



THE INFLUENCES OF MIND WANDERING ON DECISIONS FROM EXPERIENCE

Bachelor's Project Thesis

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Abstract: When we try to focus on a primary task, we can get distracted by physical sensations or task-unrelated thoughts. Our attention shifts away from the primary task, and we start to mind wander. Previous work has demonstrated that the frequency and content of mind wandering affect decisions. The decision making task used in this research requires people to make decisions based on current obtained experience (experience-based decision making). A stock trader who follows the behavior of several stock options over time and certainly decides to buy some stock options, based on his experience, can be seen as an experience-based decision maker. In this research we investigate what the influence of mind wandering is on decisions from experience. When people are forced to focus on repetitive samples (stock options), an increased delay between the samples will increase the amount of mind wandering, but the data collected do not allow us to tell whether mind-wandering affects decision making. The data collected shows that people reported less mind wandering than in previous experiments, possible explanations are given.

1 Introduction

1.1 Mind wandering

Reading a book, driving a car or writing a thesis are examples of daily tasks that all require attention. People can get distracted by several factors while doing these tasks. The focus can drift away from the primary task towards unrelated inner thoughts, feelings or other musings (Smallwood and Schooler, 2006). When people experience their mind drifting away from the primary task, people are mind wandering. When the primary task requires us to be focused and concentrated, mind wandering is considered as a risky form of distraction. A driver who often loses his attention is a danger in traffic. A student who is continuously focused while studying for an exam will be more likely to pass the exam than his fellow student who often mind wanders while studying.

Mind wandering may be helpful in processing earlier obtained information. But when the primary task requires people to be focused, mind wandering can be considered as a form of distraction. By further researching mind wandering we may get a better understanding of its role in information pro-

cessing. Besides, mind wandering research can also give us new information about how and when people are being distracted and what the influence is on task performance when we are distracted.

Previous research has shown that mind wandering plays a role in several tasks. Mind wandering can cause errors, and delay in task performances, mind wandering can also have a negative impact on mood (Hawkins, Mittner, Boekel, and Forstmann, 2015; Killingsworth and Gilbert, 2010; Mooneyham and Schooler, 2013). On the other, hand mind wandering can also be useful for creativity (Baird, Smallwood, Mrazek, Kam, Franklin, and Schooler, 2012) and planning (Steindorf and Rummel, 2017) and may help to make more adaptive and rational choices (Smallwood, Ruby, and Singer, 2013).

Previous research has also shown that mind wandering can relate to both behavioral costs and benefits at the same time. The costs are measured by prolonged reaction time in sustained attention to response task, whereas the benefits are observed as improved performance in creative problem solving and planning tasks (Leszczynski, Chaieb, Reber, Derner, Axmacher, and Fell, 2017).

According to previous research, we mind wander

30-50% of our every daily life (Killingsworth and Gilbert, 2010). Why do people mind wander 30-50% of their day life? Previous research has shown that mind wandering can have both positive and negative influence on task performance. Is there a possibility that mind wandering is helpful in decision making and that the effect of mind wandering can be seen in task performance?

1.2 Decisions from experience

One of the forms of decision making is called "description-based" decision making, where people make decisions by considering the available information of the current situation. Another form of decision making is called "experience-based" decision making. The decisions that people make when using this form of decision making are based on previously obtained experience in similar situations.

In the stock market you could, for example, decide from an expert's report of the profit and risks of particular stocks which stock option to buy. When the expert has convinced you by his report, you can decide (description-based) to invest money in some stock options. Another option is that you follow the behavior of specific stock options for a while. When you think to see a good entry point you can make a decision in which stocks to invest your money based on your own obtained experience.

Stock traders follow the behavior of stocks over time and eventually decide what stocks to buy. Following the behavior of real stock options is much more complicated than observing the behavior of the stock options used in this research. But even by following the behavior of several straightforward stock options a stock trader obtains experience. The trader then uses the obtained experience to eventually make decisions. The task used in this research is so designed that participants are asked to act as a stock trader. In the first phase (sampling phase) of the task the participants observe the behavior of stock options and so obtain experience in how the specific stock options behave over time. In the next step the participants are asked to make a decision and allocate their money in one of the stock options. By using "the allocation task", we ensure that the participants use experience when making decisions.

In this research, we try to find out what the effect

of mind wandering is on decisions from experience (DFE). To study people's DFE, previous research proposed the sampling paradigm (Hertwig, Barron, Weber, and Erev, 2004). The first phase of the task where the participants gain the experience represents the sampling paradigm. In the sampling phase of the task, participants need to focus on obtaining the (right) experience. We expect that mind wandering during the sampling phase shows its costs on task performance since the attention is shifted away from the focus.

