## Contextual goal-dependent attention flexibility or rule-based learning? An investigation of a new attention flexibility paradigm

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# Highlights

- Contextual changes exacerbate attention biases towards valence-specific goals

- Attention flexibility task is a novel paradigm to test context-based flexibility

- We tested the impact of rule-based learning on attention switching in this paradigm

- No effect of rule-based learning on attention switching capacities in the paradigm

- Evidence of general switch costs in the paradigm when set-shifting between rules

**Abstract**

**Background & Objectives**: Deficits in the ability to process contextual changes have been proposed to be crucial for emotion dysregulation. A recent study found evidence for the role of contextual changes in exacerbating attention switching towards valence-specific goals using a novel attention flexibility paradigm. Despite the task indicating good reliability, the role of rule-based learning has not been clarified in this paradigm. Therefore, we examined whether the novel attention flexibility task is an index of context-based attention switching or reflects impact of rule-based learning on attention.

**Method**: We employed a neutral version of the attention flexibility task. A sample of dysphoric and non-dysphoric participants were introduced to neutral contexts which required them to shift between neutral categories of pictures depending upon the cueing shape.

**Results**: There was an existence of a switch cost for shifting between different rules owing to the features of the rules. Further, non-dysphorics were faster at set-shifting between different rules as compared to dysphoric individuals. However, unlike in the affective version of the attention flexibility task, we found no significant differences between dysphoric and non-dysphoric individuals in attention switching patterns owing to switching between different rules.

**Limitations**: Although the current study aimed to replicate the design of the previous study, a depressed patient sample must be employed to further clarify the different aspects of the attention flexibility paradigm.

**Conclusion**: Our findings were able to clarify the non-existent role of rule-based learning in the attention flexibility paradigm.

## 1. Introduction

Difficulty in processing of contextual information and changes in context are posited to be important hallmarks of depressive states (Rottenberg, 2007). Considerable empirical evidence has supported this emotion context insensitivity theory, that depressed individuals have deficits in the ability to process broader contextual changes (Aldao & Nolen-Hoeksema 2012; Coifman & Bonanno 2009; Feeser et al. 2013; Rottenberg & Vaughan 2008; Troy et al. 2013). For example, Ellis and colleagues (2009) showed that dysphoric individuals displayed similar attenuated emotional reactivity to feedback during a task when the feedback context changed from positive to negative or vice versa. This implies that depressed individuals are unable to process changes in the larger socio-emotional context within which they encounter emotional information, which leads to inability to disengage from emotional material from one context to next. For example, a depressed individual when walking on a dark street and then arriving at a party will show a similar attenuated emotional response to when leaving the party and walking home on a dark street. The change in the socio-emotional context is not processed in a similar manner as that of a non-depressed individual, who will show a more positive response when shifting from a negative to a positive context compared to vice versa (Ellis, Beevers, & Wells, 2009).

As such, recent models of depression have posited a catalytic role of deficits in the ability to process contextual changes in dysfunctional emotion regulation and cognitive processing (Aldao, 2013; Bonnano & Burton, 2013). In line with these models, in a recent study it has been found that contextual changes differentially impact attention switching towards emotional information in a sample of dysphoric versus non-dysphoric individuals (Godara, Sanchez-Lopez, Liefooghe, & De Raedt, 2020). Under conditions of changing

contexts, dysphoric individuals switched attention faster towards negative emotional faces, whereas non-dysphorics switched attention faster towards positive emotional faces. These findings provide initial evidence for a role of contextual changes in guiding executive attentional processes which are key to depression (Rock, Roiser, Riedel, & Blackwell, 2014; Snyder, 2013; Sommerfeldt et al., 2016).

Given the possible relevance of contextual changes on attention factors in depression, current measurement tasks need to be precise. In the study by Godara et al. (2020), a novel paradigm, the attention flexibility task, was used to measure attention switching under conditions of contextual change and repetition. Participants were introduced to different social contexts, which consisted of two goals each. For example, a party context consisted of the goal to enjoy the party or the goal to solve an argument with friends. In order to achieve these goals, participants had to attend to positive or negative emotional information respectively. The goal which had to be activated was indicated by an associated goal object, a blue square or blue circle. The object associated with a particular valenced goal differed depending upon the context. For example, in the party context, participants had to activate the negative goal upon seeing square and the positive goal upon seeing circle, whereas when context changed to a different scenario (i.e., a presentation scene), with new positive or negative goals (i.e., to remain confident and to solve doubts of the audience), a square indicated the activation of positive goal and a circle indicated the activation of negative goal.

Despite showing good reliability and consistent findings for context change-based attention effects, the role of rule-based learning processes in the paradigm remains unclear. It is possible that participants in the study of Godara et al. (2020) only learned to associate the picture of a context, shape, and valence to direct their attention accordingly. This would imply that participants might have ceased to process contextual factors and thus not deploy attention according to relevant goals over the course of the task, and instead simply used learned rules

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to guide their attention switching behavior. Context-dependent attention flexibility would require participants to consider both the current social context and the current context-dependent goal activated in order to deploy their attention to relevant emotional material. However, rule-based learning would allow participants to chunk combinations of stimuli pictures and shapes to deploy attention to rule-relevant stimuli. If participants are deploying attention to stimuli using constructed rules, they would be unable to deploy the goal-relevant attention because they have not processed the larger social situation and the situation-specific goals. As such, this would mean that the paradigm does not accurately measure the impact of contextual changes on attention, as intended. Therefore, we wanted to examine whether the attention flexibility task is accurately measuring the impact of contextual changes on attention switching or if the results may be merely an indication of rule-based learning.

