Impact of Mood on Cognitive Flexibility in Different Categorisation Tasks

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ABSTRACT
Previous research suggested that mood can have an impact on cognitive flexibility. This study investigated how mood affects the cognitive flexibility of 14 healthy participants with an age range of 14-49 in categorisation tasks, in which one half was induced a positive mood and the other half negative. All participants completed a rule-described and a non-rule described categorisation task. It is found that people overall performed better in the former, and negative mood seems to have a slightly positive impact on their performance in both tasks. Also, people have a tendency to conclude a rule that can easily be verbally described to conform to. Our findings provide a new area and direction for researchers to investigate how mood relates to cognitive flexibility in the future.

Keywords: *cognitive flexibility, categorisation task, rule-described, non-rule described, mood.*

1. INTRODUCTION

1.1 Rule-Described and Non-Rule Described Categorisation Tasks

Categorisation tasks can be divided into two types based on whether the rule involved can be described verbally or not. Some of these tasks involve decision rules that can be verbally described easily—these are called "rule-described (RD) categorisation tasks". However, in many cases, categorising objects involve decision rules that cannot easily be described verbally, and these tasks are called "non-rule-described (NRD) categorisation tasks" [1]. These two tasks can both be exemplified by many real-life cases. For instance, it is easy for people to verbalise a rule to differentiate circles from triangles, whereas it may be hard for beef lovers to express how they distinguish between M5 wagyu beef and M8 wagyu beef.

RD and NRD categorisation tasks are based on different categorisation systems—the verbal and the implicit, where RD categories are learnt via the former and NRD categories via the latter [2]. By definition, the former system is based on explicit conscious reasoning, whereas the implicit system is based on implicit procedural learning [2]. The theory of Competition of Verbal and Implicit Systems (COVIS) assumes that these two systems compete with each other during category learning—the verbal system initially dominates, though the implicit system often overcomes the influence of the verbal system through practice [2].

Evidence shows that children and adults have similar performances in NRD categorisation tasks but exhibit differences in the RD ones; compared with adults, children are impaired in the latter tasks, while this impairment is not shown in the former tasks [3]. This can be caused by their underdevelopment of the prefrontal cortex [3], a brain area that is linked to working memory—the system that stores and manipulates information in memory in the short term [4]. Unlike short-term memory, which is a "simple storage component" [5], working memory underlies human thought process [6]. In RD tasks, such thought processes are required—the rules need to be held in memory and recalled during task completion. A deficit in working memory can thus impair performance in RD tasks [2]. Therefore, adults, whose prefrontal cortex is fully developed, perform better in RD tasks. In contrast, the implicit system of which procedural learning is involved is mediated by the caudate nucleus, where working memory is not required. The subcortical structure in the caudate nucleus is fully developed in children [7], thus their performance in NRD categories are not impaired relative to adults [3]. Although the ability to perform RD tasks is affected by age due to the different extent of development of the prefrontal cortex, working memory is not being relied heavily on in the RD task in this study due to the easiness of the task.

1.2 Mood and Cognitive Flexibility in Categorisation Tasks

Cognitive flexibility in categorisation tasks is the ability to generate categorisations of stimuli depending on the requirement of the task [9]. Categorisation tasks are suitable to be used in the investigation of cognitive flexibility in relation to other factors such as age, health condition or damage to certain brain areas [2]. The effect of mood on cognitive flexibility, however, is rarely assessed using categorisation tasks, leading this research to investigate how positive and negative mood might effect the ability of this kind.

Although a number of reported empirical evidence suggests that there is no relationship between people's mood and cognitive flexibility in categorisation tasks—for example, in a previous study, participants in a positive mood did not perform better than those in a neutral or negative mood in a task where they listed similarities and differences between 2 TV shows [10]—a significant amount of research however, indicates a positive relationship between the two [8]. For example, it is shown that happy individuals were able to flexibly transform a mood-threatening task into an entertaining task, showing greater cognitive flexibility compared with the participants in other mood-states [10].

