

# How Does Anxiety Influence Analogical Mapping?

V. Feldman ([vfeldman@nbu.bg](mailto:vfeldman@nbu.bg)), P. Hristova ([phristova@cogs.nbu.bg](mailto:phristova@cogs.nbu.bg)), B. Kokinov ([bkokinov@nbu.bg](mailto:bkokinov@nbu.bg))

Central and East European Center for Cognitive Science, Department of Cognitive Science and Psychology,  
New Bulgarian University, 21 Montevideo Street  
Sofia 1618, Bulgaria

## Abstract

This paper presents an experimental study of the influence that the anxiety state may have on analogical mapping. Contrary to the well-known study of Tohill & Holyoak (2000), where the anxiety state impeded the analogical mapping, in this study participants in the anxiety state were significantly more inclined to produce a relational choice which is structurally consistent with the target, even though this alternative was more superficially dissimilar to the target. This result was obtained in a match-to-sample paradigm. The implications for the theory of how anxiety influences analogy-making are discussed and it is argued in favor of a more detailed and specific approach to studying the influence of anxiety on each component mechanism of analogy-making.

## Introduction

Imagine that you are in a stressful situation and you feel anxious. Will that make you more or less successful in making good analogies? Some researchers believe that this emotional state will impede the analogy-making process (Tohill & Holyoak, 2000), while others (Richert, Whitehouse, Stewart, 2005) argue that you will make more or better analogies and that is why some religious rituals are deliberately designed to increase your anxiety. This controversy has motivated our study.

The interplay between analogy and emotions has been studied from two opposite perspectives.

Thagard and Shelley (2001) have argued that analogy may influence emotions, since people may use analogies to convey emotions to others like in the famous “Saddam is like Hitler” example (Spellman & Holyoak, 1992). This theoretical account was empirically supported in a recent study using simple proportional analogies (Bliznashki & Kokinov, 2009) which demonstrated that the negative or positive attitude towards an item in one domain can be transferred to the corresponding item in the other domain via the analogy and that this transfer is bidirectional.

Several researchers explored the influence of emotions on the analogy-making process itself. Thus a series of studies was devoted to the influence of anxiety on analogy (Leon and Revelle, 1985; Keinan, 1987; Tohill and Holyoak, 2000). Why anxiety? The specific line of reasoning was that since it is well known that anxiety influences several cognitive processes, including working memory, one should expect also an influence on analogy. Thus Tohill and Holyoak (2000) provided evidence that state anxiety impedes the relational mapping and anxious participants prefer a more superficial attributive mapping. In their study anxiety was induced prior to the task by a serial subtraction task with a negative feedback. Participants were instructed

to count aloud from 1000 backwards with a decrement of 13. One experimenter corrected participants’ mistakes and another – urged participants to count faster. Moreover, participants in the anxiety group were informed that they would have to repeat this task at the end of the experiment, i.e. after the analogy-making task. The influence of anxiety on analogy-making was tested with a cross-mapping task, where participants were asked to indicate which object, presented on one of the pictures “goes with” the object, pointed to by the experimenter. The trick was that the object pointed to in the first picture could “go with” two different objects in the second picture for two different reasons, i.e. with the object which is similar in its physical appearance to the pointed object or with the object that participates in similar relations as the pointed one. Based on Eysenk’s working memory restriction theory (Eysenk and Calvo, 1992) it was assumed that anxiety restricts working memory capacity which in turn impedes higher-order relational mapping needed for finding the relational mappings in the cross-mapping task used in this particular study. Correspondingly, anxious participants<sup>1</sup> indicated fewer relational mappings than non-anxious participants (Experiment 1) even in the presence of explicit instruction to find them (Experiment 2) (Tohill and Holyoak, 2000).

It was also shown that state anxiety impedes the range of generated analogies to a given base problem (Feldman and Kokinov, 2009). Anxious participants generated a significantly smaller amount of drastically different analogies, i.e. most of their analogies belonged to one domain, while non-anxious participants were more flexible and generated analogies belonging to two or three different domains. In addition, non-anxious participants produced analogies with remote domains, while anxious ones produced mainly close analogies. At the same time no difference was found between the quality of mapping and convincingness of the analogies produced. So, no direct evidence was produced neither in favor, nor against the hypothesis that anxiety impedes analogical mapping. It was only demonstrated that anxiety impedes analogical retrieval (in an analogy generation task).

