How do we strategically balance our thought between a current task and a future task?

Bachelor's project Thesis

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Abstract

We investigated how our cognitive processes balance their workload between a current task and a future task. Previous research gave evidence to the idea that people modulate there thought processes in accordance with their expectations for a task demand. In this research 24 participants performed two consecutive computer tasks. During the second task the participants had to decide based on a set of instructions. During the first task participants had to judge whether displayed digits were odd or even. In between these digits inter-stimulus intervals were present, these inter stimulus intervals had a variable duration. In the first task the instruction for the second task could be requested. We hypothesized that with a higher inter-stimulus interval the participant would request instruction for the second task more frequently than in case of a lower inter-stimulus interval. The results from this experiment showed that participants did not request at random moments in time, but mostly at the start of the task. A change in moment of request was not found for different inter-stimulus interval duration.

Keywords: decision making, time-dependency, cognitive science, RITL, self-generated thoughts, mind wandering.

Introduction

This research is about finding out when people start acting on future tasks. During the day, life often demands us to balance our thoughts between various tasks. People tend to have thoughts about future goals and tasks while still being in the middle of another (current) task. For example, making a shopping list while playing a video game. By making a shopping list people will do their groceries faster while their video game performance deteriorates less than the benefits. This is because people try to optimally distribute their resources on the basis of their experience with each task (Seli et al., 2018) By reasoning that resources are better distributed by doing groceries faster and thereby losing some performance in the video game people make decisions. But all the processes involved in these current and future tasks are competing for attention and working power. In this study we aim to provide more insight in when people decide to focus on future goals.

Many studies herein have looked at self-generated thought. Self-generated thoughts are characterized by being independent from external stimuli. These are thoughts such as planning or rehearsing past experiences. Self-generated thought can be formed with intention and without intention. The self-generated that happen with intent are the subject of our current study.

These self-generated thoughts have been found useful in solving creative problems. By engaging in an undemanding task people will improve performance on a previous encountered task. This is because undemanding tasks maximize mind wandering (Baird et al., 2012) This improvement in performance on a future and previous encountered task shows that self-generated thoughts serve an adaptive purpose. With their research, Baird et al. (2012) furthermore show that working memory load is the key aspect that explains the amount of mind-wandering.

These self-generated thoughts have been researched multiple times. Some focus on difficulty of the task (Baird et al., 2012) other focus on the mood of participants (Smallwood & O'Connor, 2011). And other such as Andrews-Hanna, Smallwood, & Spreng (2014) focus on the context and content in which self-generated thoughts fall. They found for many people with disorders it is hard to regulate self-generated thoughts, this was because of the difficulty these persons had with shifting between various types of self-generated thoughts.

In these researches the self-generated thoughts have adaptiveness in that it the thoughts can differ in intention. For example in experiment by Smallwood & O'Connor (2011) participant could indicate whether their self-generated thoughts were about something in the future or in the past. In the current research the scope of adaptiveness will be reduced.

In this research we will intent to provide a better understanding of the effect of pacing on self-generated and the moment of occurrence of self-generated thoughts that are goal related.

Seli et al., (2018) have shown is that participants modulate their mind wandering in accordance with their expectations for a task demand. In their research the time on a clock was used as a dependent variable. Participants only had to press a button when the minute timer hit 0. This showed an increase in mind wandering during the period after the clock had just hit the 0 and a button press was performed. This thus indicates that when participants expect a workload, they will mind wander according to that workload. In the current research we focus on modulating the moment of planning with task demand. Participant do not know about an expected

workload. Although this workload will vary according to certain rules.
Participant can learn to find out how the workload will be. This is called trial and error-based learning. This in contrast to instruction-based learning, used in the research by Seli et al. (2018).

To test whether pacing has an influence on these self-generated thoughts we will use two tasks. One task to measure the moment of planning and one task on which planning could be performed. The first of the two tasks is the choice reaction time task (CRT). With a CRT task alertness and motor speed can be tested. In this experiment we will be measuring when the CRT task gets interrupted by the participants for the instruction for the subsequent task. Within the CRT task we will be varying the intervals between stimuli. By doing this we can hen the CRT task has varying times to click the right response. By adjusting the pacing for every trial, we are therefore able to change the workload that someone experiences. With this we can then find out whether this workload will influence the self-generated thoughts and its decision process.