In the current study, we adapted the attention flexibility task with neutral, i.e. non-social and non-emotional, stimuli to answer our question. Other than the change in the stimuli used in the task, the design of the study was kept identical to the study conducted by Godara et al. (2020). Also, in line with their methodology, we employed eye-tracking technology to implement the task. In contrast to regular reaction time tasks that require participants to press one of two buttons, eye-tracking allows for continuous and direct measure of eye movements and overt attention (Waechter et al. 2014). Whereas reaction time tasks tend to have poor psychometrics and only provide a proxy measure of covert attention, eye-tracking based tasks have been able to delineate stable biases in attention for emotional information (Armstrong and Olatunji 2012; Zvielli et al. 2016). Further, the study of Godara et al. employed a sample of both dysphoric and non-dysphoric individuals. Therefore, we decided to employ a sample of identical nature. This allowed us to investigate between-group differences, if any, in shifting between different rules and switching attention to rule-relevant neutral stimuli depending upon rule activated. Considerable research has shown that there is an existence of a

general switch cost when shifting between different mental sets (Monsell, 2003). As such, we expected that all participants would have a general switch cost associated with mental set-shifting between different rules (i.e., larger times to prepare to respond in switch trials compared to repeat trials). We expected this general switch cost in mental set-shifting (i.e., time to prepare to respond) to be higher in dysphoric individuals based on previous empirical findings in depression indicating greater inhibition and set-shifting difficulties compared to controls (De Lissnyder et al., 2012). However, in line with the proposal that context-based attention switch costs are not due to mere rule-based learning, we expected no differences in switching external attention towards rule-relevant neutral stimuli (non-social, non-emotional) between dysphoric and non-dysphoric individuals (i.e., actual switching attention behaviors toward learned rule-relevant stimuli in the external attention switching section of the task) owing to the non-valenced nature of stimuli used.

## 2. Method

### 2.1 Participants

Fifty-six individuals (48 females; $M_{age}$ = 22.25, $SD_{age}$ = 3.57, 18 – 34 years) took part in the study. We recruited participants from the Ghent University research participant pool ($N$= 134) based on their pre-screening scores on the Anhedonia Depression (AD)[1] subscale of the Mood and Anxiety Symptoms Questionnaire – D30 (MASQ – D30; Wardenaar et al., 2010). However, one participant was excluded at the data analysis stage due to low quality of eye-gaze data obtained on the task (<75% samples collected). Accordingly, 31 participants were included in the dysphoric group ($M_{high}$ = 33.29, $SD$ = 6.70), and 24 participants were

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[1] The AD subscale of MASQ-D30 is not a scale that exclusively measures Anhedonia, and gives a good assessment of dysphoric symptoms. The items in the AD subscale measure a variety of variables like optimism, feeling happy, feeling talkative, etc. The scale covers a variety of dysphoria symptoms in addition to some regular symptoms of anhedonia like not feeling pleasure.

part of the non-dysphoric group ($M_{low}$ = 20.63, $SD$ = 2.12), as measured at the time of testing[2]. The dysphoric group consisted of scores >= 25 on the AD subscale of MASQ – D30, and the non-dysphoric group consisted of individuals scoring <= 23. The Mini-International Neuropsychiatric Interview was used to confirm the absence of any mental disorder which the participants had not revealed, and which could otherwise interfere with our study. The sample size for the study was estimated using G-Power (Faul, Erdfelder, Lang, & Buchner, 2007), prior to data collection, based on a power of .95, an alpha of .05, an effect size ($f$= 0.6), within-between interaction, and correlation among repeated measures set at 0 (effect size based on Godara et al., 2020). The study was approved by the ethical committee of the Faculty of Psychology & Education Sciences at Ghent University. All participants provided informed consent and were compensated for their time (€10).

**2.2 Materials**

*2.2.1 Questionnaires.* Participants completed the Mood and Anxiety Symptoms Questionnaire – D30 (Wardenaar et al., 2010). The short adaptation of the self-report questionnaire consists of 30 items, out of which 10 items are depression-specific on the AD subscale. Participants had to respond to statements using a 5-point scale, wherein '1' was "Not at all" and '5' was "Extremely". The items on the AD subscale are reverse scored. MASQ – D30 has a Cronbach's alpha of .92 in young adults, and in our sample the internal consistency was .92 as well. Further, participants were also administered the Mini-International neuropsychiatric interview, which is a short, structured diagnostic interview (Sheehan et al., 1998).

