UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

# THE INFLUENCE OF COGNITIVE CONTROL ON THE MAGNITUDE OF PRIMING AND ANCHORING EFFECTS

Ljubljana, December 2021 GAŠPER GRAD

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The undersigned Gašper Grad, a student at the University of Ljubljana, School of Economics and Business (hereafter: SEB LU), author of this written final work of studies with the title The influence of cognitive control on the magnitude of priming and anchoring effects, prepared under the supervision of Prof. Dr. Simon Čadež

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# TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF FIGURES

# LIST OF APPENDICES



# LIST OF ABBREVIATIONS

***SD*** – standard deviation
**AVG** – average
**etc.** – et cetera
**e. g. –** exempli gratia
**EU27 –** 27 European Union countries
**ms -** millisecond

# INTRODUCTION

The priming effect, the anchoring effect, and other cognitive biases are a part of our everyday lives. Since we are typically not aware of them, we also tend to underestimate the influence they have on our judgment. They can affect simple decisions like which cereals we buy at the grocery store, where we go on vacation, or what we eat for a snack, as well as more important decisions like how much we are willing to pay for a new car or real estate. They are also a part of our professional lives. They can affect how finance managers or CEOs evaluate deals, negotiate, how human resources managers interview and select new employees, etc.

Historically, studies of biases have primarily focused on group-level effects, but Robinson and von Hippel (2006), Yap, Hutchison & Tan (2015), Robinson (2010), Eroglu and Croxton (2010), and McElroy and Dowd (2007) showed that individual susceptibility might depend on personal traits and capabilities. Even though they are called cognitive biases, the understanding of how they are related to cognitive abilities is limited. De Fockert, Mizon & D'Ubaldo (2010) and Ortells, Noguera, Álvarez, Carmona & Houghton (2016) suggest that the magnitude of the priming effect might depend on the availability of cognitive control resources. The concept of cognitive control has been known for more than 50 years, but in the last few years, it has become particularly popular among researchers in cognitive science.

Response inhibition is one of the pillars of cognitive control. It refers to the capability of inhibitory processing of misleading or irrelevant information. Since anchors and primes can be (but are not necessarily) both irrelevant and misleading, we suggest that a higher level of cognitive control might contribute to inhibitory processing of unhelpful information and thus reduce the magnitude of priming and anchoring effects. As a result, we propose the following hypotheses: (1) A higher level of cognitive control is related to a lower level of susceptibility to the anchoring effect, and (2) A higher level of cognitive control is related to a lower level of susceptibility to the priming effect.

The purpose of the master's thesis is to find out to what extent people are susceptible to the priming and anchoring effects and how this is related to cognitive control. Our main goals are to conduct a systematic literature review, to fully explore and demonstrate the effect of anchoring and priming in our experiment throughout all the studied tasks, and test whether the priming and anchoring effects depend on cognitive control ability.

We used the quantitative method to suggest that the results from our sample might apply to the general population. For manipulating judgments with the use of anchors and primes, we chose an experimental study. While the cognitive control test was the same for all the participants, they were randomly assigned to one of the three groups in the second phase. The first group was exposed to the low anchors and a prime that was expected to provoke negative thoughts. The second group was exposed to the high anchors and a prime that was

expected to provoke positive thoughts. The third, the control group, was not exposed to any anchors or primes.

Our sample included business students attending the University of Ljubljana School of Economics and Business. We got 386 complete results in the priming, anchoring, and socio-demographic parts and we were able to connect those to 186 results from the cognitive control test. We analyzed the results using Microsoft Excel and SPSS. We excluded outliers, calculated indices, averages, standard deviations (*SD*), and correlations, and performed independent-samples t-tests. We also analyzed where the priming or anchoring effects occurred and if there was any correlation with the measurement of cognitive control.

In line with previous studies, our results also show the effect of priming and achoring on decision-making in most of the studied tasks. In the low-anchor group, we found some evidence that a higher level of cognitive control is related to a lower level of susceptibility to the anchoring effect. However, the results in the high-anchor group did not support this finding, and therefore, we could only partially confirm our hypothesis that a higher level of cognitive control is related to a lower level of susceptibility to the anchoring effects. Furthermore, we could not confirm our hypothesis that a higher level of cognitive control is related to a lower level of susceptibility to the priming effect because we did not achieve any non–numerical priming effect in our experiment.

The practical implications of our results could include assisting organizations and individuals in reducing their susceptibility to cognitive biases or using them to their advantage. We anticipate that understanding how cognitive control is related to priming and anchoring effects will be useful in human resource management (e.g., selecting new employees, arranging work, providing training and workshops), marketing (e.g., producing marketing materials and campaigns), finance (e.g., analyzing agreements), general management (e.g., negotiating), and other areas of business.

The master's thesis is structured as follows: The first section includes a review of the literature on cognitive biases, the priming effect, the anchoring effect, individual differences in susceptibility to both effects, cognitive control, and the influence of cognitive control on the magnitude of the priming and anchoring effects, as well as hypothesis development. We introduce our research method in the second section by describing the participants, design, procedure, variables, and method of analysis. We examine the descriptive statistics in the third section to see where priming and anchoring effects occurred and how significant they were. We provide the results of the cognitive control test and comment on our hypotheses based on the correlations between priming and anchoring effects and cognitive control. In the final section, we examine the results, as well as the limitations of our research and future research possibilities.

# 1 THEORETICAL BACKGROUND

## 1.1 Cognitive biases

Neoclassical economic theory is based on the assumption that humans always make perfectly rational decisions. However, science has demonstrated in recent decades that the so-called *homo economicus* does not always behave in such a manner. In 1957, Herbert Simon was among the first to use the term "*bounded rationality".* This premise acknowledges that our decisions may be biased due to information and computational capacity (Simon, 1990). The concept has become the cornerstone of modern behavioral economics.

If our judgment errors were random, the deviations would cancel each other out on a large scale (Hilbert, 2012). However, it has been demonstrated that people tend to make judgement errors in the same direction. Ariely (2008) provides the expression to describe this phenomenon—"*predictably irrational,"* which is also the title of his book. Daniel Kahneman, Paul Slovic, Richard Thaler, and Amos Tversky made significant contributions to this topic in the second part of the twentieth century. Slovic (1972) noted that limited memory, attention, and reasoning capabilities lead people to apply strain-reducing cognitive strategies when processing information and making judgments.

In his best-selling book, Thinking Fast and Slow, Kahneman (2011) uses the metaphor of system 1 and system 2 to explain how our brains function. The concept of a dual system was originally proposed by Stanovich and West (2000). System 1 is in charge of quick decisions and works with little or no effort and no sense of intentional control. System 2, on the other hand, is in charge of more complex judgments. It requires cognitively demanding activities, such as calculations.

Tversky and Kahneman are also the authors of the term "*cognitive bias*". The expression is defined as "individual tendency to make systematic judgment errors as a result of information processing shortcuts of heuristics that are embedded into the decision-making process" (Tversky & Kahneman, 1974, pp. 1130–1131). In other words, cognitive biases happen when people unconsciously let system 1 solve problems that should be solved by system 2. Similarly, Buss (Ed). (2015, p. 968) defines cognitive biases as "cases in which human cognition reliably produces representations that are systematically distorted compared to some aspect of objective reality." Based on previous experience or fresh evidence, cognitive biases can occur. When confronted with type X evidence or experience, the decision-maker will consistently choose option B over option A, which neoclassical economic models of probability and utility theory would consider to be the best option. Because of the consistency, those models have high predictive power (Hilbert, 2012).

Cognitive biases are systematic errors that are caused by heuristics, including rules, strategies, and other mental shortcuts that help us make effortless decisions. The term heuristics comes from the Greek word εὑρετικός (heuretikós) which means to find, to

discover. Johnson, Blumstein, Fowler & Haselton (2013) used the example of a stick and snake to illustrate that heuristics can positively affect our decision-making process. Due to heuristics, we sometimes think that sticks are snakes (which is harmless), while we rarely confuse snakes for sticks (which might be deadly). However, heuristics are not always that beneficial. Even though we are typically not aware of them, cognitive biases can lead to wrong judgments in literally every situation where humans make decisions. Research can help us gain a better understanding and prevent systematic cognitive biases when making important judgments. There is also evidence that some cognitive biases can be used to change our thoughts and emotions for the better.

Cognitive biases are a part of our personal and professional life and they can make a tremendous impact. Individual proneness to cognitive bias can influence how successful startups and companies are. In the past two decades, there have been more than 50 studies that researched cognitive biases in the context of entrepreneurship. Overconfidence bias and (over)optimism bias have got the most attention.

Most entrepreneurs are excessively optimistic and, on average, more optimistic than their non-entrepreneurial peers. Hmieleski and Baron (2009) defined overoptimism as the tendency to expect positive outcomes even though such expectations might not be rationally justified. Evidence suggests there is a curvilinear connection between entrepreneurs' proneness to overoptimism bias and the performance of new ventures. Some degree of optimism is necessary for entrepreneurs to start new ventures even though most startups fail. However, it has been shown that excessive optimism of entrepreneurs is related to lower revenue and slower employment growth (Gudmundsson and Lechner, 2013; Hmieleski and Baron, 2009; Thomas, 2018).

While overoptimism mostly refers to the perception of the environment, overconfidence refers to self-perception. Overconfidence refers to overestimating the reliability of one's decisions (Parikh, 2009). Various studies have found a strong connection between new venture creation and the overconfidence of the founders (Koellinger, Minniti, and Schade, 2007; Wu and Knott, 2006).

Overconfidence could also indirectly influence entrepreneurs' behavior through risk perception. Simon, Houghton, and Aquino (2000) and Keh, Der Foo, and Lim (2002) could not confirm this hypothesis. On the other hand, Grichnik (2008), Kannadhasan, Aramvalarthan, and Kumar (2014), and Robinson and Marino (2015) found that overconfidence lowers risk-perception. The results might be inconclusive because of different approaches to conceptualization and operationalization of risk perception (Thomas, 2018).

In the context of entrepreneurship there has also been some research of other cognitive biases including the law of small numbers and illusion of control (Simon, Houghton, and Aquino, 2000; Keh, Der Foo, and Lim, 2002; Kannadhasan, Aramvalarthan, and Kumar; 2014). To

gain a more structured overview of cognitive biases we present a list of most well-known ones.