The second task is based on the rapid instructed task learning (RITL) paradigm. Which is the ability to rapidly reconfigure our minds to perform new tasks from instruction (Cole, Laurent, & Stocco, 2013). As a RITL task depends on instruction it is suitable to use as second task for which instruction can be requested during the first task. Next to the results in the RITL task will indicate whether planning during the first task is beneficial in speed and accuracy.

The measurement is in the form of number of correct answers in both tasks and their accuracy. The research question therefore is: Does the decision between focusing on the current task and focusing on a future task change if the intervals between the current tasks get smaller/bigger? The hypothesis is that with a greater interval the decision to focus on a future task becomes bigger.

Method

Participants

In total 24 participants (11 female, 13 male), the age of the participants varied between 20 and 27 years, with an average age of 22.4 years. All of them were students of university of Groningen or Hanze university of applied science. All participants were native Dutch. All participants received the same instruction and performed the experiment under similar conditions. The participants received a compensation of €10 after finishing the experiment.

Experimental Design

The experiment consisted of two tasks. In task 1 participants performed a choice reaction time task (CRT; Smallwood et al., 2011). While in task 2 the participants perform rapid instructed task learning (RITL) task (Cole et al., 2018)

CRT

In the CRT task the stimulus was in the form of a digit between one and nine, which were alternated with a fixation: +. In total there were 11 stimuli in every trial. These digits were either black colored (non-targets) or red colored (targets), the participants only had to respond to red colored digits. These distribution of targets versus non-targets was completely random, such that the participants did not know whether a target or non-target was upcoming. For targets that were even participants had to press the “M” button while for odd targets the “N’’ key had to be pressed. The stimuli were displayed for 1000ms each. While doing this task the fixation time changed. There were four curves in which the fixation time changed (Figure 1): With sinusoidal curves the trial starts with the lowest or highest inter stimulus interval and going up or down in interval. In the sinusoidal curves the fixation time went down or up through the 11 stimuli in the parabola the lowest/biggest fixation time is in the middle. The fixation times were between 0.5 and 2 seconds. The average was 1.25 seconds for the sinusoidal trials (Figure 1a&b). And respectively 0.8 and 1.7 seconds for the trials with the parabola curve (Figure 1c&d), the average of these two trials together was again 1.25 seconds. These different fixation time curves were randomly selected for every trial with every curve equally recurring. This was chosen with the reasoning that participants will not be able to strategically decide to start planning for the RITL task if they knew what curve would follow. Curve C and D were chosen to see the performance with higher and lower average fixation times, which would indicate whether there is a difference in pacing and average fixation time. This was done by pressing the spacebar. the first time the spacebar was pressed the first of the three instruction will be displayed above the stimuli or fixation for 1 second. For every subsequent key press the next instruction would follow. After three times pressing the first instruction was displayed again. The CRT task was not stopped by hitting the spacebar. The intention for doing this was finding out at what time participants disengaged from the CRT task. The design of the keypress was made to mimic internal planning processes.

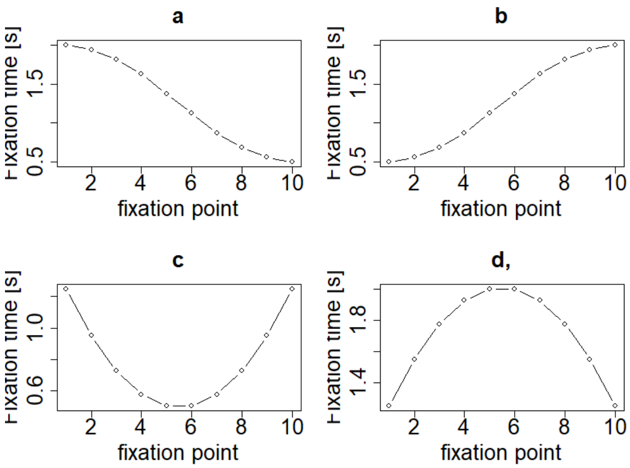

Figure 1: Four different fixation time curves during the CRT task. On the y-axis the fixation time in seconds is given. On the x-axis the number of the fixation point is given. In between these fixation points a stimulus of 1 second was shown.