*2.2.2 Apparatus.* We presented the stimuli on a 23-inch high screen which had a resolution of 1920 x 1080 pixels and luminance of 300 cd/m$^2$. The stimulus presentation was

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[2] Although 68 individuals were invited from the participant pool based on their scores on the questionnaire, only 56 agreed to take part in the study.

programmed using E-prime Professional 2.0. Participants were seated at a distance of 59 – 65 cm from the screen. Eye movements were tracked using Tobii TX 300 eye tracker, at a sampling rate of 300 Hz (binocular). Tobii Studio was used to map eye movement patterns on to the stimulus presentation, in order to extract reaction time attention indices towards stimuli.

*2.2.3 Pictures.* Two neutral context images were obtained which consisted of nature scenes (flat lands, and mountains), without humans in the picture[3]. Twenty pictures each for two neutral categories, kitchen supplies and office supplies, were also obtained. These pictures displayed an instrument, used in a kitchen or an office setting, on a white background. All pictures were obtained from Google Images by filtering the search results according to usage rights. We used pictures marked "Labeled for reuse" and "Labeled for noncommercial reuse".

**2.3 Attention Flexibility Task**

*2.3.1 Task.* Participants were introduced to information about four different rules as presented in Table 1. Depending upon the rule presented, i.e. context and the shape combination, participants were directed to attend to pictures of either kitchen supplies or office supplies. Two shapes, square and circle, were used in the task. Depending upon the context picture, the shape changed meaning. Thus, when presented with the flat lands context, square indicated that participants had to look towards pictures of kitchen supplies, but

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[3] In order to evaluate the neutrality of the context pictures, we conducted a separate validation study with 43 participants (36 females, Mage = 28.41, SDage = 7.59, 18-45 years), who did not take part in the main study. In this validation study, we intermixed the context pictures with neutral filler pictures (neutral valence, low arousal) from the Open Affective Standardized Images Set (OASIS; Kurdi, Lozano, & Banaji, 2017). In comparison to the neutral filler pictures (M = 4.17, SD = .99), we found that the first context picture (flat lands, M = 4.39, SD = 2.77) was not significantly different based on valence, t(42) = .47, p = .32, dav = .12 . Furthermore, when comparing arousal created by the first context picture (M = 3.60, SD = 2.08) with the neutral fillers pictures (M = 3.77, SD = 1.06), we found no significant differences, t(42) = .48, p = .32, dav = .11. In comparison to the neutral filler pictures, we found that the second context picture (mountain, M = 4.53, SD = 2.74) was not significantly different based on valence, t(42) = .81, p = .21, dav = .19. Lastly, in comparison to the neutral filler pictures based on arousal created, we found that the second context picture (M = 3.63, SD = 2.63) was not significantly different, t(42) = .34, p = .37, dav = .08. Therefore, it can be said that both the context pictures can be perceived as neutral and non-arousing in nature.

presented with the mountains context, the square denoted attention towards pictures of office

supplies. By contrast, when presented with the flat lands context, circle indicated that

participants had to look towards pictures of office supplies, but presented with the mountains

context, the circle denoted attention towards pictures of kitchen supplies.

| Context | Shape | Look at… |
|---------|-------|----------|
|  | ■ | Kitchen supplies (pots, pans, cutlery, etc.) |
| | ● | Office supplies (pen, pencil, stapler, etc.) |
|  | ● | Kitchen supplies (pots, pans, cutlery, etc.) |
| | ■ | Office supplies (pen, pencil, stapler, etc.) |

Table 1: Neutral rules presented to the participants. The combination of context, shape and which category of pictures to look at formed the rules.

The four rules were then presented in the form of a reaction time task, similar to the

original affective attention flexibility tasks trials (Godara et al., 2020). Each trial began with

an 8mm high white fixation cross in the center of a black screen (see Figure 1 for trial

sequence). After 500ms, the cross was replaced by a single context image (flat land or

mountains:1024 x 682) with a shape on top if it (square or circle; 100 x 100), in the center of

the screen. Participants had to fixate their eye-gaze on the center of the shape for 100ms