The DFE task used here is based on previous research (Debnath, Sharma, and Dutt, 2015). According to Smallwood and Schooler mind wandering is less likely to occur when the task is demanding and more likely to happen when doing a more straightforward task (Smallwood and Schooler, 2006), in constructing the experiment this is taken into account.

1.3 Mind wandering and DFE

One of the possible function of mind wandering could be to sample the space of possibilities before making a decision. In this case, "task-related" mind wandering could be beneficial in decision making. Mind wandering about the space of possibilities before making a decision then results in a deliberated choice since all options are considered.

Previous research shows that decisions of people differ when making description-based decisions and when making DFE (Hertwig et al., 2004). When people make description-based decisions, they extract information from the surrounding environment. When their mind drifts away, they can make a new attempt to find the right information. But what is happening when people are mind wandering while doing a DFE task? When their mind drifts away, people are no longer consciously obtain the required information in the allocation task.

When people are mind wandering, and the focus is off-task the right information is probably missed. While mind wandering but having task-related thoughts, task-related information can be processed, or task-related representations can be strengthened. Is it then the case that on-task thinking increases the probability of performing optimal in the DFE-task and that off-task thinking decreases the probability of performing optimal in the DFE-task?

1.4 Cognitive modelling

1.4.1 ACT-R

To find the detailed cognitive mechanisms underlying mind wandering and its influence on decisions from experience, we provide a suggestion of a cognitive model. The model uses the concepts of the cognitive architecture ACT-R (Anderson, 2009). ACT-R has been used to explain human cognition, by developing models of the knowledge structures that underlie the human cognition. The neurally plausible architecture is structured as a set of modules (*perceptual-motor modules* and *memory modules*) that represent specific brain functions. The modules are connected to a central production pattern-matching module and interact through buffers.

ACT-R structures knowledge in declarative knowledge and procedural knowledge. Declarative knowledge are facts and things we are aware of. ACT-R uses *chunks* to represent and store declarative knowledge in memory. The knowledge that is not about facts, but about how to do things, is called *procedural knowledge*. Procedural knowledge controls how information is flown and processed in the brain. ACT-R uses production rules to represent procedural knowledge.

The ACT-R models can be used to represent the underlying cognitive mechanisms of specific tasks. The productions that are required for these tasks are processed through buffers. Productions could be in conflict if multiple productions satisfy the conditions of the buffers. ACT-R deals with these conflicts by estimating the relative costs and benefits associated with each production. The model then decides to select the production with the highest utility for execution. When multiple facts are in conflict, the model takes the context and history of usage (*activation value*) of the facts into account, to determine which fact to retrieve from declarative memory.

1.4.2 Decisions from experience

Our model is based on previous DFE research (Gonzalez and Dutt, 2011). The model uses the Instance-Based Learning (IBL) algorithm. The algorithm is based on the Instance-Based Learning theory (Aha, Kibler, and Albert, 1991) and has been used in previous cognitive models that have

represented decisions from experience (Gonzalez and Dutt, 2011, 2012; Sharma and Dutt, 2017).

The IBL theory can be used to explain an predict decision making in dynamic tasks (Gonzalez, Lerch, and Lebiere, 2003). The theory proposes an instance as the key for representing cognitive information. An instance is stored in the memory and represents an occurrence of an outcome of an option. Each sample that is presented to the model can be seen as an instance containing three parts: the current situation (a choice for two options), the decision that is made in the current situation (the choice that is made and presented in the sample, see Figure 2.1), and the goodness of the decision (the outcome of the decision).

The theory also proposes the decision-making process. When a decisions needs to be made, the model can chose out of two options. The corresponding instances belonging to the options are retrieved from memory and blended together. The model calculates the blended value for both options. The blended value is a function of the activation of the instances in the sampling phase, for a more detailed description see (Sharma and Dutt, 2017). The activation of the instances is dependent on the recency and the goodness of the decisions.

The model selects the option with the highest blended value as its final choice. The stock option that has the highest outcome over time is more likely to have the highest blended value and is therefore most likely to be selected as the final choice.

1.4.3 Mind wandering

When the model is not interrupted by task-unrelated events, the model can take all samples into account and has the ability to perform optimal in the DFE task. However, our model is a combination of a mind wandering model and the IBL-model. The mind wandering results in the fact that not all samples are taken into account since the model is interrupted by task-unrelated thoughts.