1.3 the Current Research

Although RD categorisation tasks may appear to be easier than the NRD ones, it does not mean that people will perform worse in the latter. Many people like to use their strong intuition or other methods that they cannot explain to categorise objects and have high accuracy as well. Regarding the mood impact, which has not been intensively investigated in yet, we also have a myriad of confusion. It is hard to believe that mood can directly cause an impact on the categorisation tasks.

To solve the puzzle, this paper is going to investigate the difference between people's performance in RD categorisation tasks and NRD categorisation tasks, and the impact of mood on people's performance when doing the two tasks.

There are two hypotheses in this study. First, people tend to have a better performance when doing RD categorisation tasks. Second, people who are in a relatively negative mood condition tend to perform worse in general, whether the task is rule-described or non-rule described. The former will be tested by comparing the participants' performance in both of these tasks, while the latter will be tested by playing mood-inducing music before and during their completion of the tasks.

2. METHOD

2.1 Participants

14 healthy participants (11 females and 3 males) with an age range of 14-49 participated in the experiment. The sample was a mixture of 11 white-collar workers and 3 students with each vocation containing both genders. All participants have a Chinese nationality and currently work or study in Suzhou city. Around half of the participants were recruited at a local company in Suzhou using opportunity sampling method while the other half volunteered to participate after seeing online posts. Participants were assigned one of the two mood-induction conditions (7 participant in each condition) via random allocation and were asked to do both of the tasks required.

2.2 Materials and design

A mixed design in which the emotional state of the participants is a between-subject factor and the type of categorisation task that they complete is a within-subject factor was used; these are the independent variables of the experiment.

Participants will be randomly allocated to either the positive-mood condition or the negative-mood condition. This is manipulated by letting the participants listen to a mood-inducing music composition, depending on the condition they are assigned to. Two pieces of background music composition to evoke participants' emotional state were used. Prior to the main experiment, three external judges rated the level of the influence on their affective states on an 11-point scale ranging from 0 (= huge negative influence) to 10 (= huge positive influence) that the pieces of music composition had. The average rating for the music composition "Schnappi" (positive-mood-induction) was 7.00 and for "Lament" (negative-mood-induction) the rating was 3.33.

There are two types of tasks—one being rule-described (RD) categorisation tasks and the other being non-rule-described categorisation (NRD) tasks. RD tasks are based on decision rules that can be verbally described and NRD tasks are based on decision rules that are difficult to described by words. This is operationalised by asking participants to compare the gradients of the gratings within two circles (RD) or comparing the size of a circle with the spatial frequency of its grating within it (NRD). All participants finished both of the categorisation tasks.

In the NRD category set, the diameters (x-axis) of the circles and the spatial frequencies (y-axis) are plotted as below. A diagonal line is drawn and the circles that correspond to the 5 dots on the graph are exemplary circles that have the same size as their spatial frequency. These 5 circles are shown to the participants before the trial begins. The rest of the dots represent the circles in the main trials. The circles represented by the dots above the line are set to have a larger frequency compared to the size; the circles represented by the dots below the line are set to have a larger size than the frequency.

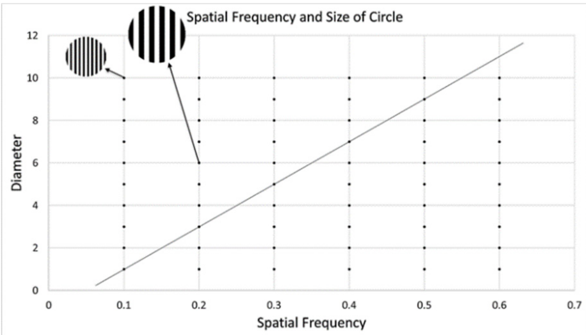

Figure 1. The diameter and the spatial frequency of the circles. The dots plotted on the line represent circles that have the equal size and spatial frequency. These circles were presented to the participants before the main trials as exemplary circles. The rest of the circles are included in the main trials. The circles that correspond to the dots above the line have a larger spatial frequency compared to the size and vice versa.

The dependent variables in our experiment are the number of the correct answers and the incorrect answers of the participants, and their reaction time for each question recorded by the software PsychoPy. These will be analysed in the Results section.