Because authors choose to name and group them in different ways, the list is not definitive. We attempted to summarize and integrate various cognitive bias typologies (Cherry, 2020b; CFI Education, n.d.; Paloyelis, Asherson & Kuntsi, 2009; Jones & Harris, 1967; Parikh, 2009; Thakar, 2018; Tversky & Kahneman, 1971, Langer, 1975; Staw, 1976; Samuelson & Zeckhauser, 1988):

- *Actor-observer bias*: attributing one's own behavior to external causes while attributing other people's actions to their internal causes.
- *Affinity bias*: being more favorable towards similar people like oneself.
- *Anchoring bias*: unconsciously using irrelevant numbers as a fixed reference point for making subsequent decisions.
- *Attentional bias*: focusing on some specifics while simultaneously ignoring other specifics.
- *Availability bias*: giving stronger value to the information that comes to one's mind first.
- *Confirmation bias*: placing more value on information that supports one's current beliefs.
- *Delay aversion bias*: preferring small immediate rewards over large delayed rewards.
- *False consensus bias*: overestimating to what extent other people agree with one's view.
- *Framing cognitive bias*: making a decision based on how information is presented.
- *Functional fixedness bias*: seeing an object as if it had only a particular functionality or way of use.
- *Fundamental attribution bias*: giving too much weight to personality-based explanations of the situation compared to situation-based explanations.
- *Hallo effect bias*: unconsciously letting an impression in one area affect the perception of the same person or object in another area.
- *Herd mentality bias*: copying what others are doing.
- *Hindsight bias*: when correctly predicting a correct outcome, wrongly stating that one "knew it all along."
- *Illusion of control bias*: believing that one's skills could enhance performance in situations when skills are not required or play a minor role.
- *Law of small numbers:* drawing firm conclusions and generalizing based on small, non-randomized samples.
- *Loss aversion*: fearing losses more than wishing to make a profit.
- *Misinformation effect bias*: the recalling of memories of the event which is affected by post-event information.
- *Narrative fallacy bias*: choosing less desirable outcomes just because they have great stories behind them.
- *Optimism bias*: believing in a better outcome than could be rationally expected.
- *Overconfidence bias:* overestimating the reliability of one's decisions.

- *Priming bias*: being unconsciously influenced by a stimulus when responding to a subsequent stimulus.
- *Representativeness bias*: similarity of objects or events affects people's judgments about the probability of an outcome.
- *Self-serving bias*: taking credit when good things happen and blaming the environment when bad things happen.
- *Status quo bias*: selecting previously chosen alternatives disproportionally more often.
- *Sunk cost bias*: being overly commited to the original choice and, thus, making irrational subsequent decisions.
- *The Dunning-Kruger effect bias*: believing to be smarter and more capable than one really is.

We hope to gain a better understanding of how cognitive control affects susceptibility to one of the most robust effects in behavioral economics, the *anchoring effect*, and the closely related *priming effect*.

### 1.2 Priming effect

The priming effect, also known as short priming, is defined as the event in which exposure to one stimulus affects the response to another without the subject being aware of the connection (The Decision Lab, n.d.). The APA Dictionary of Psychology (n.d.) offers a similar definition: "*The effect in which recent experience of a stimulus facilitates or inhibits later processing of the same or similar stimulus."* The first stimulus is called prime, while the second one is known as the target (Sperber, McCauley, Ragain, & Weil, 1979).

According to Cherry (2020a), priming works by activating an association or representation in memory shortly before another stimulus or task is introduced. The understanding of how the priming effect works is based on the idea that our brain stores information in schemas that can be activated when a related stimulus occurs. When the activity of a particular schema is increased, the information from that schema becomes more accessible and is, therefore, more likely to enter into our consciousness and influence our behavior. When schemas are frequently activated together, they become connected, and our brain forms a network of connected concepts. Activation can spread through the network, so that when one schema is active, all of the connected schemas become more accessible as well. It is a unique tool that helps our brain prepare for what we are expected to encounter next and respond as quickly as possible (Psychology, n.d.).

Bargh and Pietromonaco (1982), Beller (1971), and Sperber, McCauley, Ragain & Weil, (1979) were among the first scientists to empirically demonstrate the priming effect. In recent decades, the effect has been noticed in a variety of experiments, and it is clear that it is a powerful factor in our daily judgment in both professional and personal environments. Cherry (2020a) identifies seven main conceptual categories of priming effects:

- *Positive and negative priming*: positive priming causes faster processing of the target stimulus, whereas negative priming causes a slower response to the target stimulus.
- *Semantic priming* takes place when the prime and target words are logically or linguistically connected, e. g., banana and yellow.
- *Repetition priming* happens when stimulus and response are paired repeatedly. After a certain number of repetitions, people tend to become more likely to act a specific way every time the stimulus occurs.
- *Perceptual priming* occurs when stimuli are perceived as similar. People are more likely to recognize the word goat if they have previously been primed by the word boat.
- *Associative priming* happens when exposed to two stimuli that are often linked to one another, e. g., mouse and cat; exposure to the first stimulus can cause a more rapid response to the second stimulus.
- *Conceptual priming* involves two stimuli from the same conceptual category. A person is expected to respond more quickly to the word chair if they have previously been primed by the word table.
- *Masked priming* occurs when a part of the initial stimulus is obscured in some way, e. g. with hash marks. Even though one cannot see the entire expression, it still causes a response.

Priming effects can happen across all five human senses: sight, hearing, touch, smell, and taste (Cash, 2017; Caballero Lete, Reales Avilés & Ballesteros Jiménez, 2018). If the stimuli are in form of numbers, the effect is called numerical priming, and the numbers can serve as anchors. They can be given externally or generated by the judging person. Furthermore, the anchors can be related to the issue or completely irrelevant. Even if the anchors are obviously irrelevant and uninformative, they still affect the reaction to the target stimuli (Newell, 2014).

### 1.3 Anchoring effect

Brown (1953) was among the first scientists to explore anchoring. Later, Slovic, Tversky, and Kahneman went much further and made the concept more popular. According to Hayes (2021), it is a heuristic that alludes to the unconscious use of irrelevant information as a fixed reference point for making subsequent decisions. It is a phenomenon of behavioral laboratories as well as a part of our everyday lives. Anchoring has been studied in a variety of fields, including general knowledge, probability estimates, legal judgments, valuation and purchase decisions, forecasting, negotiations, and self-efficacy, among others (Furnham & Boo, 2011). Kahneman (2011) asked one group of respondents if the world's tallest tree is higher or lower than 180 feet, while the other group was asked if it is higher or lower than 1,200 feet. Then he asked both groups what their best estimation was for the height of the world's tallest tree. He found that the estimates of the first group were much lower than the estimates of the second group.

Insufficient adjustment might be the principal reason for the anchoring effect if the anchor is self-generated by the victim of the anchoring effect or if it is externally given but presented as informative. When we try to determine a value that must be at a specific distance from the relevant anchor, we tend to underestimate the distance from the anchor because we stop at the beginning of the area of uncertainty (Kahneman, 2011). In other words, people exposed to higher anchors tend to make insufficient downward adjustments, and vice versa (Furnham & Boo, 2011).

While adjustment is a conscious activity of system 2, numerical priming is an unconscious phenomenon that happens in system 1. Strack, & Mussweiler (1997) illustrate this type of priming with the results of an experiment where they asked participants whether Mahatma Gandhi was younger or older than 140 years when he died. Since nobody in history has lived for 141 years, it is quite clear that he died younger than 140 years old, which confirms that the anchor should be ignored. However, people who were exposed to the numerical priming (the number 140) estimated Gandhi's age on the day he died significantly higher than the control group. Another experiment showed that real estate agents can be primed almost as much as ordinary people when estimating the value of a property.

Furthermore, the effect works even when it is clear that the anchor and target numbers are not related in any way. In one of the empirical studies, German judges would have sentenced a criminal to a 60% longer prison sentence if they had been primed by a rolling dice (Englich, Mussweiler & Strack, 2006). Critcher and Gilovich (2008) discovered that the number in a restaurant's name affected spending estimates (Studio 17 vs. Studio 97).

Apart from the insufficient adjustment and numerical priming explanations, there is another explanation of the anchoring effect that is not contradictory to the previously mentioned explanations. It is called "*confirmatory hypothesis testing.*" Chapman and Johnson (1999) and other researchers argue that the anchoring effect is the result of the activation of information that is consistent with the anchor presented. This process is also called "*confirmatory search*" or "*selective accessibility.*"

In the late '90s and early 21st century, there was a disagreement about whether anchoring happens due to semantic or numerical priming. Carroll (2009) showed that both semantic and numeric priming can contribute to the anchoring effect.

The magnitude of the anchoring effect depends on the type of problem and the person's attitude towards it. Anchoring becomes more powerful with a higher level of ambiguity, lesser familiarity, relevance, or connection with the problem, a more trustworthy source of priming number, and a more plausible bid, according to Van Exel, Brouwer, van den Berg & Koopmanschap (2006).

The anchoring effect is one of the few psychological phenomena that can be measured objectively. The anchoring index is the ratio of the difference between the average estimates of the low-anchor group and the high-anchor group to the difference between the low anchor

and the high anchor. See Kahneman's anchoring index formula (1). If the anchoring index equals 0, there is no effect. If it equals 100%, participants adopt the anchor as their estimate (Kahneman, 2011).

$$\text{Kahneman's anchoring index} = \tag{1}$$

$$= \frac{\text{high anchor group's average estimate} - \text{low anchor group's average estimate}}{\text{high anchor} - \text{low anchor}}$$

### 1.4 Individual differences in susceptibility to the priming effect

The power of the priming effect can depend on the features of the prime and the object's previous experience and personal traits. The magnitude of the effect is controlled by the extent to which the prime can trigger memories, needs, and desires. Most of the research so far has been focused on the group-level priming effect. However, empirical evidence shows that not all people tend to react to priming in the same way. Some research projects are focusing on finding and explaining systematic individual differences in responses to priming.

Wilson, Nusbaum, Whitney & Hinson (2018) examined whether susceptibility to cognitive biases could be related to a person's age. They found that older people showed less cognitive flexibility and were more prone to cognitive biases than younger participants. However, they were able to improve their performance throughout the trials.

According to Stankov (2013), some measures of rationality have a 0.35 correlation with IQ measures. Everaert, Grahek & Koster (2017) were examining if cognitive control of emotions could modulate depression. Their results show that a lack of inhibitory control over negative emotions may be associated to negative interpretive bias and lead to depression. However, limited cognitive resources are only one possible reason for susceptibility to cognitive bias. The other one is cognitive laziness—a motivational aversion to engaging in cognitively demanding tasks (De Neys & Bonnefon, 2013).

Robinson and von Hippel (2006) were researching how individual life satisfaction influences how individuals organize positive and negative concepts in their memory. They discovered that a higher degree of life satisfaction can be associated with a higher magnitude of positive priming effect and a lower magnitude of negative priming effect.