before a text appeared at the bottom of the screen "Press Spacebar for pictures". At this point in the trial, participants could take as much time as they needed to recall the correct response (i.e., look towards pictures of kitchen or office supplies) according to the combination of context image and shape presented on the screen. Upon pressing the spacebar, 8 pictures (4 kitchen and 4 office supplies) were presented around a fixation cross for 3000ms. Participants had to direct their eye gaze, as quickly as possible, to the correct category of stimuli (i.e., kitchen or office) based on the rule activated. Each trial ended after the 8 pictures were presented for 3000ms. Participants performed 64 trials of such nature. The trials were presented in a pseudo-randomized manner, such that participants performed equal number of "repeat" (i.e., the shape and/or context was the same as in the previous trial) and "switch" trials (i.e. the shape and/or context was different to the one in the previous trial) for all four of the rules. We had 8 trials each for the following combinations: repeat context-repeat shape (look at kitchen supplies), repeat context-repeat shape (look at office supplies), repeat context-switch shape (look at kitchen supplies), repeat context-switch shape (look at office supplies), switch context-repeat shape (look at kitchen supplies), switch context-repeat shape (look at office supplies), switch context-switch shape (look at kitchen supplies), switch context-switch shape (look at office supplies).
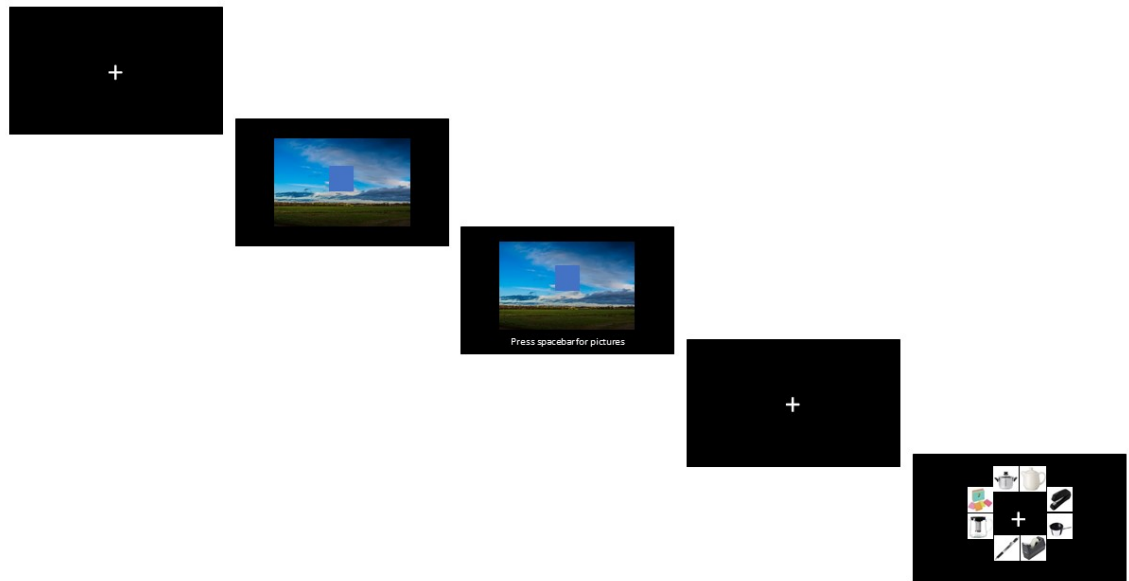
Figure 1: A trial sequence in the attention flexibility task.

*2.3.2 Dependent variables.* We obtained 2 dependent variables from the attention

flexibility task. First, using Tobii Studio, we obtained the attention switching index, "first

fixation to rule-relevant category" attention index from the eye-tracking data. Mean time to

make a first fixation, i.e. how quickly participants looked towards the pictures of correct

category after the images had been presented on the screen, were obtained for all 64 trials.

This index allowed us to evaluate the ability of participants to switch their attention between

different contexts, shapes, and rules. Based on the first fixation times, we calculated 8

switching variables based on the combinations described in the previous paragraph. Second,

we also assessed how quickly participants were able to set-shift between the different rules.

The attention switching index provided information on how quickly participants were able to

deploy attention to the rule-relevant stimuli. However, it is also necessary to assess how

quickly participants were able to internally shift between the different sets of rules. This will

provide a view into whether there are differences between the dysphoric and non-dysphoric

groups in their ability to switch between the rules themselves and not just rule-relevant external deployment of attention. Therefore, we obtained a "set-shifting index" measure based on the time it took participants to press the spacebar for stimuli. For each trial, we obtained the total presentation time of context picture and shape, as measured from the beginning of the context and shape presentation until the moment that participants pressed the spacebar to indicate end of preparation. The set-shifting measure also had 8 indices according to the combinations described for first fixation indices in the previous paragraph.

*2.3.3 Practice phase and knowledge check.* Prior to performing the task trials, participants went through a short practice phase. First, participants were introduced to the rules and given time to memorize the information. Next, participants then practiced their knowledge of the contexts, shapes, and associated response towards images of the two neutral pictures categories. During the practice trials, participants were presented with a picture of a context with a shape on top of it. Using one of two buttons, participants had to indicate whether they had to attend to pictures of the kitchen or office supplies category depending upon the context-shape combination presented. All 4 context-shapes combinations were presented 3 times each during the practice phase. Further, in order to verify the retention of the rules, participants then underwent a knowledge check procedure, wherein they had to write down the rules according to the context-shape combinations. Participants had to correctly identify at least 75% of the context-shape combinations presented. If they scored below 75%, they had to redo the practice phase and undergo the knowledge procedure again. Participants performed the knowledge check procedure both pre- and post-task, i.e. main trials, to ascertain recollection of rules throughout the main trials.

**2.4 Procedure**

All participants provided informed consent. First, we administered the MINI psychiatric interview to all participants, and no participants were removed based on the results

from this interview. Next, participants completed the questionnaires, followed by an eye-tracker calibration procedure. Upon calibration, they were introduced to the rules to be used during the task, which was followed by the practice phase and pre-task knowledge check procedure. Then, the participants performed the 64 experimental trials, and finally, completed the post-task knowledge check. At the end, we debriefed the participants about the purpose of the study, and compensated them for participation.