2.3 Procedure

Each participant was taken into a quiet room and seated in front of a table with a computer on it. Based on their allocated mood condition they were assigned to, the song "Schnappi" or "Lament" was played at a comfortable volume. The researcher asked them to recall a memory that made them feel happy/sad while listening to the music.

Before the experiment began, the researcher read out the following instructions:

"The instructions of the task will appear on the screen. Click "start" when you are ready."

The counterbalancing technique was used--half of the participants did the RD task first and half did the NRD task first.

In the RD task, participants were required to compare the gradient of the gratings of two circles grouped together. The decision-making here is based on rules that can easily be described verbally. All participants received the following instructions:

If you feel that the gradient of the grating of the circle on the left is larger than the one on the right, please press key 'f'.

If you feel that the gradient of the grating of the circle on the right is larger than the one on the left, please press key 'j'.

90 groups of circles were then presented to the participants randomly. Participants received immediate feedback ("Correct!" or "That was wrong!") after each trial.

In the NRD task, participants were required to compare the size of a set of circles and the spatial frequency of the gratings within them. It is difficult for the participants to conclude a rule that can be verbally described for this task, so they were expected to make the decisions based on their instinct. 5 exemplary circles were presented to the participants for them to have a basic impression of what a circle that has the same size as its spatial frequency would look like. Then, before the trials begin, each participant received the same instructions as follows:

If you feel that the size of the circle is bigger than the spatial frequency, please press key 'f'.

If you feel that the size of the circle is smaller than the spatial frequency, please press key 'j'.

Subsequently, a total number of 56 circles were displayed on the screen one by one in a randomly generated order. Participants received immediate feedback ("Correct!" or "That was wrong!") after each trial, just as the RD task.

After the experiment, the participants were required to report their mood on a 11-point scale ranging from 0 (=very sad) to 10 (=very happy). If any participant reported a mood that did not align with their mood condition, their data would be transferred to the other condition. If any participant reported 5 (=neutral), their data would be discarded.

3. RESULT

The analysis focuses on participants' reaction time and accuracy. The average reaction time and accuracy for two tests in with mood impact are listed as table 1 shows.

Table 1. Average reaction time and accuracy in two tests with mood impact

Type of tests	Mood condition	Reaction time(s)	Accuracy
RD	Positive mood (7.3)	2.36	88.24%
	Negative mood (3.3)	1.97	89.83%
	Average (5.4)	2.16	89.03%
NRD	Positive mood (7.3)	2.35	76.17%
	Negative mood (3.3)	2.20	78.70%
	Average (5.4)	2.27	77.44%

Since we want to find out whether the participants' performance in both RD test and NRD test are impacted by their mood, we separate the data in each test into 2 groups as table 1 shows, depending on the participants self-rate from 1~10 on their mood after they are given by specific emotion inducing. All the participants who receive the positive emotion inducing rate themselves with a mood above 5 with an average of 7.3, and all the participants who receive the negative emotion inducing rate themselves with a mood below 5 with an average of 3.3, so all their data are valid.

We also calculate the average reaction time and average accuracy in overall RD test and NRD test, not separated by mood condition. The average mood of all the participants is 5.4.

It can be found from table 1 that that the average reaction time of all the participants in RD test with value 2.16s is shorter than the average reaction time in NRD test, which is 2.27s. The percentage error between the reaction time in two tests is:

$$(\text{NRD rt-RD rt})/(\text{RD rt})\times 100\%=(2.27-2.16)/2.16\times 100\%\approx 5.10\% \quad (1)$$

Similarly, we can find that the average accuracy in overall RD test, which is 89.03%, is higher than the average accuracy in NRD test, which equals to 77.44%. The percentage error between two accuracy is:

$$(\text{RD corr-NRD corr})/(\text{NRD corr})\times 100\%=(89.03\%-77.44\%)/(77.44\%)\times 100\%\approx 14.97\% \quad (2)$$

According to the data in table1, the histograms of the average reaction time and accuracy in RD test and NRD test (Figure2&3) in positive or negative mood are both graphed with data labels.