The model makes the assumption that mind wandering starts by a retrieval from memory, possibly an episodic memory, or any other currently salient memory trace (Christoff, Irving, Fox, Spreng, and Andrews-Hanna, 2016). The retrieval is initiated by an operator that is activated because there is nothing else to do at that moment. When the retrieval

from memory has been initiated, there is a possibility that the retrieved thought is placed in working memory. This is only possible if the working memory is not used by the main task at that moment (during the inter-sample interval). If the retrieved thought finds an entrance in the working memory, the mind wandering process is possible.

In the case of the DFE-task the model has nothing to do for a large proportion of the time. The model is following behavior of two stock options by watching over a sequence of samples. However, in the inter-sample interval there is nothing to do for the model. This is the moment that the model can initiate the mind wandering process. When the period of 'nothing to do' is increased, the chances to initiate mind wandering are increased as well. We therefore predict that an increase in the inter-sample interval increases the probability of mind wandering.

When the model is mind wandering, it can not focus on the DFE-task and the samples of the behavior of the stock options will be missed. When samples are missed, the model can not optimally calculate the blended value for the options since instances are missing. We therefore predict that more mind wandering decreases the ability of finding an optimal solution in the DFE-task.

1.4.4 Temporal focus

Previous research suggest that individuals who show future-related thinking make a variety of future-oriented decisions, such as investing in the future (Thorstad and Wolff, 2018). The study also suggests that future thinking may affect decisions since the future seems to be more connected to the present of the individuals.

The principal that prospective thinking is associated with future-oriented decisions can be developed in the model by weighing option on a more extended horizon. When the activation values are less influenced by the recency of the samples, the model is weighing the options on a more extended horizon. We predict that when the model takes the activation values of the options on a more extended horizon it will find more optimal solutions.

1.4.5 Affective valence

The model uses the assumptions that positive thinking is associated with reward experience and negative thinking is associated with punishment experience. Observing winning and losing situations can be considered as reward and punishment experiences.

The model increases the activation value of an option if a sample represents a winning stock option and decreases the activation value if a sample represents a loss-making stock option. These increases and decreases of the activation values can be seen as reward and punishment experiences, respectively. In this way, the financial direction of the stock options is part of the determination of the amount of positive and negative thinking.

In the experiment, we investigate how mind wandering affects decisions that people make from experience. By interrupting the participants with thought probes while they do the DFE task, we investigate the ongoing thoughts at the moment of obtaining experience. The first research question is whether peoples ability to find the best stock option is affected by the extent and the content of mind wandering during the sampling phase. The second question is whether delay in the sampling sequence increases the probability of mind wandering. We predict that participants who mind wander more are less likely to find the best stock option because they are more likely to have missed samples and so remember a less complete version of the samples they have seen. We also predict that introducing delays in the sampling sequence increases the amount of mind wandering.

Thirdly, we hypothesize that thinking about the future predicts more optimal decisions, given that previous studies suggested that prospective thinking is associated with longer-term outcomes (and therefore weighing options on a more extended horizon). Finally, we predict that when the samples are formulated in a loss frame, participants report more negative thinking, and when the options are expressed in a gain frame, participants report more positive thinking.

2 Method

2.1 Participants

In this experiment, 25 participants are tested with an average age of 22.7 (mean=22.72, SD=3.55, range=18:30). Of the 25 participants, 17 are female, and 8 are male. All participants participate in return for a monetary compensation. The compensation contains a fixed element and a variable element. The variable part is dependent on how well participants perform. A condition for participating in the experiment is that the participants are not allowed to have experience in professional stock trading. To make sure participants are aware of what they are doing, they are forced to make a practice trial before they can participate in the experiment. In the practice trial participants are asked to watch over a sequence of six samples, give answer to the three thought probes and make one final decision.

2.2 The experimental design

In this experiment, the participants are asked to do an allocation task. The task is a replica of an allocation task used in previous research (Debnath et al., 2015). The task that is created for this research has been designed with OpenSesame (Mathôt, Schreij, and Theeuwes, 2012). The allocation task contains six classical decision problems used in many studies. The problems exist of two phases, the sampling phase, and the final decision phase. In the sampling phase, the participants watch over a sequence of samples and obtain experience in allocating money on different stock options. The samples represent a choice in one of the two stock options and show the corresponding monetary return of a stock option, see Figure 2.1.

In the final decision phase, the participants are asked to allocate a virtual 1000\$ on one of the stock options. Based upon these allocation a participant could end-up gaining or losing money. The goal of the task is to gain as much money as possible. Paying attention and carefully observing the behavior of the stock options could, therefore, lead to higher task performance. Participants receive an additional bonus upon their monetary compensation if the final allocation results in a profitable decision.