## 3. Results

*Set-shifting index*. Using the 8 set-shifting reaction time indices, we conducted a 2 (Context Switch) x 2 (Shape Switch) x 2 (Category Type) x 2 (Group) mixed measures ANOVA. We did not find any significant 4-way interaction, $F(1, 53) = .08$, $p = .77$, $\eta_p^2 = .002$. However, we found a significant main effect of Context Switch, $F(1, 53) = 50.42$, $p < .001$, $\eta_p^2 = .49$, and Shape Switch, $F(1, 53) = 63.27$, $p < .001$, $\eta_p^2 = .54$. This indicates that all individuals found it more difficult to set-shift between rules when the context switched versus repeated. Similarly, the results also indicate that all individuals were faster in set-shifting between rules when the shape repeated versus when it switched. Further, we also found a significant main effect for Group, $F(1, 53) = 11.54$, $p = .001$, $\eta_p^2 = .18$, which indicates that dysphorics had slower reaction times when set-shifting compared to non-dysphoric individuals. None of the other main or interaction effects reached significance (all $F$s < 3.77, all $p$s > .05, all $\eta_p^2 < .066$). Conducting a Bayesian repeated measures ANOVA, we were able to confirm lack of evidence for a 4-way interaction effect (BF$_{inclusion}$ < .01). Replicating our frequentist analysis, we found very strong to strong evidence supporting the main effects of Context Switch (BF$_{inclusion}$ = 30.46), and Shape Switch (BF$_{inclusion}$ = 18.14). We also found substantial evidence supporting the main effect of Group (BF$_{inclusion}$ = 4.17). These results suggest that all individuals were slower in set-shifting between rules when context and shape

switched versus when they repeated from the previous trial. Further, dysphoric, compared to non-dysphoric, individuals were slower overall in set-shifting between rules regardless of changes in context and shape (see Figure 2).
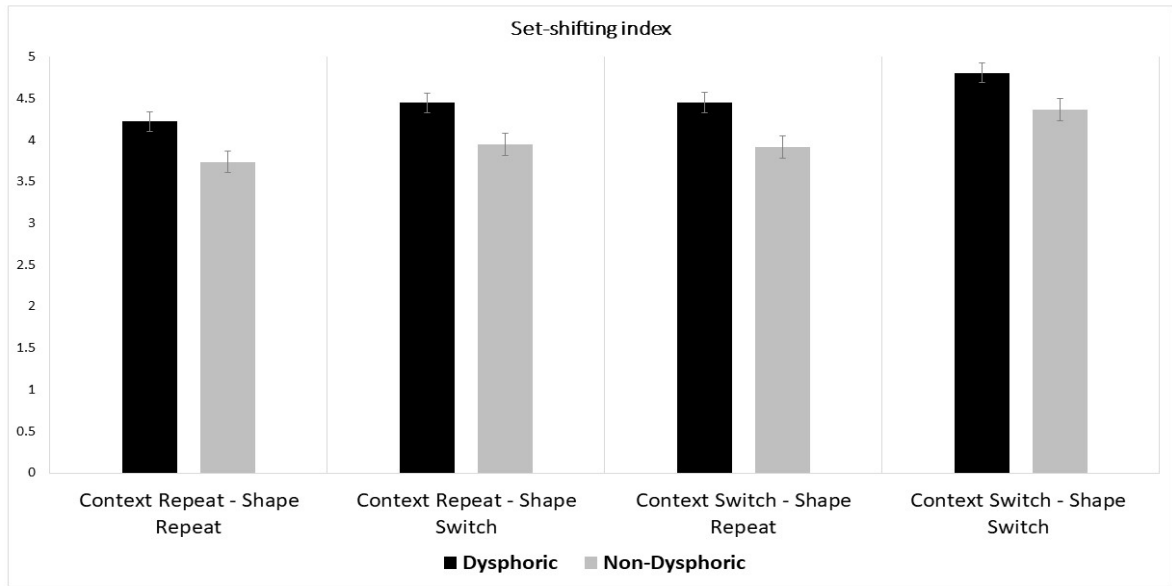


Figure 2. Reaction times (i.e., time to press spacebar) are presented for both dysphoric and non-dysphoric participants for the four different conditions, combinations of context switch (repeat vs. switch context) and shape switch (repeat vs. switch shape). Times are presented in seconds (along the y-axis). Error bars represent standard error.

*Attention switching index*. Using the first fixation attention switching indices as dependent variable, we also conducted a 2 (Context Switch) x 2 (Shape Switch) x 2 (Category Type) x 2 (Group) mixed measures ANOVA. Context Switch (repeat vs. switch context), Shape Switch (repeat vs. switch shape), and Category Type (kitchen supplies vs. office supplies) were the within-subjects factors. Group, i.e. dysphorics vs. non-dysphorics, served as the between-groups factor. We found no significant main effects for Context Switch, $F(1, 53) = .72$, $p = .79$, $\eta_p^2 = .001$, for Shape Switch, $F(1, 53) = .48$, $p = .49$, $\eta_p^2 = .009$, for Category Type, $F(1, 53) = .012$, $p = .91$, $\eta_p^2 = .0002$, or for Group, $F(1, 53) = .0002$, $p = .99$,