On the other hand, it has been shown that people in negative mood are more likely to choose the relational match rather than the attribute matches compared to people in positive mood in a simple matching-to-sample task (Hristova, 2009). In this study both the relational and the attribute mappings were possible, but curiously people in negative mood prefer the former ones, i.e. they choose the

<sup>1</sup> state anxiety is used here, not trait anxiety.

relationally similar target as being more similar to the base stimulus. Hristova (2009) argues that the triples of figures used as stimuli in this experiment presuppose that the relational mappings were harder than the attribute ones, since they require an extra effort for encoding of relations, which were not explicitly drawn between figures. Hence participants in negative mood invested more effort while doing the task than participants in positive mood, consistent with the cognitive tuning hypothesis (Schwarz, 2002) that has inspired this experimental work. Since the core of analogy-making is exactly the mapping between relations, rather than attributes (Gentner, 1983) the straightforward inference from this work is that negative, rather than positive mood may enhance analogy-making by facilitating the encoding of relations.

In conclusion, it seems that there is controversial evidence for the role of emotions on analogical mapping. Tohill and Holyoak (2000) have found that state anxiety may change analogical mapping from relational toward attribute based one, while Hristova (2009) has found that negative mood, which can be considered as similar in valence to the state of anxiety (i.e. anxiety is a kind of negative emotional state) facilitates relational mapping compared to positive mood.

It could be that anxiety exerts a completely different influence on analogical mapping than negative mood: an interesting hypothesis that insists on fine grade distinction between the negative emotions themselves and therefore, between the cognitive mechanisms that these emotions may change. This hypothesis however, cannot fully explain the variety of results obtained in the field of analogy-making, since two experiments that manipulate state anxiety report different results with respect to analogical mapping: Tohill and Holyoak, (2000) demonstrated less relational mappings due to anxiety, while Feldman and Kokinov (2009) did not report any effect of anxiety on analogical mapping.

The present research aims to further explore the influence of anxiety on analogical mapping by exploiting the anxiety-inducing procedure used by Feldman and Kokinov (2009) and the analogical mapping task used by Hristova (2009). If anxiety impedes relational choices in this task rather than facilitate them, as shown under negative mood (Hristova, 2009), then it would be relatively safe to conclude that the diverse negative emotions (to be more specific, anxiety compared to negative mood) exert different effects on analogy-making. If the opposite trend is observed then the picture of influence of anxiety on analogical mapping is more complicated.

## Experiment

### Method

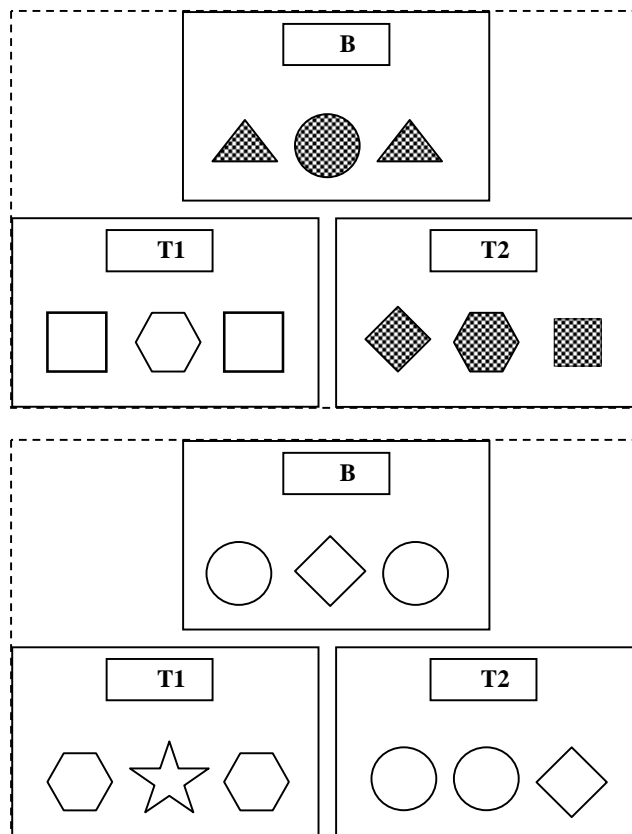
The main idea of this experiment is to test whether an induced state of anxiety will change the type of relational processing performed by the participants and in particular whether the proportion of relational choices will be higher or lower than in a non-anxiety state.

### Design

This experiment has a between-subject design with one independent variable – the state of anxiety (an anxiety and a non-anxiety group), and one dependent variable the proportion of relational choices made. Two other variables were used for control purposes only – the state of anxiety as measured by a self-report on a scale and the response times.