2.3 The sampling strategies

In decisions from experience, people are the master of their information search (Hills and Hertwig, 2010). People control how they distribute their attention over options and for how long they do so. This results in different search strategies among people.

To increase the probability of a good decision being made in the allocation task one must gather information about returns offered by the two stock options before making a consequential decision. While gathering information, some people may explore the prices of a stock option repeatedly before switching to a different stock option (comprehensive strategy). However, some people may examine prices of a stock option once and then turn to exploring the stock prices of a different option (zigzag strategy) (Sharma and Dutt, 2017). To allow for individual differences in sampling strategies, both strategies are implemented in this research.

In each problem, we will give participants an experience of 100 samples, consisting of 50 samples of the risky option and 50 samples of the (more) safe option. The comprehensive and zigzag strategy are used as sampling strategies in this experiment to make the sampling more natural. For the first 50 samples, the participants are shown the zigzag strategy of sampling, for the second 50 samples the comprehensive strategy (Sharma and Dutt, 2017). In the comprehensive sampling strategy, we present one stock option repeatedly before switching to the other option. In contrast, in the zigzag sampling strategy, we continuously switch between the two stock options. The order of how the problems are represented is randomized among participants.

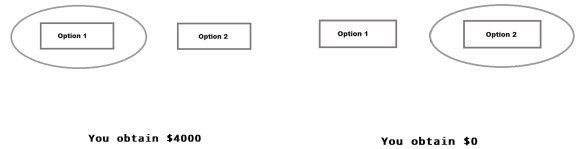


Figure 2.1: The samples show the monetary return when the highlighted options were chosen

2.4 The control condition and the delay condition

To investigate if a delay in the sample sequences increases the probability of mind wandering, we manipulate the inter-sample interval. A larger inter-sample interval can cause a mind drifting away from the task since participants need to focus for a more extended period. Therefore the hypothesis is that the delay in the sampling sequence increases the probability of mind wandering.

Each sample is shown for 1 second with a 1-second inter-sample interval in the control condition, and with a 3-second inter-sample interval in the delay condition. The experiment has been programmed so that three random problems are represented in control condition, and three random problems are represented in delay condition. This way we ensure that all participants do three problems with an inter-sample interval of 1 second and three problems with an inter-sample interval of 3 seconds.

2.5 Timeline of a problem

A sample is represented for one second, and the duration between the samples depends on whether a problem is assigned as a control or a delay problem. Participants have fifteen seconds to provide an answer to the thought probes and infinitely time to make a final decision. In Figure 2.2 we see the timeline of a problem. In each of the six problems, we interrupt the participants after 25, 50 and 75 samples with three thoughts probes. Problems in control condition take approximately 4 minutes, and problems in delay condition take about 7.5 minutes.

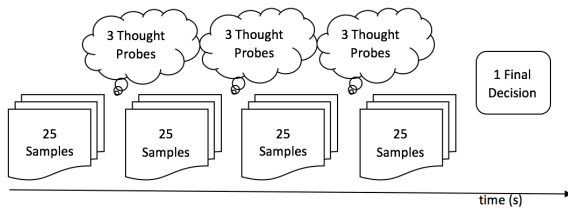


Figure 2.2: The timeline of a problem

2.6 Thought probes

To find out how several thoughts can affect the decisions being made we ask the participants after each first three blocks of 25 samples in each problem about what they are thinking. We interrupt the participants with three different thought probes that are used in previous studies while the participants are watching the samples.

2.6.1 Measuring mind wandering

The first thought probe we present the participants is based on previous research (Stawarczyk, Majerus, Maj, Van der Linden, and D'Argembeau, 2011; Unsworth and McMillan, 2014). The participants are asked to characterize their current conscious experience and could choose one of the following options:

1. I am focused on options from the sampling phase.
2. I am focused on my upcoming choice.
3. I am thinking about my performance on the task or how long it is taking.
4. I am distracted by sights/sounds/temperature or by physical sensations (hungry/thirsty).
5. I am daydreaming/my mind is wandering about things unrelated to the task.
6. I am not very alert/my mind is blank or I'm drowsy.

By asking the participant to characterize their current conscious experience at the moment of obtaining information that is required for the final decision, we obtain information about their wandering mind. We consider the answer one, two, and three as participants being on-task and we consider the answers four, five, and six as participants being off-task. The hypothesis is that participants who mind wander (off-task) more are less likely to find the optimal stock option. So we predict that people who respond more often with answer four, five or six to the first question are less likely to find the optimal stock options.

2.6.2 Temporal focus

The second thought probe measures the temporal focus of the participants. We ask the participants to indicate their current temporal focus, by answering the thought with future, past or present.