Furthermore, the relationship between some of the big five personality traits and the susceptibility to priming effects has been investigated. Robinson (2007) suggests that neuroticism might be related to negative affective priming but not to positive affective priming. Robinson (2010) also notes that extraversion might be a predictor of more powerful positive affective priming but not negative affective priming. On the other hand, Rebernjak

and Buško (2018) did not find a significant connection between positive affective priming and extraversion, nor between negative affective priming and neuroticism.

Yap, Hutchison & Tan (2015) studied individual differences in semantic priming performance and found that individuals with more attentional control and better reading skills achieved a stronger priming effect. The Stroop task, the automated operational span task (Unsworth, Heitz, Schrock & Engle, 2005), and the antisaccade task were used to measure attentional control (Payne, 2005). As they explain, the priming effect requires preserving the information in working memory, so participants with better working memory may experience a stronger effect. Their results, however, revealed a correlation only for the automated operational span task, with no significant correlation between the results of the other two tasks and the magnitude of the priming effect.

## 1.5 Individual differences in susceptibility to the anchoring effect

In comparison to the priming effect, there is more literature available on individual variability in response to anchoring. Researchers studied the influence of mood, knowledge and experience, motivation, personality, cognitive ability, and other factors (Furnham & Boo, 2011; Englich & Soder, 2009; Chapman & Johnson, 1994; Wilson, Houston, Etling & Brekke, 1996; Tversky & Kahnema, 1974; Eroglu & Croxton, 2010; McElroy & Dowd, 2007; Caputo, 2014; Stanovich & West, 2008; Oechssler, Roider & Schmitz, 2009;

Various studies have shown that people in a happy mood are more likely to use heuristic strategies while the information is processed more efficiently by people in a sad mood (Furnham & Boo, 2011). However, Englich and Soder (2009) found that this rule might not be true in the case of the anchoring effect. As their results show, sad people's judgments are more biased by the anchoring effect in comparison to people in a happy mood. A possible explanation is that people in a sad mood engage in more effortful processing of information by judging whether the anchor is acceptable or not. The concept is similar to the confirmatory hypothesis testing mechanism (Wegener, Petty, Blankenship & Detweiler-Bedell, 2010). This suggests that people in a happy mood might be more immune to the anchoring effect. Englich and Soder (2009) also suggest that experts are prone to the anchoring effect regardless of their current mood.

It is generally accepted that knowledge, expertise, and experience affect the magnitude of the anchoring effect. It could be assumed that if a person has more knowledge, there is less uncertainty regarding the right answer, and therefore, the information given in the anchor affects the decision to a smaller extent. This hypothesis has been supported by Chapman and Johnson (1994), Wilson, Houston, Etling & Brekke (1996) and other researchers. Smith, Windschitl & Bruchmann (2013) also showed that knowledge reduces the anchoring effect regardless of whether it is measured by subjective self-assessment or an objective knowledge test.

However, empirical evidence shows that expert's judgments are still biased by the anchoring effect. For example, real estate agents with years of experience evaluated the identical house significantly differently based on the stated ask price that functioned as an anchor (Northcraft & Neale, 1987). A possible reason could be that they were willing to engage in effortful thinking and unwillingly they compared the anchor to their existing knowledge which led to confirmatory hypothesis testing and insufficient adjustment effect. Moreover, experts tend to be overconfident about the accuracy of estimations they can provide (Tversky & Kahneman, 1974).

Researchers also tested the influence of motivation on the vulnerability to the anchoring effect. Tversky and Kahneman (1974) tested whether offering rewards for accurate answers might reduce the robust anchoring effect. They did not find any significant differences in responding to the anchor between the group that was offered rewards and the control group. This finding was confirmed by Wilson, Houston, Etling & Brekke (1996)

In contrast, Simmons, LeBoeuf & Nelson (2010) argue that monetary incentives could enhance the response to anchoring. As they explain, people do not always know which way from the anchor they have to adapt. If they knew which way the adaptation had to go, the incentives might have caused them to respond better. Wilson, Houston, Etling & Brekke (1996) also tested whether the anchoring effect could be eliminated by warning the participants about it. The results suggest that the anchoring effect persists even if participants know about it. However, the warning can play a role in reducing the magnitude of the effect.

Important and systematic differences in responding to the anchoring effect can also be caused by the personal traits and cognitive abilities of individuals. So far, the research on the influence of personality and cognitive abilities on the vulnerability to anchoring effects has been rather limited. Speaking about personality as a factor, it has mostly been focused on its influence on the big five personality traits.

To date, science has not come to any conclusion about how different levels of the big five personality traits influence susceptibility to the anchoring effect. Eroglu and Croxton (2010) found that high levels of conscientiousness, agreeableness, and low levels of extraversion are related to a stronger anchoring effect. They also found that challenge-seekers are less prone to anchoring while their locus of control does not make a significant difference in the magnitude of the effect. Moreover, openness to experience has been suggested to correlate with a more powerful anchoring effect (McElroy & Dowd, 2007). In contrast, Caputo (2014) came up with contradictory results, showing that openness to experience and agreeableness are related to a lower level of susceptibility to the anchoring effect.

It is undeniable that cognitive biases affect individuals to various extents. According to Stanovich and West (2008), the varying susceptibility of individuals to anchoring stems from many factors that influence the activation of the slower and more effortful system 2. When system 2 takes control of our brains, we are less prone to being a victim of the anchoring

effect. The question is, what factors can cause the activation of system 2 and thus reduce or prevent the anchoring effect? Stanovich and West (2008) suggest that one of the potential factors might be cognitive ability, specifically analytic intelligence.

Individual differences in vulnerability to the anchoring effect have also been examined in terms of how people make decisions. Oechssler, Roider & Schmitz (2009) used the cognitive reflection test to find how impulsive versus more reflective decision-makers tend to be biased by the anchoring effect. They did not see a significant difference between the two groups.

### 1.6 Cognitive control

Cognitive control is defined as "*the ability to flexibly adjust behavior in the context of dynamically changing goals and task demands"* (Carter & Krug, 2012, p. 89), as *"a set of superordinate functions that encode and maintain a representation of the current task ... marshaling to that task subordinate functions including working memory ... attention ... action selection and inhibition"* (Botvinick & Braver, 2015, p. 85) and as a real-time optimization of reactions (emotion, attention, and motor) for achieving a goal (Botvinick & Cohen, 2014). The mechanism of cognitive control is activated when the brain has to override automatic responses that would otherwise be elicited by stimuli (Psychology Wiki, n.d.).

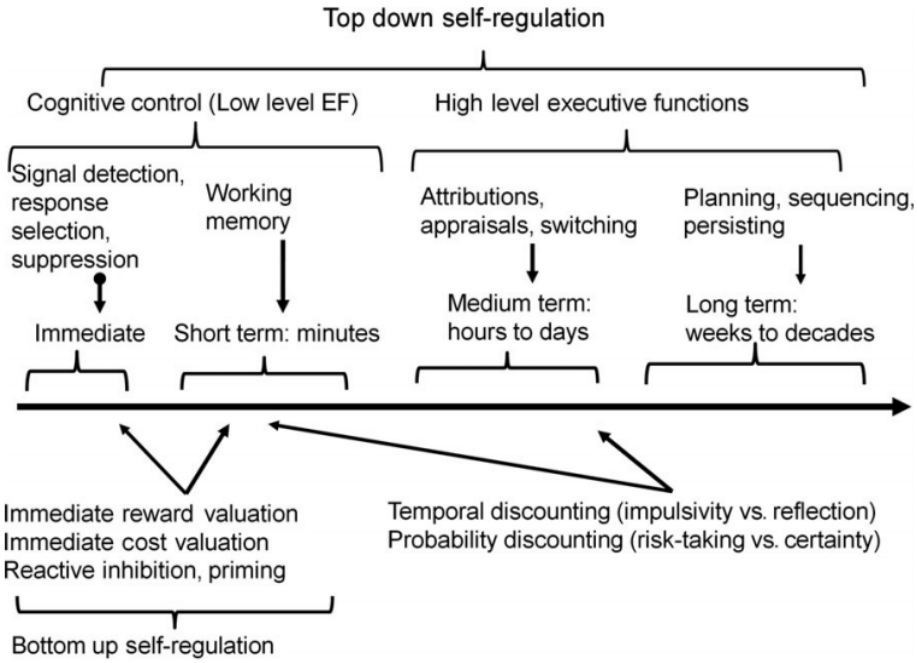
The British psychologist Donald Broadbent (1952) is considered one of the first scientists who indirectly researched cognitive control. He suggested that we should differentiate between automatic and controlled processes and introduced the term "*selective attention,*" to which cognitive control is closely related. Further, in 1975, the US psychologist Michael Posner titled a chapter of his book "Attention and Cognitive Control" (Psychology Wiki, n.d.). Even though cognitive control has been discovered since the late 1950's, it has become more popular only in the past 20 years.

Cognitive control is controlled by reciprocal connectivity between the prefrontal cortex and the sensory, limbic, and motor cortexes. Miller and Cohen (2001) found that cognitive control is the primary function of the prefrontal cortex and that the control is executed by increasing the gain of sensory or motor neurons that are activated by goal-relevant elements in the environment. The activated neurons affect sensory modalities as well as systems responsible for response execution, memory retrieval, emotional evaluation, etc. (Psychology Wiki, n.d.).

Cognitive control is often used interchangeably with the term "*executive function*". Despite the fact that the expressions are closely related and overlap to some extent, they should be clearly distinguished. According to Nigg (2017), cognitive control is narrower than executive function, with less emphasis on sophisticated cognition. The executive function consists of higher-level functions such as attributions, appraisals, switching, planning,

sequencing, and persisting, and lower-level functions such as signal detection, response selection, suppression, and working memory. While high-level executive function typically refers to longer periods (hours, weeks, decades), lower-level executive function refers to immediate responses and responses in a matter of minutes. As explained by Diamond (2013), cognitive control equals lower-level executive functions. Executive function depends on cognitive control, but it also includes more complex cognition and emotions (Nigg, 2017). Figure 1 shows the relationship between cognitive control and executive function.

*Figure 1: Relationship between executive function and cognitive control*




*Source: Nigg (2017)*

Cognitive control is an umbrella term in cognitive psychology that encompasses executive attention, working memory, response inhibition, and interference control. Some authors also suggest components such as signal detection, action selection, and signal execution (Nigg, 2017) or updating, task switching, and response selection (Miyake et al., 2000).

Although not all people have the same abilities for cognitive control, this does not mean that an individual's levels are fixed. Empirical evidence shows that they can be manipulated. Cognitive control can be affected by factors such as motivation and emotions (Chiew & Braver, 2011), monetary incentives and social pressure (Ličen, Hartman, Repovš & Slapničar, 2016; Ličen et al., 2019) and even mindset (Schroder, Moran, Donnellan & Moser, 2014).