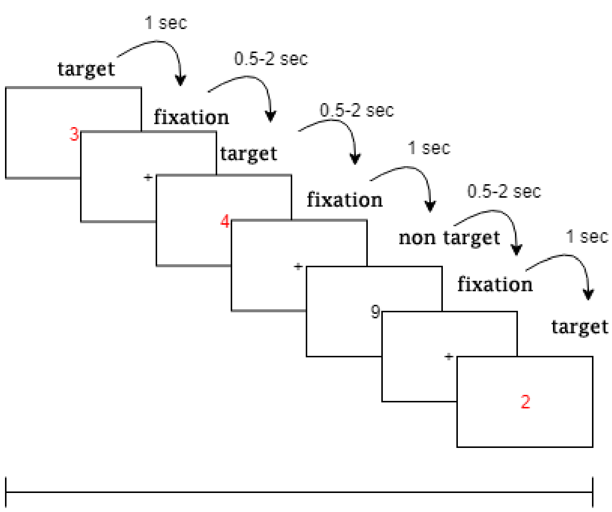

Figure 2: Partial timeline of the choice reaction time (CRT) task. The CRT task exists of a series of numbers alternated with fixations. Participants had to respond to targets (red colored numbers). The fixation times were equal to the curves shown in Figure 1.

RITL

Immediately after completion of the CRT Task the RITL paradigm started. In this task the participants got three sets of rules which were the instruction for the task. With these rules the participant had to decide whether the subsequent pair of noun words were in correspondence with the instruction. This pair of words was chosen from a library of words for which the meaning was set by a survey (Cole et al., 2018). These noun words were then adapted to Dutch.

The instructions were displayed in three rows: The first row gave the logic rule; the second row gave the semantic meaning of the pair of words and the third and last row gave the response. The participants had to indicate whether the instruction together with the pair of nouns were valid or not and respond accordingly. For example, if the logic rule states:" SAME", that means that the attribute should be found in both the nouns or none of the nouns. If the semantic rule then states: "GREEN" and the response rule states: "LEFT-INDEX", the participant had to respond with their left index finger, if the logic rule could be applied to the noun words with the given semantic value. To give an example: Of the word pair: "lemon" and "grass", only grass is green, thus the response is not pressing with the left index finger, but the left middle finger.

During the RITL task the rules were always displayed next to the noun words. As there was no fixation time between instruction and noun words there was no extra time to plan during the RITL task, which maximized the speed performance in case of planning. There was no time limit for responding to a pair of noun words. At the end of the RITL task feedback was displayed in the form of number of correct answers and speed for both the CRT and RITL task.

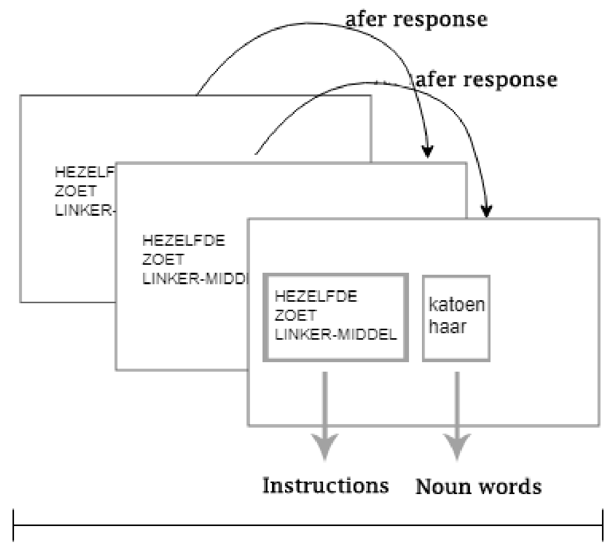

Figure 3: RITL task timeline (in Dutch), in this task participants must respond to the given instructions (without a time limit) after a response the instructions stay the same and the noun words change.