### Stimuli

22 stimuli were used in this experiment. Each of them was a match-to-sample-triple consisting of a base item B and two target items T1 and T2. The question that the participants had to answer was “whether T1 or T2 is more similar to B”. The stimuli were prepared in such a way that one of the targets was sharing the same objects or the same color of the objects as the base, i.e. was superficially similar to the base, while the other one shared some spatial or transformational relations but consisted of different objects, i.e. was structurally similar. Both choices make perfect sense. Three groups of stimuli were used in the experiment and representatives of each group are presented in Figure 1. There is a forth group of stimuli which are only partially analogous (i.e. none of the two is a good match) since only some of the relations/attributes are shared (Figure 2). These stimuli were used by Hristova (2009) and are variations of the stimuli used by Medin, Goldstone, and Gentner (1990) and Sloutsky and Yarlas (submitted). We have used them for replication purposes.



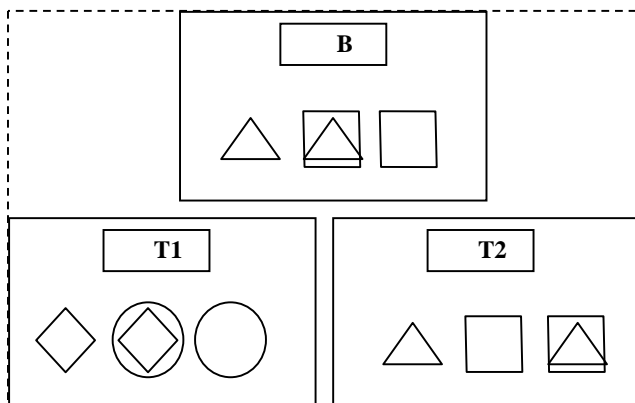


Figure 1. Three examples of items from the Match-to-Sample task, one example from each category of stimuli. In all three cases T1 is the relational choice, while T2 is the superficially similar one. Of course, in the experiment the order of T1 and T2 presented as relational/superficial choice has been contra balanced.

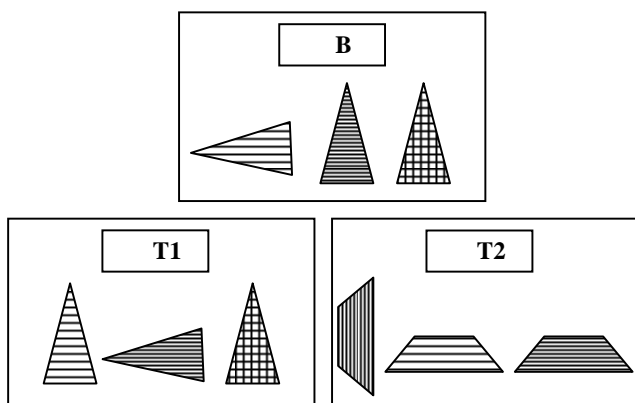


Figure 2. An additional type of examples used in the Match-to-Sample task for replication purposes. Neither T1, nor T2 makes perfect analogy to B, but T2 keeps the spatial relationships, while T1 keeps the relations between textures.

## Procedure

The participants were tested individually by an experienced experimenter in a sound proof booth on a personal computer running e-Prime automated script.

Participants were enrolled in a matching-to-sample experiment for about 5 minutes. Their task was to judge whether “T1” or “T2” are more similar to the standard “B” by pushing the respective button on a BBOX: the left button “T1” and the right button for “T2”. When participants gave their answer the next stimulus appeared on the screen. The presentation order of the stimuli was randomized across participants. A fixation cross was presented for 50 ms before each trial.

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; Feldman & Kokinov, 2009). The participants in the Anxiety group when invited were instructed that at some point they will be interrupted and will be asked to make a presentation on a topic that they will not know in advance. The task will be to argue in favor of a specific claim. They will have to talk spontaneously and without interruption for 5 minutes. Their presentation will be video recorded and then later on their communication skills will be evaluated. In that moment the experimenter installed a camera in front of the participant, but no recording was initiated. They were asked meanwhile to participate in another experiment and they were given the match-to-sample task described above. The participants were never asked to make the public speech and were never recorded, however, they were constantly expecting that this was going to happen. At the end the participants were debriefed about how they were feeling and they also rated on a 5 point scale how nervous they were during the experiment.

## Participants

38 participants (15 male and 23 female) took part in the experiment. All of them were students at the New Bulgarian University some in psychology and some in other programs. Their age varied from 17 to 37 years and the average was 22.95. The participants were randomly assigned in equal numbers to the two conditions, maintaining equal ratios between female and male participants in each group.

## Results

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 ( $t(36)=4.624$ ,  $p<0.001$ ,  $d=1.50$ ) – the Control group ( $M=0.79$ ,  $SD=1.134$ ) and the Anxiety group ( $M=2.32$ ,  $SD=0.885$ ).