Braver (2012) established the "*dual mechanism of control framework*". It suggests that there are two possible cognitive control strategies: proactive control and reactive control. Proactive control refers to the strategy whereby, in anticipation of a cognitively demanding

event, a person maintains all goal-relevant information in working memory to adjust their response to the event in a goal-driven manner. On the other hand, in the case of a reactive control strategy, attention is engaged as a correction mechanism that is activated after the cognitively high interference event is recognized. Banich et al. (2009) found the prefrontal cortex plays a crucial role in performing cognitive control. Braver (2012) noted that from the neurological point of view, proactive and reactive control do not look the same. While in the case of proactive control, only the lateral prefrontal cortex is activated, in the case of reactive control, other regions of the brain also get active.

For cognitive control to be activated, a conflict is needed. There are four main categories of conflicts in this area: (1) Response conflict occurs when the expected (primed) event differs from the actual event, (2) Perceptual conflict occurs when relevant and irrelevant – but comparable – information interferes with the achievement of a desired goal, (3) Cognitive conflict occurs when task-irrelevant associations interfere, and finally, (4) Objective conflict occurs when pursuing one goal undermines the situation for pursuing the other (Nigg, 2017).

## 1.7 The influence of cognitive control on the priming and anchoring effects

Up to date, there has been a very limited number of studies that would examine how cognitive control might affect susceptibility to cognitive biases, in particular priming and anchoring effects. However, there has been more research on the influence of cognitive ability on an individual's susceptibility to cognitive biases. Cognitive ability is a concept that strongly overlaps with the concept of executive function. It can also be referred to as general intelligence (Newman & Newman, 2020). It is an umbrella term that includes the mental capacities to *"reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience.*" (Gottfredson, 1997, p. 13).

Stanovich and West (2008) predicted that cognitive ability and biased responding should be negatively related. In seven different studies, they examined whether cognitive ability reduces the susceptibility to the anchoring effect and other thinking biases, but they did not find a significant correlation. However, their hypotheses have been confirmed by Bergman, Ellingsen, Johannesson & Svensson (2010), who found that the anchoring effect in the group with higher cognitive ability was significantly lower than the one in the group with lower cognitive ability, although the anchoring effect was robust in both groups.

In contrast, Oechssler, Roider & Schmitz (2009) discovered that cognitive ability affects conjunction fallacy and conservativism in probability updating, yet they did not find any influence on the anchoring effect. Their results even show that higher cognitive ability might be related to a stronger anchoring effect, but the connection was not significant. Bergman, Ellingsen, Johannesson & Svensson (2010) criticized the use of the cognitive reflection test for predicting the anchoring effect because it covers only limited dimensions of cognitive system skills. Furnham and Boo (2011) suggest that apart from cognitive reflecting, anchoring might depend on other cognitive skills in reasoning and information processing.

The results of studies examining the impact of cognitive abilities on the susceptibility to the anchoring effect are mixed and contradictory to some extent. Researchers have failed to identify any cognitive ability component or personal trait that would systematically and explicably affect the power of the anchoring effect (Furnham & Boo, 2011). Therefore, further research is needed.

One of the leading scientists researching the influence of cognitive ability on susceptibility to cognitive biases Stanovich (2011) suggested that high cognitive ability does not make people immune to cognitive errors. He suggests that we should strictly distinguish intelligence from rationality. With his colleagues, they showed that some tasks that demand a high level of cognitive reflection can be a better indicator of an individual's susceptibility to cognitive biases than the classical intelligence quotient test.

One of the problems that they presented in their cognitive reflection test was a bat-and-ball problem: If a bat and a ball cost $1.10 combined, and the bat is exactly $1 more expensive than the ball, how much does the ball cost? The numbers typically prime participants to give the wrong answer of $0.10. Therefore, the participants need to ignore the appealing and easy-primed response to correctly answer the bat-and-ball problem. In other words, to succeed, they have to apply cognitive control to the response conflict. Thus, we can assume that cognitive control might be a powerful predictor of susceptibility to cognitive biases too. As argued by Stanovich, West and Toplak (2011), intelligence-related differences in thinking occur primarily due to differences at the algorithmic level of cognitive control.

Gardner (1959) was one of the first researchers to connect cognitive control to perceptual behavior. He found consistent differences in spontaneous attention deployment among individuals. While some focus more on anchoring objects, others tend to use their attention in a more balanced fashion, which results in systematically different responses to anchoring.

Ortells, Noguera, Álvarez, Carmona & Houghton (2016) were among the few authors who examined whether cognitive control resources could affect negative or positive priming effects in an indirect manner. The main variable was working memory capacity. They differentiated relevant primes from those primes that should be ignored. Negative semantic priming results suggest that the group with higher working memory capacity (and, presumably, a higher level of cognitive control) is able to engage in more active inhibitory processing of irrelevant primes.

De Fockert, Mizon & D'Ubaldo (2010) took another approach. Instead of dividing their participants into high and low cognitive control groups, they divided the tasks depending on the cognitive control load. Their results show that in the trial with a high cognitive control load, the effect of negative priming was eliminated, suggesting that negative priming is affected by the availability of cognitive control resources.

Cognitive control can moderate priming and anchoring effects by either amplifying neural representation of task-relevant information, inhibiting neural representation of task-

irrelevant information, or both. Cognitive neuropsychology has been researching the three alternatives for decades, but it is still not clear whether cognitive control upregulates the processing of relevant information or downregulates the processing of irrelevant information.

Egner and Hirsch (2005) proposed that human brains use cognitive control to intentionally bias perceptual processing by amplifying relevant information rather than inhibiting irrelevant ones. In contrast, Banich (2019) claims that cognitive control areas in the dorsolateral prefrontal cortex inhibit task-irrelevant information perceptual processing rather than the other way around. They do not, however, rule out the possibility that task-relevant information processing improves performance. Instead, they claim that there is no evidence that this occurs as a result of the cognitive control mechanism being activated.

## 1.8 Hypotheses development

Research on cognitive biases has been primarily focused on group-level effects. However, Robinson and von Hippel (2006), Yap, Hutchison & Tan (2015), Robinson (2010), Eroglu and Croxton (2010), McElroy and Dowd (2007), and others have found systematic and predictable differences in how individuals react to priming and anchoring effects.

Various variables have been tested, including the big five personality traits, life satisfaction, attentional control, reading ability, mood, knowledge and experience, motivation, and others. (Robinson, 2007; Robinson & von Hippel, 2006; Yap, Hutchison & Tan, 2015; Furnham & Boo, 2011; Englich & Soder, 2009; Chapman & Johnson, 1994; Wilson, Houston, Etling & Brekke, 1996; Tversky & Kahnema, 1974; Eroglu & Croxton, 2010; McElroy & Dowd, 2007; Caputo, 2014; Stanovich & West, 2008; Oechssler, Roider & Schmitz, 2009; Even though the anchoring and priming effects are cognitive biases, science still has not found any cognitive ability that would predictably affect people's reactions to them.

Stanovich & West (2008), Bergman, Ellingsen, Johannesson & Svensson (2010) and Oechssler, Roider & Schmitz (2009) examined whether a higher level of general cognitive ability correlates with a lower magnitude of anchoring effect. Stanovich & West (2008) and Oechssler, Roider & Schmitz (2009) did not find any significant correlation, whereas the results of Bergman, Ellingsen, Johannesson & Svensson (2010) show that the concepts might be correlated. Furnham and Boo (2011) suggested that anchoring might depend on other cognitive skills in reasoning and information processing. There might be better and narrower predictors of an individual's susceptibility to priming and anchoring than cognitive ability. Stanovich, West & Toplak (2011) suggest that intelligence-related differences in thinking occur primarily as a result of cognitive control.

There has been some research that indirectly taps into the influence of cognitive control on the priming effect. De Fockert, Mizon & D'Ubaldo (2010) and Ortells, Noguera, Álvarez,

Carmona & Houghton (2016) showed that the negative priming effect can be influenced by the availability of cognitive control resources and that people with a higher level of cognitive control are more capable of engaging in active inhibitory processing of irrelevant primes.

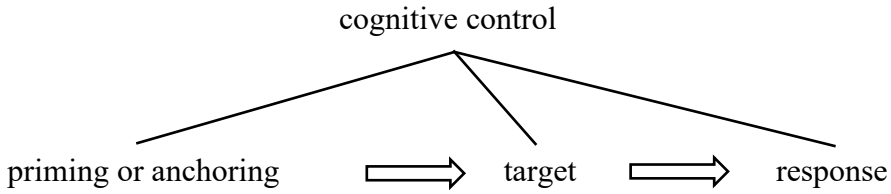
Cognitive control is needed when people encounter responsive, perceptual, or cognitive conflicts, which can be the case in priming and anchoring. As cognitive control includes executive attention, working memory, response inhibition, and interference control, it might be assumed that stronger cognitive control contributes to the inhibitory processing of irrelevant information, causing a lower magnitude of the priming and anchoring effects. Therefore, we propose the following hypotheses:

H1: A higher level of cognitive control is related to a lower level of susceptibility to the anchoring effect.

H2: A higher level of cognitive control is related to a lower level of susceptibility to the priming effect.

Figure 2 depicts the proposed hypotheses' conceptual model. We hypothesize that cognitive control influences how people perceive and react to primes, anchors, and target stimuli.

*Figure 2: Conceptual model*




*Source: Own work.*

# 2 RESEARCH METHOD

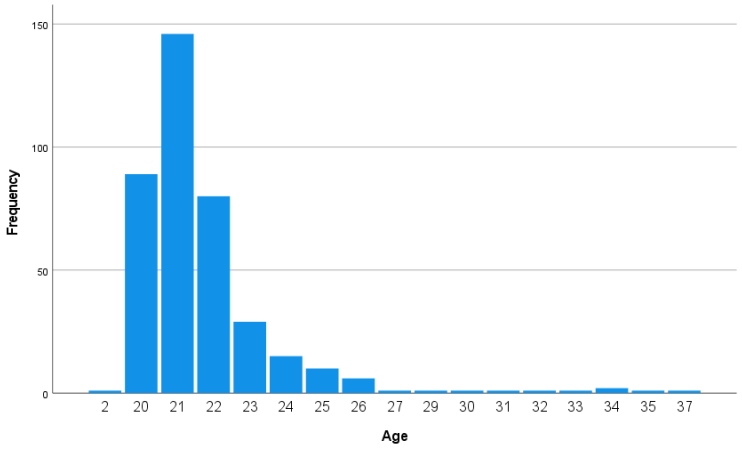
## 2.1 Participants

There were 386 participants included in our empirical research. All of them are students at the University of Ljubljana, School of Economics and Business. We recruited them at the Accounting class led by doc. dr. Mina Ličen, an informal advisor for this thesis, which enabled us to get larger sample. The attendees were randomly assigned to one of the three groups: low-anchor group, high-anchor group, or control group; 134 in the low-anchor group, 141 in the high-anchor group, and 113 in the control group[1]. The final sample

[1] Due to the online nature of the experiment, it was difficult to control for an equal distribution of participants in each manipulated condition.

included 139 (36.10%) men and 246 (63.90%) women. The mode of age was 21, *SD* = 2.21 (see Figure 3).