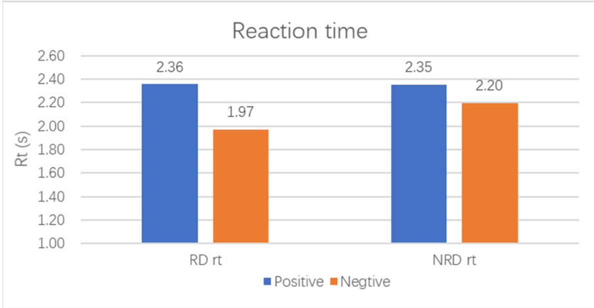

Figure 2. Average reaction time in two tests under positive/negative mood

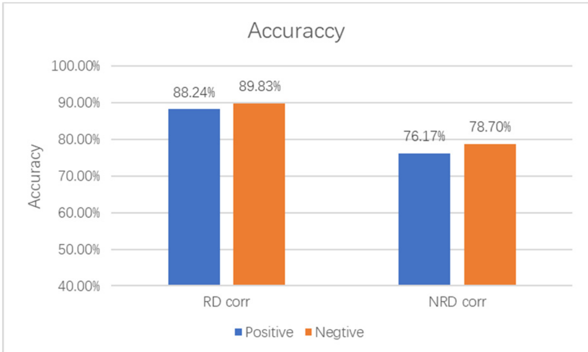

Figure 3. Average accuracy in two tests under positive/negative mood

We can obverse from the graph that the participants who are in a relatively negative mood take less time to react both in RD test (1.97s) and NRD test (2.20s) than the participants who are in a relatively positive mood do in RD test(2.36s) and NRD test(2.35s). And participants in relatively negative mood also get higher accuracy in both RD test(89.83%) and NRD test(78.70%) than the participants who are in a relatively positive mood get in RD test(88.24%) and NRD test(76.17%).

The percentage error of the performance in RD test under two mood condition is:

Percentage error of reaction time (RD):

$$(\text{positive RD rt-negative RD rt})/(\text{negative RD rt})\times 100\%=(2.36-1.97)/1.97\times 100\%\approx 19.80\% \quad (3)$$

Percentage error of accuracy (RD):

$$(\text{negative RD corr-positive RD corr})/(\text{positive RD corr})\times 100\%=(89.83\%-88.24\%)/(88.24\%)\times 100\%\approx 1.80\% \quad (4)$$

The percentage error of the performance in NRD test under two mood condition is:

Percentage error of reaction time (NRD):

$$(\text{positive NRD rt-negative NRD rt})/(\text{negative NRD rt}) \times 100\% = (2.35-2.20)/2.20 \times 100\% \approx 6.82\% \quad (5)$$

Percentage error of the accuracy (NRD):

$$(\text{negative NRD corr-positive NRD corr})/(\text{positive NRD corr}) \times 100\% = (78.70\%-76.17\%)/(76.17\%) \times 100\% \approx 3.32\% \quad (6)$$

4. DISCUSSION

The data indicates that participants overall response more quickly and correctly in RD test while they spend longer time to response and have lower accuracy in NRD test, which fits our first hypothesis. Regarding the mood impact, there isn't great difference in the factors of reaction time and accuracy. To elaborate the difference, when participants are in relatively negative moods, they take shorter reaction time and have higher accuracy in both RD test and NRD test than those in positive moods do, which contradicts our second hypothesis.

4.1 Comparison between previous and our study Procedure

The results were not consistent with other findings in the literature. In the study by Nadler et al. [1], where three mood-induction groups (positive, neutral and negative) were allocated and music was only played before the completion of task, it was found that positive mood enhances performance of the RD categorisation tasks while no relationship between a negative mood and RD categorisation tasks were found. However, what we have found is that there was no significant relationship between either positive or negative mood and the performance individuals had. The difference might have occurred due to the fact that, although the participants' mood was intended to last until the trials ended, their mood was not significantly impacted. However, we also found is that most participants did RD task better than NRD task, which is aligned with most of the findings in the literature.