2.6.3 Affective valence

The third thought probe measures the affective valence of the participants. We ask the participants to indicate their current feelings, by telling whether they have a positive, negative or neutral feeling while watching the samples.

2.7 The monetary bonus

In each of the six problems the participants, are asked to allocate a virtual 1000\$. The participants will be rewarded for their choices according to the principles of the underlying algorithm. For each of the six problems we can calculate the reward with Equation 2.1.

$$Reward = 1000(Outcome * Probability) \quad (2.1)$$

The variable part of the monetary compensation can be calculated with Equation 2.2.

$$Bonus = Reward/400 \quad (2.2)$$

2.8 Problem details

In the six problems, we vary the probability of the outcomes and the occurrence of rare events as can be seen in Table 2.1. The six problems differ in expected value, four problems offer a positive return, and two problems provide a negative return. When participants need to make a final allocation they can pick out of two stock options. One of the two stock options represents the optimal choice, and the other represents the non-optimal choice.

These are classical decision problem used in many studies (Barron and Erev, 2003). The problems are arranged by problem number. However, the order of how the problems are represented is randomized among the participants. In the six problems, the probability of rare events is varied.

2.9 Statistics and pre-registration

We used the R-statistical programming language (www.r-project.org, version 3.3.2) to perform all the statistics. The research has been pre-registered on the Open Science Framework (www.osf.io).

3 Results

3.1 General performances

To give a short overview of how participants performed in the allocation task, we present some general results. All participants have made a final decision in each problem, resulting in 6 final decisions per participant. None of the participants found all the optimal solution and performed optimally in the allocation task. The chance of finding the optimal solution in each problem was 50%. So in the six problems, participants would find three optimal solutions by chance. In this experiment is the average number of optimal decisions per participant 2.72 (n=25).

One participant found in five of the six problems the optimal solution, resulting in the highest monetary compensation. One participants found in one of the six problems the optimal solution, resulting in the lowest compensation.

We examined whether there was a difference in the amount of optimal decision between the six problems. We found that Problem 2 had the most significant number of optimal decisions (21) and we found that Problem 6 had the lowest number of optimal decision (5), see Figure 3.1.

Previous research has shown that in decisions from experience, people often behave as if rare events have less impact than they deserve according to their objective probabilities (Hertwig et al., 2004). Underestimating the impact of rare events could be a reason why the optimality differs among the problems. Participants found less often the optimal solution in Problem 5 and 6 than in Problem 1 and 2.

An other reason why the optimality differs

Table 2.1: The 6 problems

Nr.	Options			
	Optimal		Non-optimal	
	Outcome	Probability	Outcome	Probability
1	4	0.8	3	1.0
2	4	0.2	3	0.25
3	-3	1.0	-32	0.1
4	-3	1.0	-4	0.8
5	32	0.1	3	1.0
6	32	0.025	3	0.25

among the problems could be caused by the probability of the problems. In Problem 6, is the probability of an outcome of 32 (*probability* = 0.025) ten times lower than the probability of an outcome of 3 (*probability* = 0.25). The option with the lowest probability could be considered as the risky option, and participants could prefer to allocate their virtual money in a more safe option. The ratio of the probability between the optimal and non-optimal options differs among the problems, this could be a reason why the optimality is different between the problems.

3.2 The effect of the inter-sample delay on the amount of mind wandering

The inter-sample interval of the problems has been manipulated to investigate whether a delay in the sample sequence increases the probability of mind wandering. Each participant made three problems with an inter-sample of 1 second and three problems with an inter-sample interval of 3 seconds.

In total, we showed each participants 600 samples, 300 samples in control condition and 300 samples in delay condition. While the participants had been watching the samples, they were interrupted with thought probes. The thought probes were used to measure whether participants were on-task thinking or off-task thinking while watching the samples. We considered participants mind wandering (off-task thinking) when they answered the thought probes with one of these options:

- I am distracted by sights/sounds/temperature or by physical sensations (hungry/thirsty).
- I am daydreaming/my mind is wandering about things unrelated to the task.
- I am not very alert/my mind is blank or I'm drowsy.

Participants who were not mind wandering at least once have been removed from the data. Of all 25 participants, 8 participants have not indicated that they were mind wandering and have been removed from the data.

We hypothesized that a delay in the sample sequence increases the probability of mind wandering. We found that in control condition the participants have reported that they were 19 times mind wandering while they were watching the samples. And we found that in delay condition the participants have indicated that they were 44 times mind wandering.