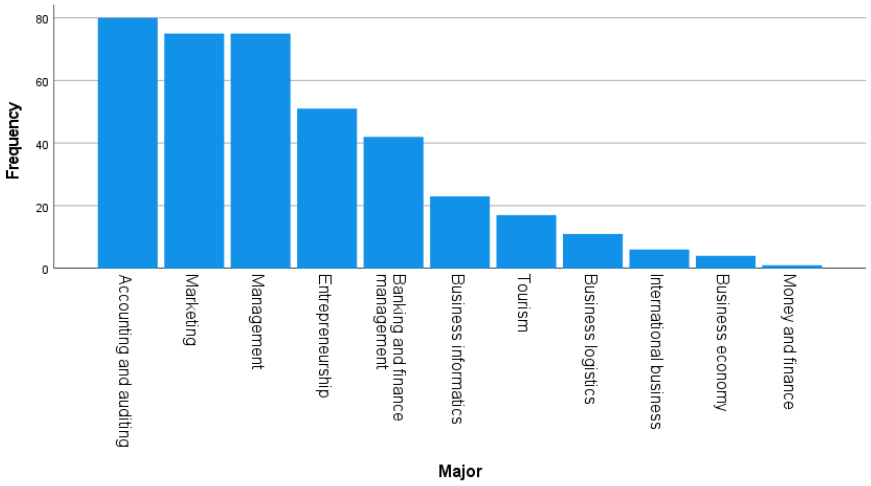
*Figure 3: Participants by age*




*Source: Own work.*

Most of the participants, 354 (91.95%), are full-time students. The most represented majors were accounting and finance, with 80 students (20.78%), followed by 75 (19.48%) students in marketing and management, respectively. There were also 51 (13.24%) students of entrepreneurship, 42 (10.91%) of banking and finance management, 23 (59.74%) of business informatics, 17 (4.42%) of tourism, 11 (2.86) of business logistics, 6 (1.56%) of international business, 4 (1.04%) of business economy, and 1 (0.26%) of money and finance (see Figure 4). There were 206 students from the UPEŠ program and 179 students from the VPŠ program.

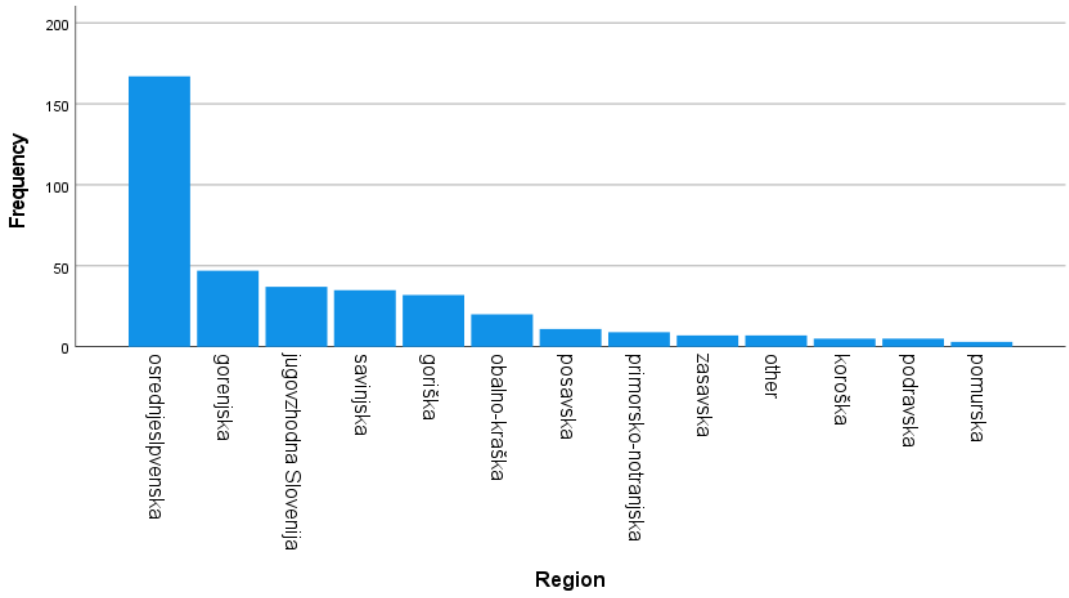
*Figure 4: Participants by major*




*Source: Own work.*

Our sample included participants from all 12 Slovenian statistical regions: 167 (43.38%) participants were from central Slovenia, 47 (12.21%) from Gorenjska, 37 (9.61%) from southeastern Slovenia, 35 (9.09) from Savinjska, 32 (8.31) from Goriška, 20 (5.19) from Obalno-Kraška, 11 (2.86%) from Posavska, 9 (2.34%) from Primorsko-Notranjska, 7 (1.82%) from Zasavska, 5 (1.30%) from Koroška, 5 (1.30%) from Podravska, 3 (0.78%) from Pomurska (see Figure 5).

*Figure 5: Participants by statistical region*




*Source: Own work.*

## 2.2 Design

We used the quantitative method for our research since our goal was to confirm our hypotheses and suggest that our results could be applied to the general population. An experimental study was used to examine how cognitive control affects the priming effect. The research was divided into two parts: the Flanker task and the anchoring and priming test with socio-demographic questions.

The Flanker task measures sustained attention, cognitive inhibition, conflict recognition, and resolution (Voelcker-Rehage, Niemann, Hübner, Godde & Winneke, 2016; McMorris, 2016). E-Prime 3.0 was used to code the task (Psychology Software Tools, 2020). It displayed a succession of seven arrows to the participants, and they had to determine which way the arrow in the middle was pointing by hitting the corresponding button (left or right arrow) on their keyboard as quickly and as consistently as possible. There were congruent trials like <<<<<<< and incongruent trials like <<<><<<. Throughout the process, the left

and right arrows in the middle had the same frequency. Incongruent trials require the activation of cognitive control. The accuracy and reaction times at incongruent trial are typically worse.

The experiment contained four blocks and lasted 6 minutes and 10 seconds. Each block included 13 trials in one minute. There were short breaks between the blocks. Each trial consisted of a 500-millisecond (ms) pattern presentation, a 1,500-ms response period, and 300-ms feedback on whether their response was accurate or incorrect. We assessed reaction times and error rates to get insights into cognitive control abilities.

The priming and anchoring test was developed using the online survey tool 1-ka. It consisted of 10 content-related questions for the experimental groups and seven content-related questions for the control group. The control group answered fewer questions because they did not answer the questions that served for anchoring. Specific tasks/questions are presented bellow in Section 2.4, Priming and Anchoring Test.

The participants were randomly assigned to one of the two experimental groups or the control group. The experimental groups filled the questionnaires with low anchors and images that stimulated negative thoughts or high anchors and images that stimulated positive thoughts, respectively. The anchors and primes were positioned just before their respective target questions. The control group answered the same questions without previously having been exposed to the primes or anchors. In the concluding part, the three groups answered seven socio-demographic questions.

## 2.3 Methodology

The research took place in May 2021, entirely online. The participants were able to join remotely through the Zoom conference calling tool. They were instructed to keep their cameras turned on at all times so that the environment was as controlled as possible. Furthermore, in that way, we were able to address additional questions.

First, the attendees were familiarized with the process, which consisted of two parts (events). The first one was the Flanker test of cognitive control, and the second one was the priming and anchoring experiment with socio-demographic questions. For the online execution of the Flanker task, we used the E-prime Go 3.0 program (Psychology Software Tools, 2020). The priming and anchoring test with socio-demographic questions was available on the online surveying tool 1-ka.

The crucial element of our study was connecting the individual results of the first and second parts. In order to provide complete anonymity of the data, we instructed the participants to make up their own 7-digit identification (ID), which had to contain four letters and three numbers. That way, we reduced the chance of having two participants with the same ID. However, some participants had problems recalling the ID when they needed to enter it in

the second study. Apart from entering the ID, the participants also had to consent to being a part of our research before starting the test or answering the questions.

The two events were not happening on the same date, and therefore, not all the participants attended both. Also, not everybody was able to perform the Flanker task because the E-prime Go program did not work properly on Apple computers, tablets, or phones. Because of that, we were not able to connect all the results from the Flanker task with the responses in the experiment with priming and anchoring tests and socio-demographic questions.

### 2.4 Priming and anchoring test

Within the experiment, the participants were exposed to the following priming and anchoring test: note that we added the marks L (low-anchor group), C (control group), and H (high-anchor group) to indicate which groups were exposed to which tasks, primes, and anchors. Those marks were not visible to the participants.

- *The number of wolves living in Slovenia*

We designed this task on our own. It aims to test if a completely irrelevant number such as the questionnaire's serial number can affect the estimate of a value that ordinary people do not know but have some expectations about – the number of wolves living in Slovenia.

This estimate served as the target variable after the participants were primed by the anchors at 38 or 138. The real number of wolves living in Slovenia is estimated to be 88 (Gov.si, 2021). We created an interval of +/–50 and thus provided 88 and 138 as the low and high anchors. The control group estimated the number without previously being primed.

L and H: *Your serial number for today's questionnaire is 38 (L)/138 (H). Please re-enter the code of your today's questionnaire in the field below.*

L and H: *Estimate if the number of wolves living in Slovenia is higher or lower than your serial number on today's questionnaire (38) (L)/(138) (H).*

L, C, and H: *Give your best guess about how many wolves live in Slovenia.*

- *The age of Mahatma Gandhi when he died*

This task was adapted from Strack & Mussweiler (1997). It presents the participant with an extremely high or low anchor, which most people know is too extreme. However, as Kahneman suggests, the anchors still affect the average response to the target question.

The participants were asked to give their best guess about how old Mahatma Gandhi was on the day of his death. Before answering this question, one group faced the low anchor – 9

years old, while the other group was exposed to the high anchor – 141 years old. [2]The control group had not previously been primed. Gandhi's real age on the day when he was assassinated was 78 years old (Biography.com, 2019).

