ,  $p=0,002$ ) – the Control group ( $M=2$ ,  $SD=0,943$ ) and the Anxiety group ( $M=3,25$ ,  $SD=0,754$ ).

The two groups did differ on a number of dimensions, but did not on others.

Thus although the number of generated analogies in the control group ( $M=3,93$ ,  $SD=1,70$ ) was a bit higher than in the anxiety group ( $M=2,93,14$ ,  $SD=1,79$ ) the difference

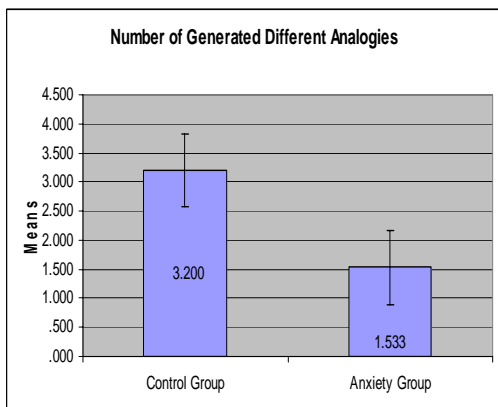
## Anxiety Restricts the Analogical Search

was not found to be significant ( $t(28)= 1,564$ ,  $p=0,129$ ).

However, when the analogies were analyzed by their content, and the experts classified them into clusters of highly similar analogies (e.g. you have the right to choose your own style of dressing, you have the right to wear your own style of shoes, etc. which is practically the same analogy with minor variation), we found significant difference between the number of different analogies generated by the participants in the two groups ( $t(28)=3,812$ ,  $p=0,001$ ) – see Table 2 and Figure 4 for the descriptive statistics.

**Table 2. Number of different analogies generated in each group**

group	Mean	Std. Deviation	N
Control	3,2000	1,42428	15
Anxiety	1,5333	,91548	15
Total	2,3667	1,44993	30



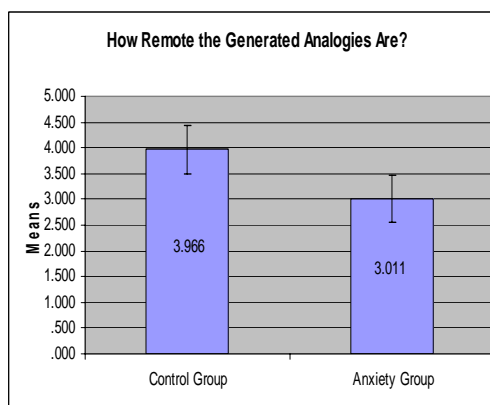
**Figure 4. Mean number of generated different analogies in each group.**

It is evident that the number of different analogies generated by the control group was more than twice as big as the number of different analogies generated by the anxiety group.

These data are related to the evaluation of *how remote* the generated analogies were. Although there was only marginal difference in the remoteness of the first generated analogy –  $t(28)=1,821$ ,  $p=0,079$  ( $M=3,8$ ,  $SD=0,94$  in the control group, and  $M=3,2$ ,  $SD=0,86$  in the anxiety group), there was significant difference in the remoteness of the second analogy ( $t(26)=2,105$ ,  $p=0,045$ ) with  $M=3,84$ ,  $SD=1,07$  in the control group and  $M=2,73$ ,  $SD=1,62$  in the anxiety group. Averaging the remoteness of all analogies generated by an individual participant we found that the control group generated significantly more remote analogies ( $t(28)=2,985$ ,  $p=0,006$ ) than the anxiety group. (Table 3, Figure 5) and the difference is about one point on the 5 point scale.

**Table 3. How remote the generated analogies in each group are?**

group	Mean	Std. Deviation	N
Control	3,9656	,77071	15
Anxiety	3,0111	,96920	15
Total	3,4883	,98784	30



**Figure 5. How remote the generated analogies in each group are?**

The remoteness was evaluated by the judges on a five point scale and reflected their assessment of how far or close the two domains are.

The two groups did not differ significantly on *how detailed* they presented the analogies ( $M=2,43$ ,  $SD=0,99$  in the control group, and  $M=2,14$ ,  $SD=1,38$  in the anxiety group) –  $t(28)=0,655$ ,  $p=0,52$ ); on *how superficially similar* they are to the target ( $M=2,20$ ,  $SD=0,75$  in the control group, and  $M=2,68$ ,  $SD=0,76$  in the anxiety group) –  $t(28)=-1,69$ ,  $p=0,102$ ); on *how structurally similar* they are to the target ( $M=2,57$ ,  $SD=0,69$  in the control group, and  $M=2,67$ ,  $SD=0,57$  in the anxiety group) –  $t(28)=-0,426$ ,  $p=0,673$ ); and *how excellent/convincing* these analogies are ( $M=2,50$ ,  $SD=0,76$  in the control group, and  $M=2,45$ ,  $SD=0,74$  in the anxiety group) –  $t(28)=0,203$ ,  $p=0,84$ ).

### DISCUSSION

The experimental data obtained in this study support the predictions of the DUAL-based theory of anxiety presented in the Introduction, namely it has been demonstrated that individuals in a state of high anxiety tend to be more rigid and focus on a more restricted domain of interest and do not have the power to search broadly LTM for remote analogies in various directions, they rather stick with the first domain found but they are still able to produce consistent structural and systematic analogical mappings and produce convincing and detailed analogies. What still needs to be tested is whether individuals in a state of anxiety will be faster in producing the first analogy as DUAL would predict. Of course, alternative theories may very well be also capable of explaining the obtained data in a different way. This is only a first step in a long process of exploring the role of emotions in analogy-making and thinking in general.

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