Materials

During this experiment an translated version of the RITL task instruction set from Cole et al. (2013) was used. The instruction consisted of the three rule types (logic, semantic and negate) that could be request during the CRT task. We used four logic rules; same, different, second and negate second. Next to that there were also four semantic rules (sweet, soft, loud, green) and four response rules (left-index, left-middle, right-index). Which gives rise to 64 different instructions sets. For the pair of noun words, we used a set of Dutch noun words, for every semantic rule there were 16 words chosen, thus a total of 64 words was used. The experiment was conducted on a MacBook pro running OSX 10.13(High Sierra) and presented on a 23.5-inch LCD-monitor (1920*1080 pixels). The experiment was programmed as an OSX application using the swift programming language (version 3.0) and the XCode development environment (version 8.0).

Procedure

Before the start of the experiment participants were moved to a separate room. There, the participants received written and verbal instruction on the task. Following the instruction, the participants filled out an informed consent form and a survey regarding age, educational level, handedness, and bilingualism. Before the start of the experiment there were several practice trials to let the participant get familiar to the two tasks. During the practice participants performed an adapted version of the CRT and RITL task separately. The RITL task was first practiced with 24 exercises in which participants practiced with four instructions, in these four instructions all the rules were used. The CRT task was practiced in four trials. In which participants could get used to pressing when stimuli were given, in this practice the four different pacing curves were used. During the practice participants received feedback on all their given answers. When a participant was wrong a red colored x would appear on the screen and if a participant was right a green colored x would appear on the screen. Practice ended after finishing the trials for the CRT task.

During the testing part, the participant performed the CRT and RITL task 32 times. In which after every CRT trial, the RITL task would immediately start. In the RITL task the participants got three pair of words for every instruction set. After this the participants received feedback on both task in the form of speed and accuracy. After this task, A new CRT trial is started again. This is done 16 times before the participant got a small break of 2,5 minutes. The total amount of time the tasks took were ~60 minutes from start of practice trials till the last trial.

Statistical analysis

The measurements that were taken from the experiment are the accuracy score for the CRT and RITL task and the reaction time for the RITL task. The time of a spacebar press was measured, to examine when planning has happened. Next to that the amount of spacebar pressing for a single trial was measured. This data was first grouped in the different fixation time curves. In each of these groups the proportion of spacebar presses was used to perform a multiple measure t-test.

Results

Performance

The average accuracy during the CRT task was: 92.69%
From all accurate responses the reaction time was on average per trial: 629.29 ms.

The average accuracy during the RITL task was: 87.41%
With an average reaction time of 2826.7ms per trial for every correctly answered stimuli.

Effect of using planning

On average participants used the spacebar button to plan 40.4 % of the time (sd:45.8 %).

We found that 11 out of 24 participants used the spacebar button (planning request) during the in at least 25% of the trials. Only the participants that used the spacebar for this 25% of the time were included in the analysis of the timing of spacebar presses. This cut off was added to the analysis to lower the changes that participant for which less data is available alter the overall result.

A comparison of the performances of participants who did use the spacebar to the full extend and participants who did not use the spacebar button to the full extend, showed us that the response time for the first part of the RITL task is on average 2.61 seconds higher during trials in which the participant did use the spacebar press three times or more, in comparison with trials in which participant used the spacebar less than three times (average: 3.12s, sd: 1.69s vs. average: 5.73s, sd: 2.55s). This difference is found to be significant with p-value<2.2e-16.

The comparison of trials during the CRT task were a spacebar press was found and tasks in which no spacebar press was found shows a difference in correct answers of 1.81% in the CRT task (93.417% vs 91.61%). By conducting a Wilcoxon rank sum test yielded a p-value of 0.061. This difference was found not to be significant.

Moment of planning

By manipulating the intervals between the stimuli during the CRT task, we were testing whether a difference in interval caused a change in moment of planning. Participant who did not meet the criterion of at least 25% planning requests were excluded from this analysis.