L and H: *Was Mahatma Gandhi younger or older than 9 (L)/141 (H) years old when he died?*

L, C, and H: *Give your best guess about how old Mahatma Gandhi was when he died.*

- *The tallest tree in the world*

This problem was also adapted from Kahneman (2011); the principle is identical to the previous task – the age of Mahatma Gandhi at the time of his death. The response to the target question is expected to be affected by the extreme anchors. The participants were asked to estimate the height of the world's tallest tree. Before answering, one group was exposed to the low anchor of 60 meters and the other the high anchor of 400 meters. No anchor was provided to the control group. The tallest tree in the world is the coast redwood sequoia in the United States of America, with a height of 116.07 meters (Records, 2019).

L and H: *Is the tallest tree in the world lower or higher than 60 (L)/400 (H) meters?*

L, C, and H: *Give your best guess about how many meters tall the highest tree in the world is.*

- *The price for a dinner*

The task concept was borrowed from Critcher and Gilovich (2008). They discovered that, ceteris paribus, the number in the restaurant's name had a considerable effect on the amount customers were willing to spend for dinner.

The three groups were given the same presentation of a restaurant with the same picture. The only difference was the name of the restaurant (see appendices 1, 2, and 3). The high anchor was Studio 97, the low anchor was Studio 17, and the name in the control group was Studio.

The participants were asked to suggest the amount of EUR that they would be willing to pay for dinner for one person in the restaurant presented. This variable served as the target, subsequent to the prime in the form of the restaurant's name.

L, C, and H: *In the picture, there is a popular restaurant in the very center of the city. It is typically visited by locals as well as tourists. It is known for its excellent food and polished ambiance. It offers simple dishes, but they are made with sophisticated procedures and the*

[2] Note, that we have used 141 instead of 140 as in the original study.

*best ingredients. Enter the name of the restaurant in the picture.* The names were Studio 17 (L), Studio (C), and Studio 97 (H) (see Appendices 1, 2, and 3).

L, C, and H: *Estimate how much EUR you would be willing to pay for dinner for one person at this restaurant.*

- *Life satisfaction*

We designed this task on our own. The aim was to test whether a single image that is meant to stimulate positive or negative thoughts can prime participants to see something as significant and complex as their lives as better or worse. A 10-item Likert scale numbered from 1 (not at all satisfied) to 10 (completely satisfied) was used to measure life satisfaction.

The priming picture had two forms. One was a picture of a woman staring through the window wearing a face mask, reminding participants of self-isolation and COVID-19 (see Appendices 4 and 5). The other picture was of a sunny meadow with a positive quote by well-known Slovene poet Tone Pavček. The control group was not exposed to any pictures. The pictures served as primes for the next question about the participants' life satisfaction.

L and H: were *exposed to an image reminding them of COVID-19 (L) and an image of a meadow with a positive quote (H), respectively.*

L, C, and H: *How satisfied are you with your life, from 1 (not at all satisfied) to 10 (completely satisfied)?*

- *The salary at the age of 30*

This task was also designed on our own. It aims to test if a piece of simple information, such as the average salary of their peers, can influence our participants' expected net monthly salary, about how much they value their time.

The variable representing average net monthly salary at the age of 30 served as an anchor for the subsequent question about the participants' expected salary at the age of 30. The participants were exposed to two different anchors – average net monthly salaries for 30-year-old economists. The high anchor was EUR 1,832 and the low anchor was EUR 1,032. The control group did not get any anchors. The real value is not known to us.

L and H: *The average net monthly salary of 30-year-old economists is 1,032 EUR (L)/1,832 EUR (H).*

L, C, and H: *What net monthly salary in euros do you expect at the age of 30?*

- *A fair price for the air purifier*

We designed this task on our own. The concept was similar to the task by Critcher and Gilovich (2008), but it put the participants in a less common situation—most people have dinners in restaurants more often than they buy air purifiers.

The air purifier was shown in the pictures. The name of the air purifier was a priming variable. It had three different forms: Sinclair Turbo 44 (L), Sinclair Turbo (C), and Sinclair Turbo 444 (H). The first and last names included numbers that could serve as anchors. The actual average retail price was estimated to be approximately 240 EUR.

L, C, and H: *What is your fair pricing estimate for the air purifier Sinclair Turbo 44 (L)/Sinclair Turbo (C)/Sinclair Turbo 444 (H) seen in the picture?* The only difference between the pictures is the name of the device. (See Appendices 6, 7, and 8.)

## 2.5 Cognitive control and other variables

- *Cognitive control – reaction times*

Apart from the results of the anchoring and priming test, the main dependent variable in our research is cognitive control. The Flanker task was used to measure it (Eriksen & Eriksen, 1974). We tested the correlation between the magnitude of priming and anchoring effects and two measures of cognitive control: reaction times and accuracy. Because reaction times seemed to correlate better with the magnitude of the effects, we employed this measure in the subsequent analysis.

- *Gender*

We included this variable to control if there were any differences between genders. Male participants were coded with 1, while female participants were coded with 2.

- *Status*

This variable differentiates full-time students (coded 1) from part-time students (coded 2), repeaters (coded 3), and others (coded 4).

- *Year of study*

This variable classifies the participants according to their year of study. We coded the 1st year of undergraduate study with 1, 2nd with 2, 3rd with 3, additional year of the undergraduate study with 4, 1st year of master's degree with 5, 2nd year of master's degree with 6, an additional year of master's degree with 7, and "*other"* with 8.

- *Major*

We tested if there was any difference among students with various specializations: Money and finance (coded 1), management (coded 2), international economics (coded 3), international business (coded 4), entrepreneurship (coded 5), business economics (coded 6), business logistics (coded 7), business informatics (coded 8), accounting and auditing (coded 9), marketing (coded 10), tourism (coded 11), and bank and finance management (coded 12).

- *Study program*

We tested if there were any differences between the two study programs of the School of Economics and Business in Ljubljana. We coded UPEŠ with 1 and VPŠ with 2.

- *Statistical region*

We asked participants in which statistical region they lived. There were 13 possibilities: central Slovenia (coded 1), Gorenjska (coded 2), southeastern Slovenia (coded 6), Savinjska (coded 9), Goriška (coded 3), Obalno-Kraška (coded 4), Posavska (coded 7) Primorsko-Notranjska (coded 5), Zasavska (coded 8), Koroška (coded 10), Podravska (coded 11), and Pomurska (coded 12). The respondents could also select "*other*" (13).

Table 1 below presents the list of all indices and variables along with their types.

*Table 1: Variables, indices, anchors, and primes with types*

| **The name of the variable/index/anchor/prime** | **Type** |
|---|---|
| The number of the questionnaire | Anchor variable |
| The number of wolves living in Slovenia | Target variable |
| The age of Mahatma Gandhi when he died | Target variable |
| The height of the tallest tree in the world | Target variable |
| The name of the restaurant | Anchor variable |
| The price for a dinner | Target variable |
| Priming picture | Priming variable |
| Life satisfaction | Target variable |
| The average net monthly salary of 30-year-old economists | Anchor variable |
| Expected net monthly salary at the age of 30 | Target variable |
| The name of the air purifier | Anchor variable |
| A fair price for the air purifier | Target variable |
| Gender | Socio-demographic variable |
| Age | Socio-demographic variable |

(table continues)

*Table 1: Variables, indices, anchors, and primes with types (continued)*

| The name of the variable/index/anchor/prime | Type |
|---|---|
| Status | Socio-demographic variable |
| Year of study | Socio-demographic variable |
| Major | Socio-demographic variable |
| Study program | Socio-demographic variable |
| Statistical region | Socio-demographic variable |
| Cognitive control - reaction times | Main dependent variable |
| Anchoring wolves 1* | Anchoring index 1* |
| Anchoring Gandhi 1* | Anchoring index 1* |
| Anchoring tree 1* | Anchoring index 1* |
| Anchoring dinner 1* | Anchoring index 1* |
| Priming satisfaction 1* | Priming index 1* |
| Anchoring salary 1* | Anchoring index 1* |
| Anchoring air purifier 1* | Anchoring index 1* |
| Anchoring index 1* | Anchoring index 1* |
| Anchoring wolves 2* | Anchoring index 2* |
| Anchoring Gandhi 2* | Anchoring index 2* |
| Anchoring tree 2* | Anchoring index 2* |
| Anchoring air purifier 2* | Anchoring index 2* |
| Anchoring index 2* | Anchoring index 2* |

*Note: * These indices were used to quantify the magnitude of the priming and anchoring effects. For a more precise explanation on how they were calculated, see the next section: 2.6 Method of Analysis.*

*Source: Own work.*

## 2.6 Method of analysis

We analyzed the data using SPSS. First, we connected the Flanker task results to the outcomes of priming and anchoring effects tests, as well as socio-demographic data. Based on identification codes generated by participants, we were able to connect 186 survey results. We were unable to connect the results of the other 199 participants because they did not complete the Flanker task or forgot their identifying numbers.

The next step was to find and eliminate outliers. In the questions where participants had to give their estimates, the distributions were typically positively skewed—asymmetric to the right. When excluding values, we were rather conservative in order to not exclude any extreme values that would occur due to the anchoring effect. We decided to replace all the values that were not within the interval (mean +/–2 *SD*s) with the mean. Once we obtained

the results without outliers, we calculated the means and *SD*s for the entire sample as well as each of the three groups separately.

We also had to quantify the priming and anchoring effects. For that, we used two separate formulas. The first expressed the estimate's percentile deviation from the real value or, if the real value was unknown, from the average value (see anchoring effect 1 formula (2).

$$\text{anchoring effect } 1 = \left| \frac{\text{estimate} - \text{real value}}{\text{real value}} \right| \times 100 \quad (2)$$

The second formula expressed the estimate's percentile deviation from the anchors (see anchoring effect 2 formula (3).

$$\text{anchoring effect } 2 = \left| \frac{\text{estimate} - \text{anchor}}{\text{anchor}} \right| \times 100 \quad (3)$$

Moreover, we calculated the average magnitude of anchoring for every participant using each of the two different priming scores for the following four variables: the height of the tallest tree in the world; the number of wolves living in Slovenia; the age of Mahatma Gandhi when he died; and a fair price for the air purifier. We chose those variables because they were the only ones with objective and known real values. We named those values anchoring indices 1 and 2, respectively.[3]

We continued our analysis with IBM SPSS Statistics. We compared the averages between groups using an independent-samples t-test. All numerical variables were subjected to a bivariate correlation analysis for the total sample, as well as for the groups that were exposed to low and high anchors, respectively. In addition, we conducted linear multiple regression along with several combinations of bivariate linear regression.