$\eta_p{}^2 < .001$. Further, we found no significant 4-way interaction, $F(1, 53) = .29$, $p = .59$, $\eta_p{}^2$ $= .006$. Lastly, there were no significant 2-way or 3-way interactions as well (all $F$s < 3.76, all $p$s > .05, all $\eta_p{}^2 < .06$). In order to clarify this pattern of results, we conducted a 2 (Context Switch) x 2 (Shape Switch) x 2 (Category Type) x 2 (Group) Bayesian repeated measures ANOVA. We found very strong evidence against main effects of Context Switch ($BF_{inclusion} = .021$), Shape Switch ($BF_{inclusion} = .018$), Category Type ($BF_{inclusion} = .02$), and Group ($BF_{inclusion} = .029$)[4]. Similarly, we also found substantial evidence against the 4-way interaction between Context Switch, Shape Switch, Category Type, and Group ($BF_{inclusion} = .32$). These results suggest that there were no significant differences in first fixations towards rule-relevant category between the two groups. Further, there were no differences in first fixations depending upon switches in context, shape or stimulus category. Overall, in line with our main hypothesis, these results indicate a lack of any difference in how quickly participants in the two groups directed their attention to rule-relevant category of stimuli, and this attention was not influenced by changes in neutral contexts, cue shapes, or neutral stimulus category.

## 4. Discussion

In the current study we wanted to examine whether the attention flexibility paradigm (Godara et al., 2020), which has recently being used to show context-based affective attention switching differences between dysphoric and non-dysphoric individuals, is a precise measure of context based attention switching, as intended, or does it reflect the possible influence of mere rule-based learning on attention. We found that using neutral instead of affective goals and stimuli, switching between different neutral rules did not have any influence on attention

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[4] We used $BF_{inclusion}$, which is the inclusion Bayes factor (Baws factor), and gives the extent to which the data support inclusion of a particular independent variable, taking all models into account. It can be interpreted similar to BF10. Baws factor is recommended when comparing complex interaction models in within-between repeated measures designs.

switching patterns in both dysphoric and non-dysphoric individuals. However, we did find the existence of a switch cost when set-shifting between different rules owing to changes in features of the rules. We also found significant differences between the two groups in set-shifting between two rules. Specifically, we found that that dysphoric individuals were slower in set-shifting between different rules than non-dysphoric individuals.

These findings have two-fold ramifications. First, our null findings for the attention switching indices (i.e., performance in the main attention task) indicate that the attention flexibility paradigm is not merely influenced by rule-based learning. In line with our expectations, we found that there were no significant differences between dysphoric and non-dysphoric individuals in directing attention to rule-relevant neutral stimuli when switching between different rules. In contrast, in the study by Godara and colleagues (2020), using an affective version of the task comprising emotional goals and stimuli, significant differences were present between dysphoric and non-dysphoric owing to context-dependent goal-directed attention switching towards emotional information. This effect was valence-specific, and found to be magnified in conditions of context switching. However, in the current study we found no such effect dependent on shifting between different contexts. Second, concurrent with our expectations, in the current study we found that there were significant differences in set-shifting between different rules related to changes in the features of the rules for all individuals. Namely, during preparation to start the actual attention task in each trial, individuals took longer to prepare to respond when the rule was different to the one in the precedent trial than when the rule was similar to the one from the previous trial. This is in line with considerable previous research on task-switching which has demonstrated that shifting between different mental sets or rules leads to a switch cost (Miyake et al., 2000; Monsell, 2003). Further, we found that switch costs in set-shifting between different rules were greater for dysphoric versus non-dysphoric individuals. These results are also in line with previous

empirical findings indicating that individuals in depressogenic states have dysfunctional

executive control processes compared to healthy controls (De Lissnyder et al., 2012; Hsu et

al., 2015). As such, our findings suggest that although the attention flexibility paradigm is

able to effectively index set-shifting processes even when using neutral, non-social,

unemotional stimuli, there is no influence of such set-shifting costs on attention switching

capacities when using neutral stimuli in the actual attention flexibility task. This is markedly

different from the findings of Godara et al. (2020), wherein valence-specific effects were

observed on attention switching capacities of dysphoric and non-dysphoric individuals in the

affective attention flexibility task. In that former study, it could be concluded that the

paradigm measures attention flexibility towards emotional stimuli as a function of context-

dependent valenced goals. Results of the current study allow the inference that all individuals

are able to switch towards rule-relevant neutral stimuli with equal ease in the attention

flexibility paradigm. This allows for the conclusion that valence context-based effects found

by Godara et al. (2020) can be disentangled from general set-shifting costs and are not due to

mere rule-based learning.

Despite the importance of the current investigation to clarifying the attention

flexibility paradigm, some limitations and future directions must be discussed. First, future

replication studies are needed to further clarify the impact of contextual changes on the ability

to flexibly shift attention between affective material. Future studies could apply both the

original affective version of the attention flexibility task along with the neutral version applied

in the current study in same samples of dysphoric and non-dysphoric or depressed versus non-

depressed samples. This would allow for direct comparisons between different context and

goal switching conditions. Further, a key limitation pertains to socio-demographic factors of

the nature of the sample. The current study was conducted in a student sample in order to

replicate the design of the study of Godara et al (2020). However, the use of a student sample

does not allow any conclusions relating to the applicability of our findings in a socio-demographically diverse sample. As such, future studies must replicate the current investigation in a more diverse, community sample to evaluate whether rule-based learning plays a role in the attention flexibility paradigm in different populations. Moreover, since the attention flexibility task is a novel paradigm with transdiagnostic mechanistic relevance, the present study should also be replicated in clinical populations. It is still possible that depressed and anxious patients might employ rule-based learning in the affective attention flexibility paradigm, leading to greater errors in deployment of attention towards goal-relevant affective stimuli. Therefore, performance on the neutral attention flexibility task, presented in the current study, might provide clarification regarding these attention patterns in clinical samples