The answers to the thought probes show that in control condition participants were mind wandering in 13% of the cases while they were watching the samples and in delay condition in 29% of the cases. The difference in the amount of mind wandering indicates that participants were mind wandering twice as often when the inter-sample interval is 3 seconds then when the inter-sample interval is 1 second.

To find out if there was a significant effect of the delay on the probability of mind wandering we used a repeated measures analysis of variance (ANOVA). The ANOVA shows that there was a statistically significant effect of the delay in the sampling sequence on the probability of mind wandering ($F(2,16)=8.621$, $p=0.0097$). The proportion of mind wandering in the delay condition is 0.29 while the proportion of on-task thinking is 0.71.

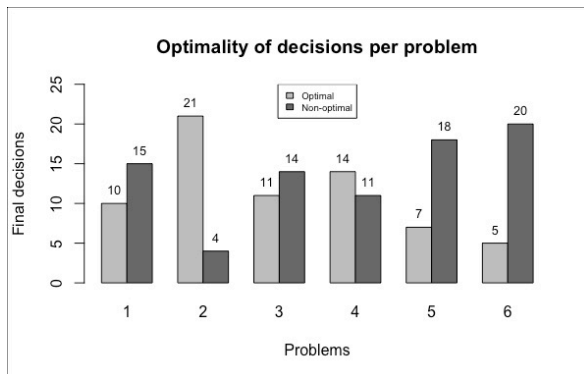


Figure 3.1: The optimality of the decisions per problem

3.3 The effect of mind wandering on finding the optimal solution

The main goal of this research is to find out what the influence is of mind wandering on decisions from experience. We do this by looking at the influence of mind wandering in the sampling phase of the allocation task. To investigate the mind wandering that occurred during the decision sampling process, we interrupted the participants after 25, 50, and 75 samples with thought probes. Partici-

pants who were not mind wandering at least once have been removed from the data.

We found that participants were off-task thinking in 21% of the cases. The majority of the time the participants reported being on task. In the discussion, we give possible explanations why this is different from previous mind wandering studies. In the 21% of the cases participant gave the following answers:

- I am distracted by sights/sounds/temperature or by physical sensations (hungry/thirsty). (6%)
- I am daydreaming/my mind is wandering about things unrelated to the task. (10%)
- I am not very alert/my mind is blank or I'm drowsy. (5%)

Of all decisions made by the participants that have not been removed from the data, 47% of the decisions resulted in the optimal choice, and 53% resulted in the non-optimal choice. While participants were mind wandering during the sampling phase, they found in 52% of the cases the optimal choice and in 48% of the cases the non-optimal choice. When participants mentioned to be on task, they found in 46% of the cases the optimal choice and in 54% of the cases the non-optimal choice, see Figure 3.2.

To find out if the ability of people to find the best stock option was dependent on the extent and content of mind wandering during the sampling phase we used a repeated measures analysis of variance (ANOVA). Participants that were not indicating any mind wandering have been removed from

the data (8 participants have been excluded). The ANOVA could not show that there was a significant effect of the amount of mind wandering on how likely people were to find the optimal stock option ($F(2,16)=0.249$, $p=0.625$).

We computed a Bayes factor here to see whether there is evidence for no significant effect of the amount of mind wandering on how likely people were to find the optimal stock option. The estimated Bayes factor (null/alternative) suggested that the data were 0.359:1 in favor of the alternative hypothesis. The data suggest that it is 2.79 times more likely that there is no significant effect than that there is a significant effect of the amount of mind wandering on how likely people were to find the optimal stock option. According to the interpretation of Jeffreys this is *substantial* evidence that there is no significant effect (Jeffreys, 1998).

3.4 Future-related thinking and finding the optimal solution

Previous studies suggested that future-related thinking is associated with longer-term outcomes. We, therefore, hypothesized that thinking about the future predicts more optimal choices. We measured the temporal focus by interrupting the participants with thought probes while they were watching the samples.

In Figure 3.3 we see the percentages of optimal and non-optimal solutions per temporal focus. Participants who showed future-related thinking found in 47% of the problems an optimal solution and in 53% of the problems a non-optimal solution.