The mean proportion of the relational choices was higher in the anxiety group (35%) than in the control group (24%) and this difference turned out to be significant tested with a t-test when the data were aggregated by item – ( $t(42)=5.695$ ,  $p<0.001$ ,  $d=0.31$ ) (Figure 3). At the same time importantly, RT did not differ significantly between the two experimental conditions:  $t(42)=0.397$ ,  $p=0.693$ , (Figure 4). Thus, the influence of anxiety cannot be attributed to spending more time and more careful inspection of the task in the anxiety group.

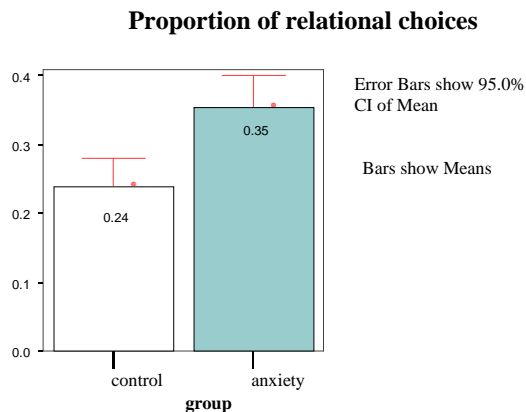


Figure 3. Mean proportion of relational choices per condition.

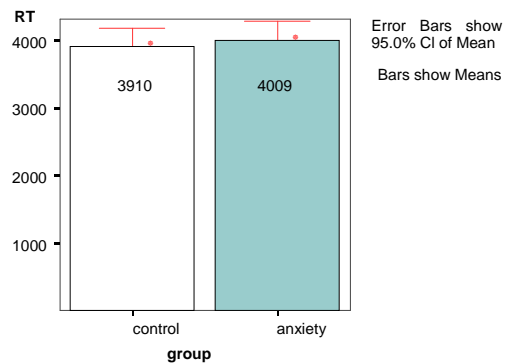


Figure 4. Mean RT per condition.

The same trend was observed for the six stimuli of Hristova (2009), included in the item pool of this experiment: the anxiety group made significantly more relational choices (38%) than the control group (25%) ( $t(10)=0.424$ ,  $p=0.016$ ,  $d=1.78$ ), while the difference in the mean RT was again not significant ( $t(10)=0.782$ ,  $p=0.452$ ). This result is comparable to the one obtained by Hristova (2009) with the same task and stimuli, where people in negative mood also made significantly more relational choices than people in positive mood.

## Discussion

The goal of this research was to clarify the role of anxiety for analogical mapping. Two conflicting findings were discussed at the beginning: anxiety may impede relational mapping (Tohill and Holyoak, 2000) or anxiety, as a kind of negative emotional state, may facilitate relational mapping (Hristova, 2009). The present research supports the latter prediction, i.e. anxiety facilitated relational mappings.

The question now is why we have obtained results opposite to the ones by Tohill and Holyoak (2000)? There are two important differences between the two studies: the

procedure of anxiety inducement and the tasks of the participants. Each of them could potentially cause the difference.

With respect to the anxiety inducement procedure there are a number of differences. It could be that one of them is inducing stronger anxiety than the other. We cannot say this with certainty, since we have not used the same instrument for measuring the anxiety state of the participants, however, there are reasons to believe that the current procedure induces stronger anxiety since making a public speech and being recorded and then your communication skills being analyzed seems more stressful than counting backwards at high speed and being corrected. In addition, in the current procedure the participants were warned that they can be interrupted any time and asked to make the public speech, while the participants in the Tohill & Holyoak (2000) study knew that they will be counting again only after the analogy task is over. Of course, these are only speculations, it is also possible that the current procedure has produced much less anxiety than the Tohill & Holyoak (2000) study and the results are due to the classical Yerkes-Dodson law (1908) that describes the inverted U shaped relationship between arousal and performance: maybe we have found the optimal level of arousal for the matching-to-sample task used in our experiment, while Tohill and Holyoak (2000) did not. In other words anxiety may both increase and decrease relational mappings depending on the degree of arousal. This explanation is unconvincing since the very same procedure has been applied by Feldman & Kokinov (2009) and it has significantly reduced the number of *different* analogies generated and their *scope*. Also additional analysis of the data shows that there is a trend: the higher the self-reported anxiety is, the more relational choices participants make, i.e. there is no point above which the relational choices have declined.