To compare the different trial lengths, we grouped the moment in time of the spacebar press. Thereby there were five groups made. Each group having two fixations and two stimuli, with the last group having an extra stimulus.

For every pacing condition the groups have a length as shown in Figure 4 The total duration for every pacing condition is shown in table 1.

Pacing	Trial length in s
Sinusoidal	23.5
Positive Parabola	28
Negative Parabola	19

Table 1: The total duration of a single trial for every pacing

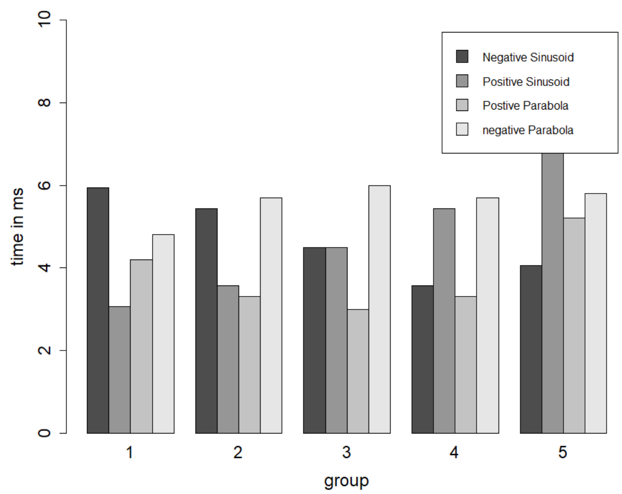

Figure 4: Duration of each group for four different pacing conditions.

These groups were then compared to simulated data. This comparison is shown in Figure 5. The simulated data consists of a random number between 0 and the trial length of every pacing condition (Table 1). The simulated data was taken from a random distribution of 10000 datapoints (min=0, max=30). From this random distribution random points were taken. These random numbers were then grouped by their value in the groups that were also used for the measured data (Figure 4).

The significance of the difference between the measured and the simulated data was tested by performing t-tests with Bonferroni correction. The result shows a significant difference for all pacing conditions (0.01 confidence interval). Negative parabola: p < 5e -06, negative sinusoid: p <2e-05, positive parabola: p < 5e -8, positive sinusoid: p<2e -11. By comparing the different groups we found that that group 1(p=1.177e-06), group 2(p=5.023073e-08), group 4 (p=3.026413e-05) and group 5 (p=7.238976e-11) had a significant difference. For group 3 no significant difference was found (p=0.4742372).

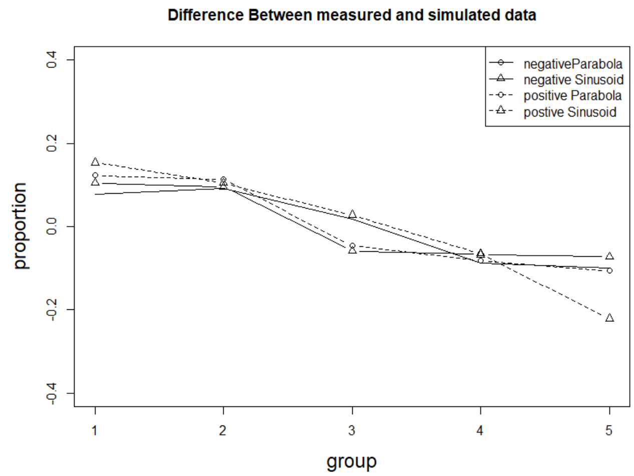

Figure 5: The proportion of measured spacebar presses subtracted by the proportion of simulated spacebar presses in every group. Each line indicates one of four pacing conditions. The groups are described in table 1.