**5. Conclusion**

In conclusion, we examined the role of rule-based learning in guiding attention switching in the new attention flexibility paradigm. Our findings, in combination with the findings of Godara et al. (2020) provide evidence for the key role of processing contextual changes on attention flexibility indices in the paradigm, which are valence-specific and not function a of rule-based attention switching. Overall, we were able to clarify the precise processes guiding, or in the present case not influencing, attention switching in this novel paradigm.

**Author statement**

All authors conceptualized the study. Author 1 collected the data. Author 1 programmed the study and analyzed the data with assistance from author 2. All the authors interpreted the findings. All authors contributed to the writing of the manuscript and further revision of drafts.

## References

Aldao, A. (2013) The future of emotion regulation research: Capturing context. *Perspectives on Psychological Science, 8*, 155–72. doi: 10.1177/1745691612459518

Aldao, A., & Nolen-Hoeksema, S. (2012). The influence of context on the implementation of adaptive emotion regulation strategies. *Behaviour Research and Therapy, 50*, 493–501. doi : 10.1016/j.brat.2012.04.004.

Armstrong, T., & Olatunji, B. O. (2012). Eye tracking of attention in the affective disorders: A meta-analytic review and synthesis. *Clinical Psychology Review, 32*, 704–723. doi: 10.1016/j.cpr.2012.09.004.

Bonanno, G. A., & Burton, C. L. (2013). Regulatory flexibility: An individual differences perspective on coping and emotion regulation. *Perspectives on Psychological Science*, 8, 591-612. doi: 10.1177/1745691613504116.

Coifman, K. G., & Bonanno, G. A. (2009). Emotion context sensitivity in adaptation and recovery. In A. M. Kring & D. M. Sloan (Eds.), *Emotion regulation and psychopathology: A transdiagnostic approach to etiology & treatment* (pp. 157–173). New York: Guilford.

De Lissnyder, E., Koster, E. H., Everaert, J., Schacht, R., Van den Abeele, D., & De Raedt, R. (2012). Internal cognitive control in clinical depression: General but no emotion-specific impairments. *Psychiatry Research, 199,* 124-130. doi: 10.1016/j.psychres.2012.04.019

Ellis, A. J., Beevers, C. G., & Wells, T. T. (2009). Emotional dysregulation in dysphoria: Support for emotion context insensitivity in response to performance-based feedback. *Journal of Behavior Therapy and Experimental Psychiatry, 40*, 443-454. doi: 10.1016/j.jbtep.2009.05.002

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175-191. doi:10.3758/BF03193146

Feeser, M., Schlagenhauf, F., Sterzer, P., Park, S., Stoy, M., Gutwinski, S., … Ströhle, A. (2013). Context insensitivity during positive and negative emotional expectancy in depression assessed with functional magnetic resonance imaging. *Psychiatry Research: Neuroimaging, 212*, 28–35. doi: 10.1016/j.pscychresns.2012.11.010.

Godara, M., Sanchez-Lopez, A., Liefooghe, B., & De Raedt, R. (2020). Contextual changes influence attention flexibility towards new goals. *Cognitive Therapy and Research*, *44*, 327-344. doi: 10.1007/s10608-019-10072-5

Hsu, K. J., Beard, C., Rifkin, L., Dillon, D. G., Pizzagalli, D. A., & Björgvinsson, T. (2015). Transdiagnostic mechanisms in depression and anxiety: The role of rumination and attentional control. *Journal of Affective Disorders, 188*, 22-27. doi: 10.1016/j.jad.2015.08.008

Kurdi, B., Lozano, S., & Banaji, M. R. (2017). Introducing the open affective standardized image set (OASIS). *Behavior Research Methods, 49*, 457-470. doi: 10.3758/s13428-016-0715-3

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49-100. doi: 10.1006/cogp.1999.0734

Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences, 7*, 134-140. doi: 10.1016/S1364-6613(03)00028-7

Rock, P. L., Roiser, J. P., Riedel, W. J., & Blackwell, A. D. (2014). Cognitive impairment in depression: a systematic review and meta-analysis. *Psychological Medicine, 44*, 2029-2040. Doi: 10.1017/S0033291713002535

Rottenberg, J. (2007). Major Depressive Disorder: Emerging Evidence for Emotion Context Insensitivity. In J. Rottenberg & S. L. Johnson (Eds.), *Emotion and psychopathology: Bridging affective and clinical science* (pp. 151-165). Washington, DC, US: American Psychological Association. doi: 10.1037/11562-007

Rottenberg, J., & Vaughan, C. (2008). Emotion expression in depression: Emerging evidence for emotion context-insensitivity. In *Emotion regulation* (pp. 125–139). Springer, Boston, MA.

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janvas, J., Weiller, E., …, & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (MINI): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *Journal of Clinical Psychiatry, 59*, 22-33.