# 3 RESULTS

## 3.1 Descriptive statistics

### 3.1.1 Priming and anchoring effects

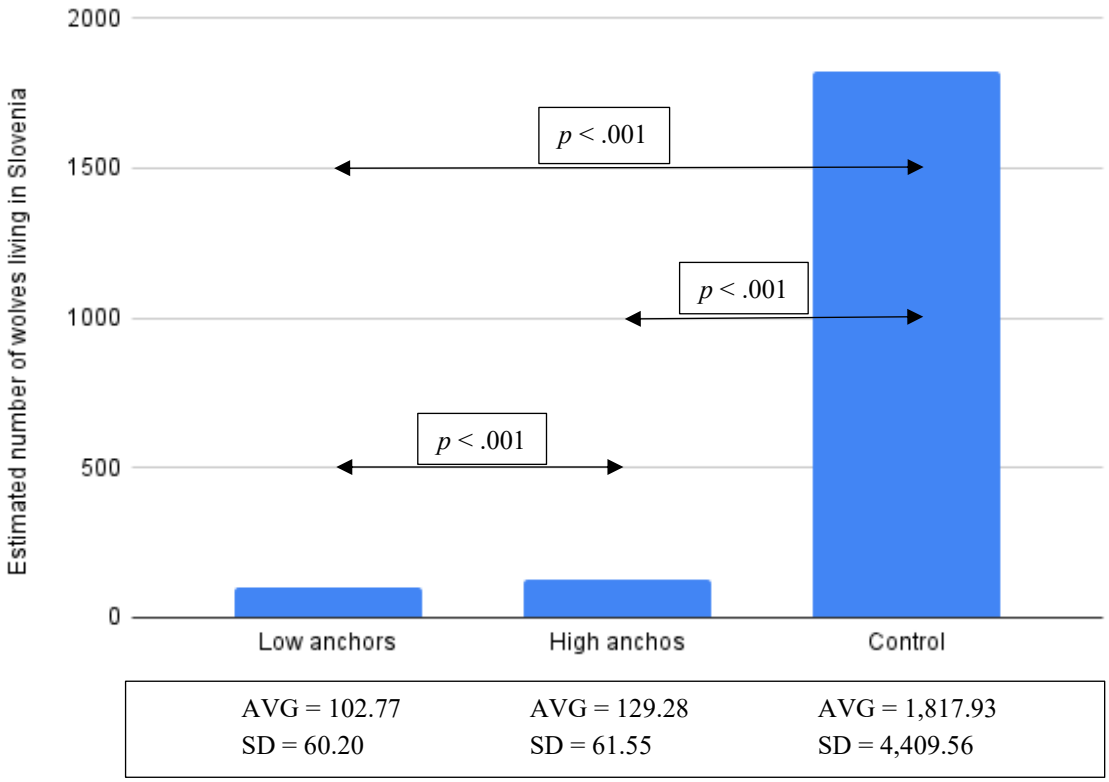
- *The number of wolves living in Slovenia*

According to Gov.si (2021), 88 wolves are living in Slovenia. The average guess of the sample was that 611.31 wolves are living in Slovenia, *SD* = 2,485.64. The low-anchor group's average guess was 102.77, *SD* = 60.20, whereas the average guess in the high-anchor

[3] *It should be noted that they are not the same as Kahneman's anchoring indices, which are designed to measure differences between groups rather than between individuals.*

group was 129.28, *SD* = 61.55. The average guess of the control group was 1,817.93, *SD* = 4,409.56 (see Figure 6).

*Figure 6: The average estimated number of wolves living in Slovenia, by group*




*Source: Own work.*

One-way ANOVA showed significant differences in average estimates between groups, $F(2,382) = 20.78$, $p < .001$. Moreover, the post-hoc t-test showed significant differences between all three pairs of groups: the control group and the low-anchor group, $t\ (110) = -4.13$, $p < .001$; the control group and the high anchor group, $t\ (110) = -4.07$, $p < .001$; and the low-anchor group and the high-anchor group, $t\ (272 = -3.60$, $p < .001$. Kahneman's anchoring index for this variable was the second-highest in our research, accounting for 26.51.

Results show that the participants adopted their estimated number of questionnaires as an anchor, even though there was no reason for them to believe that such irrelevant information could help them with their estimate. Despite the anchors' deviating 56% from the real value, they surprisingly appeared to be helpful since the average guesses of the experimental groups were significantly closer to the real value than the average guess of the control group (see Figure 8). Therefore, in this case, anchoring was actually a smart decision for an average participant. We believe the reason is that there is a misconception about how many wolves live in Slovenia. The distribution of estimates was asymmetric to the right since many participants substantially overestimated the number.

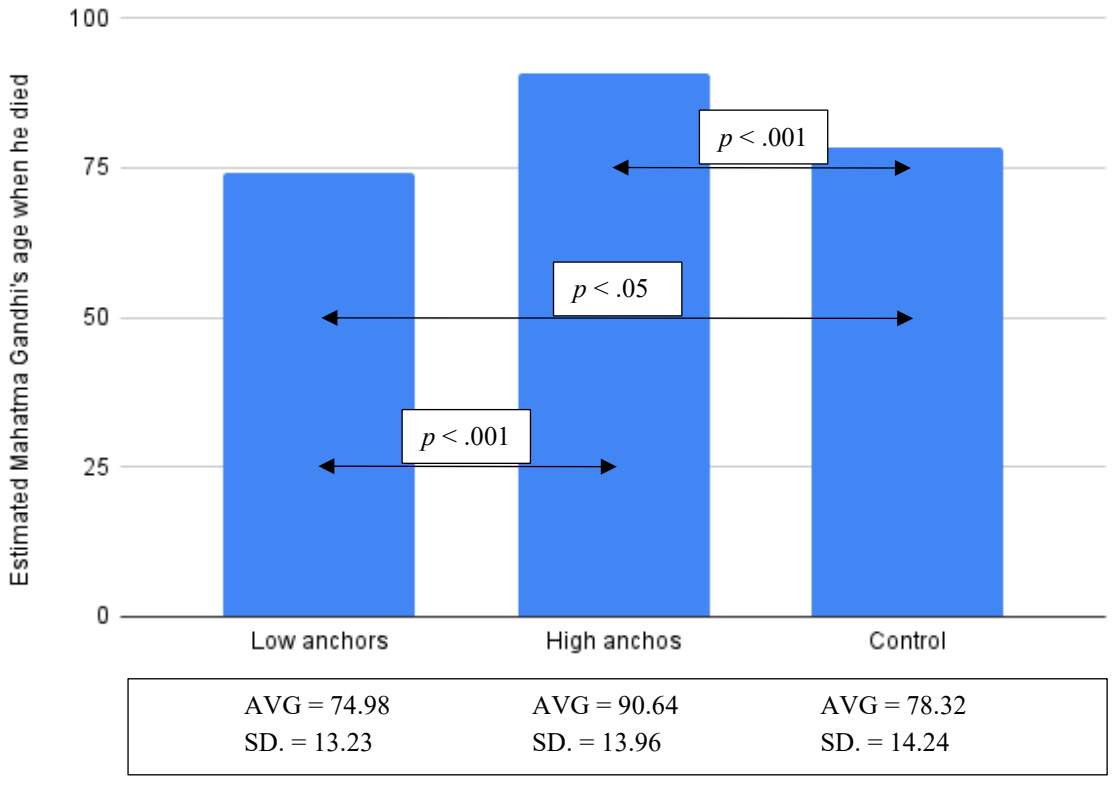
- *The age of Mahatma Gandhi when he died*

Mahatma Gandhi died at 78 years old (Biography.com, 2019). The average estimate of the entire sample was 81.44, *SD* =15.54. The average guess of the control group was accurate – 78.32, *SD* = 14.24. The low-anchor group's average estimate was 74.98, *SD* = 13.23, while the high-anchor group's average estimate was 90.64, *SD* = 13.96 (see Figure 7).

One-way ANOVA revealed significant differences in average estimates between groups; $F$ (2,382) = 52.71, $p < .001$. Moreover, the t-test showed significant differences between all three pairs of groups:the control group and the low-anchor group, $t$ (242) = –2.56, $p < .05$, the control group and the high anchor group, $t$ (250) = 6.75, $p < .001$, and the low-anchor group and the high-anchor group, $t$ (272) = –10.07, $p < .001$. Kahneman's anchoring index equals 26.51.

Results indicate that the control group's guesses were better in comparison to the experimental groups'. They were actually outstandingly precise—on average, the control group guessed Gandhi's exact age on the day of his death.

*Figure 7: Average estimate of Mahatma Gandhi's age when he died, by group*




*Source: Own work.*

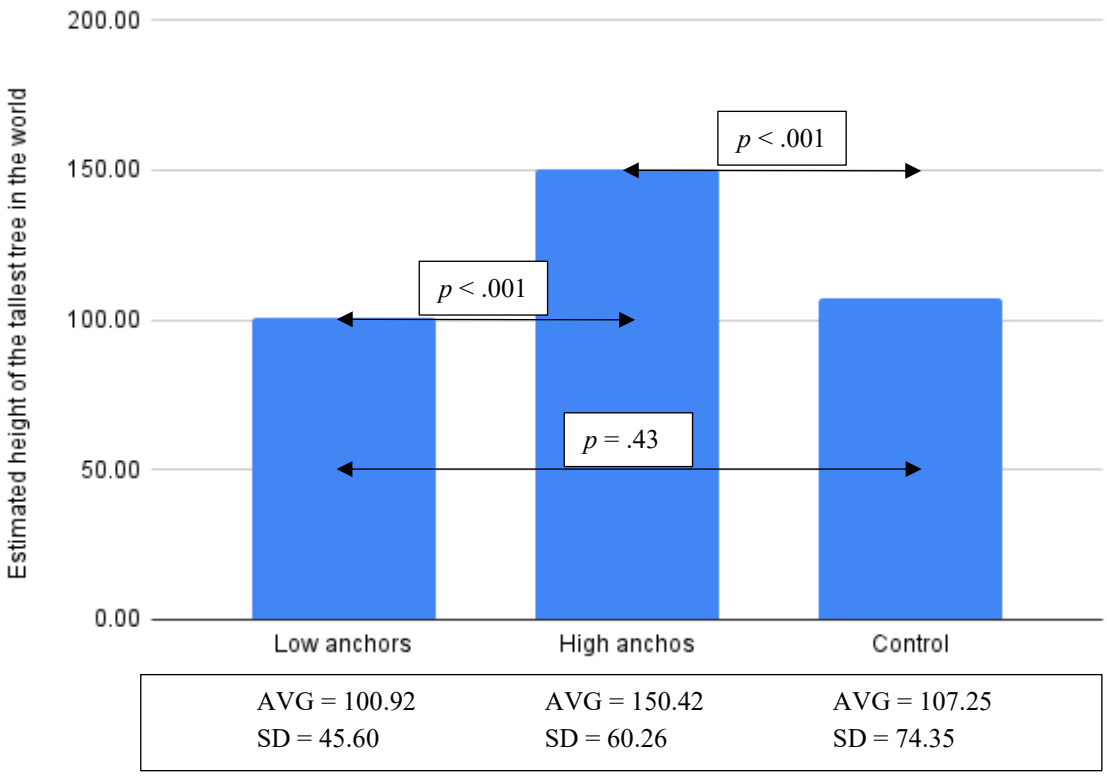
- *The height of the tallest tree in the world*

The tallest tree in the world is the coast redwood sequoia, with a height of 116 meters. The average estimate of the entire sample was 120.80, *SD* = 64.30. The average guess of the control group was 107.25, *SD* = 74.35. The low-anchor group's average estimate was 100.92, *SD* = 45.60, whereas the high-anchor group's average estimate was 150.42, *SD* = 60.26 (see Figure 8).