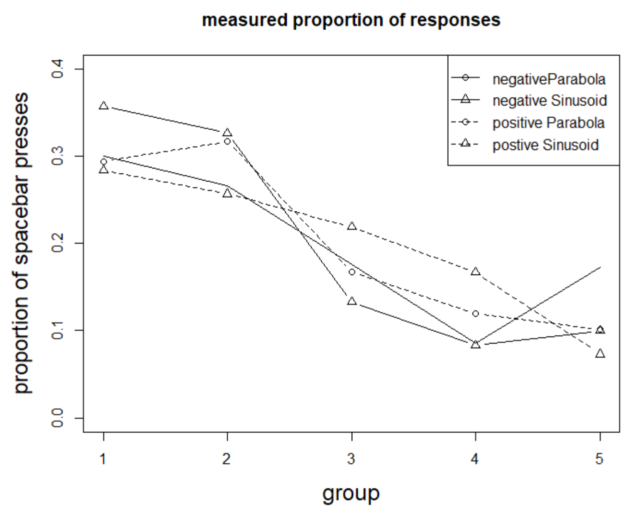

Figure 6: The measured number of spacebar presses per group. Each line indicates one of four pacing conditions. The groups are described in table 1.

The comparison between the different pacing condition is shown in figure 6. By again performing t-tests with Bonferroni correction the significances in Table 2 are found. Here we see only a significant difference between the positive parabola and the positive sinusoid.

	Negative Parabola	Negative sinusoid	Positive parabola
Negative Parabola	x	x	x
Negative Sinusoid	0.008624481	x	x
Positive Parabola	0.2047058	0.02309643	x
Positive sinusoid	0.01104376	0.03357384	0.3180018

Table 2: The p-values found by comparing the pacing conditions in a multiple measure t-test. A= Negative parabola, B= Negative sinusoid, C= Positive parabola, D=Positive sinusoid.

Discussion

This research explored the effect of pacing on the moment and quantity of planning. This was tested by varying the intervals between stimuli.

The results show that participants have a different strategy than a random distribution would suggest. It shows that the participants are more inclined to use the planning process at the start of a trial. This likely is caused by strategic pressing. As participant did not know how the pacing would change over the course of the trial, the expected workload was unknown. Participants that beforehand knew they were going to plan during the trial did this in the first part, as there was no incentive to do it at another time. This in contrast to the research by Seli et al. (2018) in which participant knew beforehand what part of the task was more demanding and adapt their self-generated thoughts to that.

Next to the unknown workload did participant plan at the start of the experiment because this would give certainty that in the end there was still time to request all three instructions. Therefore, a strategy in which participants would request information on the future task in a later part of the CRT trail can result in an incomplete instruction set and thence a lower performance. Another reason for the strategic behavior is that although the workload is higher with smaller intervals, it does not interfere with the performance during the CRT task. From the effects of planning on the CRT task we can see that even if a participant planned in one of the trials it does not result in a significant difference. This implies that participant have no incentive to balance their planning with the speed of the pacing as the result for the CRT task are equal for trials with and without planning.

In the research by Baird et al. (2012) it is shown that creative problem solving is dependent on the amount of self-generated thoughts, but not on the direction of the self-generated thoughts. Our results show that task for which cognitive flexibility is essential (RITL) (Cole et al., 2013) goal directed self-generated thoughts are of influence.

The number of participants that did not use the planning process is found to be more than half. We found that making using of planning is beneficial for the future task and there is no negative effect of planning on the performance in the current task. Therefore, the participants that did not use planning did not perform optimal. The reasoning behind this could be simply explained by forgetting to press the button, as well as participants not having any incentive to perform as well as possible. It could also be that the content of the self-generated thoughts was different from the goal oriented self-generated thoughts that the button press indicates. If this were to be the problem this could be overcome by making the demand during the CRT task differ more and making the performance on the RITL task more dependent on the self-generated thoughts. In future research, one might investigate whether more people can be motivated to plan when reward ins introduced. One might also try to make the participants more aware of the possibility of planning.

From this we can say that for future research on the subject it should be important to have a bigger interference of the planning process for the current task. By having more interference in this task, a decision for maximizing both task performances must be made. With this we will be able to measure whether different strategies of planning stem from different pacing conditions.

Conclusion

From the results we can see that there is a difference in planning between random and real data. This suggest that people have a strategy for their planning process. But it also shows that this strategy is not dependent on the pacing of the task. For future research there should be more interference between the two tasks. Such research could answer the question whether there are different strategies for different pacing conditions.

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