4.2 Limitations and Improvements

There are a few things that could be improved in this experiment.

Mood condition

Firstly, although we give mood-inducing to participants before they start their tasks, it's hard to get them into a specific mood in such a short time. Secondly, it's unavoidable that the participants may gradually get out of their mood during the experiment as their attention on fully attracted by the stimuli. It would be better if we transfer the idea of guiding people to be happy or sad to finding two groups of people who are in a permanent positive mood or negative mood, for instance, people having high happiness index and people diagnosed with depression.

Background music

Firstly, the background music may produce inference to participants, as they may attract part of their attention thus lower their ability to categorise. Secondly, the interference of the background music under two mood condition may be different. The "happy" music has lyrics while the "sad" music doesn't, so the "sad" music may have less interference to participants. We can play the music for participants for about 15 minutes to get them used to the music, then start the experiment. And we should control the music for positive mood and negative mood to be both pure music without interference to unify and minimize the interference as much as possible.

Stimuli

Firstly, there are two images for the participants to observe and compare in the RD test, while there's only one image for the participants to look in the NRD test, leading to the possibility that the participants spend more time reacting to the stimuli in RD test. Secondly, the stimuli in RD test and NRD test are the same image (a circle with gratings). The participants may get used to it in the first test and utilize the experience in the second test. One possible improvement can be replacing the stimuli in RD test (two circles) with an ellipse and ask the participants to decide whether the length in horizontal direction or in vertical direction is larger. In this case, participants only need to watch one image and make comparison inside the image just like they do in NRD test.

4.3 Other findings

We have an interesting finding from the brief interview with participants. Three of them shared the same feeling that they were first confused about the NRD test, but later they found that there was a "rule" in it. The thickness of the circle mught function as a cue. They concluded a rule that the thick grating appears because the circle is relatively big and the number of the gratings is relatively small (Figure 4); in turn, the thin gratings indicate that the circle is relatively small, and the number of the gratings is relatively large. Then they made decision based on this rule.

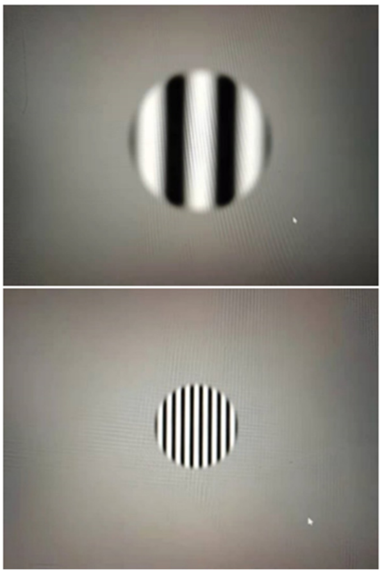

Figure 4. Cue of gratings

This finding is valuable because it indicates people's tendency to summarize a rule that can be described verbally when they find it difficult to categorise. That is, the RD rule can lower the difficulty of categorisation and allow the participants to have a better performance.

5. CONCLUSION

In conclusion, the form of categorisation tasks, in which the rule used can easily be verbalised or not, has a regular impact on people's performance. This is supported by the evidence that participants require less time and gain higher accuracy when they perform the RD categorisation task, compared to the NRD one.

Second, we have concluded that mood can influence people's performance in categorisation tasks. This paper found that participants perform better when they are in a negative mood, although the impact is relatively insignificant. This piece of finding is different from all the previous studies this article has referred to. Instead of a positive relationship between mood and cognitive flexibility, our study shows a negative relationship between the two. Perhaps this paper can arouse people's curiosity about this and guide latter studies to investigate the promotion effect of negative emotions on cognitive ability.

Based on our current study, a new area can be explored. People with a diagonosis of depression can be the targeted sample since they are persistently in a state of negative mood. Their performance in categorisation tasks can be compared with those of the non-clinical population to see which group of people have an advantage or disadvantage in cognitive flexibility. Moreover, the direct impact of music itself on people's cognitive flexibility is also worth studying. By changing the types of music, the interference of music on people's cognitive flexibility can be studied.

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