Alternatively, the difference might be due to the difference in the analogy tasks used in both experiments. This would be an interesting avenue for research since it would require task analysis and decomposition of the “analogy-making process” into simpler mechanisms and exploring the role of anxiety for each of these components. Thus, for example, in both tasks – the cross-mapping corresponding task used by Tohill & Holyoak (the subject has to point to the corresponding object of a hinted one) and the match-to-sample task used in the current study (the subject has to chose which of two alternative situations is more similar to the sample) – the participants have to encode certain relations and attributes of the objects and than build the two alternative mappings, and finally chose the better one. According to some models of analogy-making like ARCS (Holyoak & Thagard, 1989), AMBR (Kokinov, 1994, Kokinov & Petrov, 2001), CopyCat and TableTop (Hofstadter, 1995), LISA (Hummel & Holyoak, 1997) there are at least 3 subprocesses of analogy-making: perceiving (encoding) the relations, forming hypotheses of possible correspondences, and competition between them (constraint satisfaction), other models like SME (Gentner,

1983, Falkenhainer, Forbus, Gentner, 1989) offer alternative but analogous subprocesses. Anxiety may influence each of these subprocesses specifically. Since Tohill & Holyoak (2000) allow their subjects to observe the two pictures for 15 sec before the question was asked, this would mean that all relations are already encoded and possibly also most of the hypotheses are formed and after the query mostly the constraint satisfaction process continues. Thus the influence of anxiety would be mainly on the constraint-satisfaction outcomes. In our study participants used on average 4 sec for the whole task of encoding, hypotheses building, and constraint satisfaction. Therefore, it is reasonable to assume that they do not have the time for full relational encoding, building all possible hypothesis, etc. Most probably they encode only a few relations and form a few hypotheses and therefore the constrain-satisfaction process is quite straightforward. Thus most probably the anxiety state influences mostly the process of relational encoding in this case. According to the DUAL architecture and the AMBR model (Kokinov, 1994, Kokinov & Petrov, 2001) anxiety concentrates the activation over a smaller area of Long-Term Memory thus causing a smaller search space but faster processing within this space (Feldman & Kokinov, 2009). Thus maybe the anxiety state in our task causes a speeded search for relational encoding (especially given the restricted number of relations used in the stimuli) and hypotheses formation and that is how anxiety enhances relational choices.

Such a possibility is potentially and indirectly backed up by neuroscience approaches to anxiety and its influences on cognitive processes. Posner, Rueda, and Kanske (2007) distinguished 3 main attentional neural networks – *alerting network* (associated with the right frontal and parietal brain areas which contributes to the maintenance of the sensitivity level needed for perceiving and processing stimuli), *orienting network* (associated with the superior parietal lobe, frontal eye fields, and temporoparietal junction which contributes to the selection of information from among numerous sensory stimuli), and *executive control network* (associated with midline frontal areas, anterior cingulate gyrus, and lateral prefrontal cortex which contributes to the conflict resolution and voluntary action control) which could be somehow related to the three processes described above: encoding relations, building hypotheses, and constraint satisfaction. The encoding of relations would depend on the alerting network allowing bottom-up recognition of relations; the hypotheses formation – on the orienting network selecting potential correspondences; and the constraint satisfaction depending on the inhibitory capacity of the executive control. A recent study by Pacheco-Unguetti, Acosta, Callejas, Lupianez (2010) found that the anxiety state enhances the work of the alerting and orienting networks, while no significant effect was found on the executive network, while the trait anxiety has no effect on the alerting and orienting networks, but severely diminishes the executive control and its possibilities for inhibition. Thus “state anxiety is related to greater orienting

and alerting effects, thus making participants more sensitive to bottom-up processing” (Pacheco-Unguetti et al., 2010). This might mean that in an anxiety state people are more rapidly encoding the relations which are otherwise difficult to be perceived and this could explain why the anxiety-induced subjects made more relational choices in our experiment. This hypothesis can be potentially backed up also by the study of Becker (2009) who found that in the presence of threatening stimuli people are faster in visual search also for non-threatening stimuli, i.e. faster encoding is performed. It is true that the search he has studied is for objects, not relations, but we plan an experimental study to test whether this speeded processing will also be extended to relations as we assume. At the same time the anxiety-induced subjects in the Tohill and Holyoak (2000) study had the necessary time to encode all relations in advance and therefore the effect could be due either to the limited capacity of working memory (Eysenck & Calvo, 1992) or to impoverished constraint satisfaction. Of course, all these are wild speculations and further studies are necessary to test these hypotheses.

The main conclusion from this study is that the influence of anxiety on analogical mapping is much more subtle and complicated than previously thought and that we need to study more carefully the influence of anxiety on each of the components of the analogy-making process before jumping to bold conclusions.

## Acknowledgments

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