Snyder, H. R. (2013). Major depressive disorder is associated with broad impairments on neuropsychological measures of executive function: a meta-analysis and review. *Psychological Bulletin, 139*, 81. Doi: 10.1037/a0028727

Sommerfeldt, S. L., Cullen, K. R., Han, G., Fryza, B. J., Houri, A. K., & Klimes-Dougan, B. (2016). Executive attention impairment in adolescents with major depressive disorder. *Journal of Clinical Child & Adolescent Psychology, 45*, 69-83. Doi: 10.1080/15374416.2015.1072823

Troy, A. S., Shallcross, A. J., & Mauss, I. B. (2013). A person-by-situation approach to emotion regulation: Cognitive reappraisal can either help or hurt, depending on the context. *Psychological Science, 24*, 2505–2514. doi: 10.1177/0956797613496434.

Waechter, S., Nelson, A. L., Wright, C., Hyatt, A., & Oakman, J. (2014). Measuring attentional bias to threat: Reliability of dot probe and eye movement indices. *Cognitive Therapy and Research, 38*, 313–333. doi: 10.1007/s10608-013-9588-2.

Wardenaar, K. J., van Veen, T., Giltay, E. J., de Beurs, E., Penninx, B. W., & Zitman, F. G. (2010). Development and validation of a 30-item short adaptation of the Mood and Anxiety Symptoms Questionnaire (MASQ). *Psychiatry Research*, *179*, 101-106. doi: 10.1016/j.psychres.2009.03.005

Zvielli, A., Vrijsen, J. N., Koster, E. H. W., & Bernstein, A. (2016). Attentional bias temporal dynamics in remitted depression. *Journal of Abnormal Psychology, 125*, 768–776. doi: 10.1037/abn0000190.

Table 1. Mean and standard deviations for the set-shifting index (in seconds) for all the 8 switching conditions for both dysphoric and non-dysphoric participants.

| Condition | Group | Mean (*SD*) |
|---|---|---|
| Context Repeat – Shape Repeat (Category – Kitchen supplies) | Dysphoric | 4.2 (*0.58*) |
| | Non-Dysphoric | 3.7 (*0.36*) |
| Context Repeat – Shape Repeat (Category – Office supplies) | Dysphoric | 4.2 (*0.62*) |
| | Non-Dysphoric | 3.8 (*0.46*) |
| Context Repeat – Shape Switch (Category – Kitchen supplies) | Dysphoric | 4.4 (*0.80*) |
| | Non-Dysphoric | 3.9 (*0.43*) |
| Context Repeat – Shape Switch (Category – Office supplies) | Dysphoric | 4.5 (*0.75*) |
| | Non-Dysphoric | 4.0 (*0.43*) |
| Context Switch – Shape Repeat (Category – Kitchen supplies) | Dysphoric | 4.5 (*0.74*) |
| | Non-Dysphoric | 3.9 (*0.45*) |
| Context Switch – Shape Repeat (Category – Office supplies) | Dysphoric | 4.4 (*0.82*) |
| | Non-Dysphoric | 3.9 (*0.50*) |
| Context Switch – Shape Switch (Category – Kitchen supplies) | Dysphoric | 4.8 (*0.63*) |
| | Non-Dysphoric | 4.4 (*0.73*) |
| Context Switch – Shape Switch (Category – Office supplies) | Dysphoric | 4.8 (*0.52*) |
| | Non-Dysphoric | 4.4 (*0.75*) |

Table 2. Mean and standard deviations for the attention switching index for all the 8 switching conditions for both dysphoric and non-dysphoric participants.

| Condition | Group | Mean (*SD*) |
|---|---|---|
| Context Repeat – Shape Repeat (Category – Kitchen supplies) | Dysphoric | 0.58 (*0.18*) |
| | Non-Dysphoric | 0.58 (*0.22*) |
| Context Repeat – Shape Repeat (Category – Office supplies) | Dysphoric | 0.59 (*0.20*) |
| | Non-Dysphoric | 0.70 (*0.27*) |
| Context Repeat – Shape Switch (Category – Kitchen supplies) | Dysphoric | 0.61 (*0.18*) |
| | Non-Dysphoric | 0.59 (*0.16*) |

| | | |
|---|---|---|
| Context Repeat – Shape Switch (Category – Office supplies) | Dysphoric | 0.55 (*0.18*) |
| | Non-Dysphoric | 0.62 (*0.19*) |
| Context Switch – Shape Repeat (Category – Kitchen supplies) | Dysphoric | 0.66 (*0.23*) |
| | Non-Dysphoric | 0.56 (*0.21*) |
| Context Switch – Shape Repeat (Category – Office supplies) | Dysphoric | 0.60 (*0.16*) |
| | Non-Dysphoric | 0.61 (*0.20*) |
| Context Switch – Shape Switch (Category – Kitchen supplies) | Dysphoric | 0.65 (*0.20*) |
| | Non-Dysphoric | 0.61 (*0.20*) |
| Context Switch – Shape Switch (Category – Office supplies) | Dysphoric | 0.60 (*0.23*) |
| | Non-Dysphoric | 0.57 (*0.23*) |