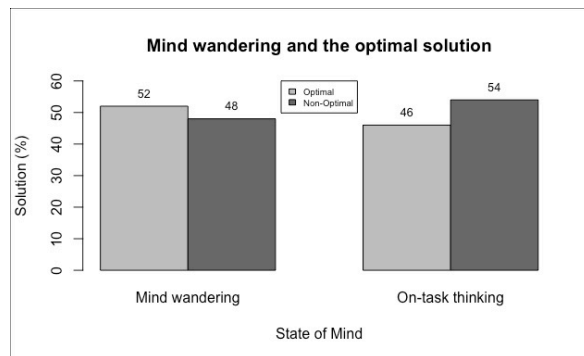


Figure 3.2: The optimality of the decision per state of mind

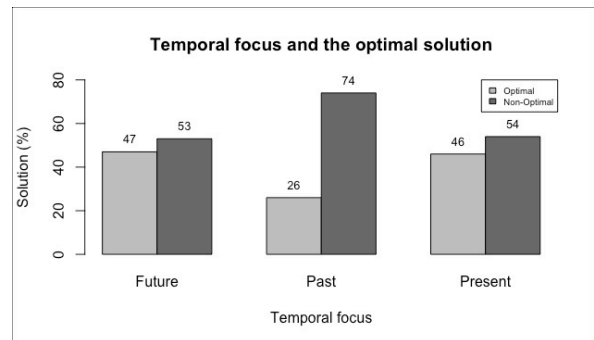


Figure 3.3: The optimality of the decisions per temporal focus

To find out if the future-related temporal focus of the participants had a significant effect on finding the optimal solution we used a repeated measures analysis of variance (ANOVA). Participants that were not indicating any future-related thoughts have been removed from the data (2 participants have been excluded). The ANOVA could not show that there was a significant effect of future-related thinking on finding the optimal stock option ($F(2, 22) = 0.018$, $p = .895$).

We computed a Bayes factor here to see whether there is evidence for no significant effect of future-related thinking on finding the optimal solution. The estimated Bayes factor (null/alternative) suggested that the data were 0.294:1 in favor of the alternative hypothesis. The data suggest that it is 3.40 times more likely that there is no significant effect than that there is a significant effect of future-related thinking on finding the optimal stock option. According to the interpretation of Jeffreys this is *substantial* evidence that there is no significant effect.

3.5 Affective valence

In the sampling phase participants were watching to either profitable stock options or loss-making stock options. To see what the effect is of the financial direction (profit or loss) on the mood of the participants, we interrupted them with thought probes. In the thought probes participants could indicate their affective valence (positive/negative/neutral).

In each problem, the participants were asked to indicate what their current feeling was after having seen 25, 50 and 75 samples. In four of the six problems participants have observed behavior of a profitable stock option and in two of the six problems participants have observed behavior of a loss-making stock option*.

The corresponding samples that were presented in the problems have an underlying gain-frame in profitable problems and a loss-frame in loss-making problems. By comparing the answers to the thought probes in profitable problems with answers to the thought probes in loss-making problems, we can see what the emotional difference is between observing behavior of a profitable stock option and observing

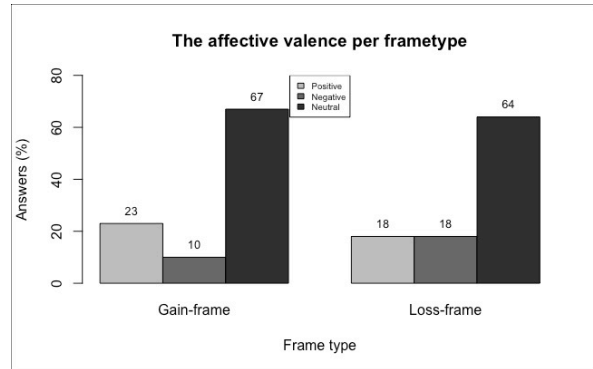


Figure 3.4: Feelings per frame type

behavior of a loss-making stock option.

In Figure 3.4 we see that participants reported in 23% of the situations to have a positive thought while observing a profitable stock option. And participants reported in 18% of the situations to have a positive thought while observing a losing stock option.

Besides, we found that participants reported in 10% of the situations to have a negative thought while observing a profitable stock option. And participants reported in 18% of the situations to have a negative thoughts while observing a losing stock option.

To find out if participants showed more positive thinking when they observe a profitable stock option and more negative thinking when they observe a loss-making stock option, we used a repeated measures analysis of variance (ANOVA). Participants who reported to have only neutral feelings have been removed from the data (4 participants have been excluded). The ANOVA showed that participants had more positive thoughts when the frame type was winning than when the frame type was losing, so there is a significant effect of the frame type on the amount of positive thoughts ($F(2, 20) = 8.331$, $p = .00913$).

The ANOVA could not show that participants had more negative thoughts when the frame type was losing than when the frame type was winning. The ANOVA could not tell if there is a significant effect of the frame type on the amount of negative thoughts ($F(2, 20) = 0.323$, $p = .576$).

We computed a Bayes factor here to see whether there is evidence for no significant effect of the frame type on the amount of negative thinking. The

*see Table 2.1 for more details

estimated Bayes factor (null/alternative) suggested that the data were 0.363:1 in favor of the alternative hypothesis. The data suggest that it is 2.75 times more likely that there is no significant effect than that there is a significant effect of the frame type on the amount of negative thoughts. According to the interpretation of Jeffreys this is *substantial* evidence that there is no significant effect.

4 Discussion

4.1 General thoughts on the experiment

The main goal of this research was to find out what the influences of mind wandering are on decisions from experience (DFE). We have used a method in which participants are forced to make decisions based on obtained experience. By interrupting the participants with thought probes while they were obtaining the experience we tried to find out what the influences of a wandering mind are on DFE.

Although none of the participants mentioned not to understand the task, we suggest to improve the practice trial. By improving the practice trial, we can increase the probability that all participants completely understand their purpose in the task. Instead of showing a short example of all what will be seen in the task, we suggest to show a whole problem with instructions and advice.

Participants reported less mind wandering in this research than in most other mind wandering studies (see e.g., Huijser, van Vugt, and Taatgen, 2018). Possible explanations why this did happen and suggestions how further research can be improved are discussed here.

4.2 The effect of the inter-sample delay on the amount of mind wandering

We have shown in the experiment that adding a delay in the sample sequence increases the probability of mind wandering. Since 8 of the 25 participants have indicated that they have not been mind wandering during the experiment we suggest to do the same research but with larger inter-sample intervals.

The influence of mind wandering can be better researched when more mind wandering occurs. Adding more delay in the inter-sample interval might cause more mind wandering and therefore makes better research possible.

4.3 The effect of mind wandering on finding the optimal solution

By looking at the amount of mind wandering together with the ability of people to find an optimal solution we tried to find out what the influences of a wandering mind are on decisions from experience. We expected to see that people who showed more mind wandering were less likely to find an optimal solution.

We have not found proof that the decisions being made in this experiment were affected by mind wandering. To further research and test our hypothesis we suggest to do the same research with a larger sample size ($n=30$) since only 17 participants in this experiment mentioned to have mind wandered.

Less mind wandering occurred in this research than in previous mind wandering studies. A possible explanation that less mind wandering happened is that participants have not correctly report their mind wandering. The participants could have answered the thought probes socially desirable and could have indicated to be more on-task than that they actually were.

Another reason that participants did not correctly report their mind wanderings could be because the participants possibly have not felt free to mind wander. The participants were aware of the fact that their monetary bonus was dependent on how well they performed in the allocation task. They could have thought that their monetary bonus would decrease if they showed off-task thinking. In further mind wandering research, we suggest to explicitly mention that participants should feel free to mind wander.

To avoid participants from not reporting or incorrectly reporting mind wandering, other mind wandering measure techniques can be used. We suggest to do the same study but use techniques like EEG or eye tracking to measure mind wandering.

4.4 Future-related thinking and finding the optimal solution

We predicted that people who showed more future-related thinking would be more likely to find the optimal decision than people who showed less future-related thinking. We have not found significant results that support our expectations. Collecting data of more participants can help to further research the relation between the temporal focus and finding optimal decisions.

4.5 Affective valence

When someone makes an investment in a stock option he hopes to see a profitable outcome. Our results show that the participants show more positive thinking when they observe behavior of a profitable stock option than when they observe behavior of a loss-making stock option.

We could not show that there was a significant effect of observing loss-making stock options on negative feelings. To find out whether the number of negative thoughts increases when people observe loss-making stock options we suggest to do the same research but with more participants since only 12 participants mentioned to have negative thoughts.

Besides experimenting with more participants, we suggest to enlarge the difference between the profits and losses of stock options since that increases the effect size. An experiment where the monetary compensation is no longer divided in a fixed part and a variable part but entirely depends on the decision of the participants is interesting for further research.

5 Conclusions

We investigated the influences of a wandering mind on people's ability to find an optimal stock option by the hand of an allocation task. The allocation task contains the sampling paradigm which is used in previous research to study decisions from experience. In this research, we have not found evidence that mind wandering is influencing people's ability to find an optimal solution. By explicitly mentioning that participants should feel free to mind wander, or by using other mind wander measure

techniques the research can be improved. Further improved research can help to investigate the effects of mind wandering on decisions from experience. Besides, it would be helpful and interesting to develop the model suggested in Section 1.4.

This research shows that the probability of mind wandering is increased when more inter-sample delay is added. It would be interesting to see if an additional increase in the inter-sample interval will cause more mind wandering. Further research with multiple delay conditions could give answers.

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