One-way ANOVA revealed significant differences in average estimates between groups; $F(2,382) = 27.106$, $p < .001$. There were also significant differences between the high-anchor group and the control group, $t(250) = 5.12$, $p < .001$, and between the two experimental groups, $t(259) = -7.69$, $p < .001$. The difference in average estimates of the control group and the low-anchor group was not significant, $t(175) = -.78$, $p = .43$. There was a significant difference in estimate accuracy between genders, $t(362) = 3.07$, $p < .01$. On average, men missed the real value by 35.65 meters, while women missed it by 46.23 meters. Kahneman's anchoring index was 14.56.

The distribution of the three groups' average estimates was as expected. The low-anchor group's guess was the lowest, the high-anchor group's was the highest, and the control groups' was in between (see Figure 10).

*Figure 83: Average estimated height of the tallest tree in the world, by group*



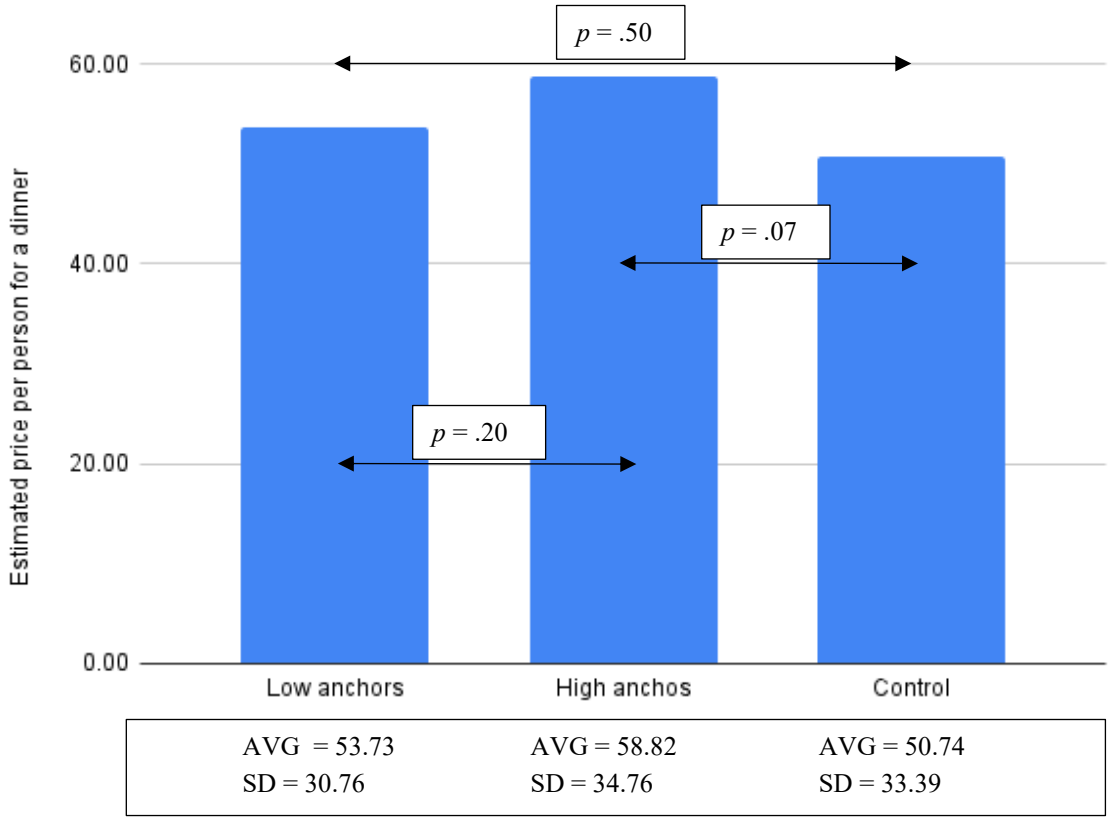

*Source: Own work.*

- *The price for a dinner*

The average price that the participants would pay for a dinner in the restaurant in the provided picture was EUR 54.79, *SD* = EUR 33.10. On average, the participants in the control group would pay the least EUR 50.74, *SD* = EUR 33.39. In the low-anchor group, the average estimate was EUR 53.73, *SD* = EUR 30.76, while in the high-anchor group, the average estimate was EUR 58.82, *SD* = EUR 34.76 (see Figure 9). One-way ANOVA revealed no significant differences in average estimates between groups, $F$ (2,382) = 1.876, $p$ =.155.

We did, however, discover a significant gender difference, $t(383) = 1.90$, $p < .05$, indicating that women are willing to pay more for dinner than men. On average, men would pay EUR 50.34 while women would pay EUR 56.30.

*Figure 94: Average price per person that the participants would pay for dinner, by group*




*Source: Own work.*

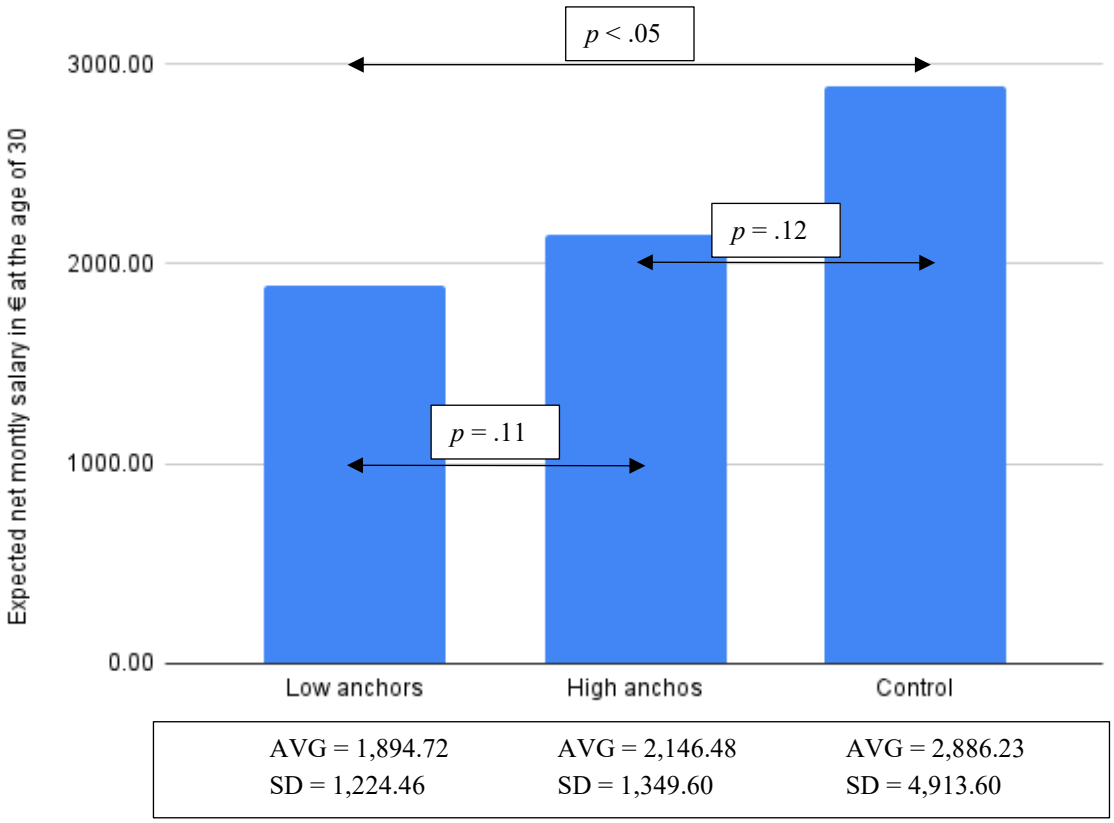
Even though the differences between groups were not significant, we perceived some effect. We assume that a stronger effect might appear if the name of the restaurant was better visible in the picture so that it would make a greater impression. It is also noteworthy that women would pay EUR 5.96 (11.84%) more than men.

- *Expected net salary at the age of 30*

The average expected net salary at the age of 30 for the entire sample was EUR 2,276.55, *SD* = EUR 2,874.80. On average, the control group was the most optimistic, expecting a salary greater than the low and the high anchor, EUR 2,886.23, *SD* = EUR 4,913.60. The low-anchor group expected an average of EUR 1,894.72, *SD* = EUR 1,224.46, whereas the high-anchor group expected an average of EUR 2,146.48, *SD* = EUR 1,349.60 (see Figure 10).

One-way ANOVA showed significant differences in average estimates between groups; $F(2,382) = 3.986$, $p < .05$. There is also significant difference between the control group and the low-anchor group, $t(121) = -2.10$, $p < 0.05$. There is, however, no significant difference between the control and high-anchor group, $t(123) = -1.59$, $p = .12$, or between the experimental groups, $t(272) = -1.61$, $p = .11$. Nevertheless, Kahneman's anchoring index for this variable is the highest in our study — 31.47. There is also a statistically significant gender difference, $t(363) = -3.24$, $p < .001$. On average, men expect a salary of EUR 2,846.87, while women expect EUR 1,954.47.

*Figure 10: Average expected net monthly salary in EUR at the age of 30, by group*




*Source: Own work.*

A similar phenomenon was observed in the case of wolves in Slovenia. The estimates of the control group were higher on average than those of the high-anchor group. The cause of this

phenomenon could be that the anchors stimulated the participants to make more realistic estimations, as the *SD* in the control group was approximately three times higher than in the experimental groups. Kahneman's anchoring index is the highest in our study, despite the fact that the difference between the experimental groups was not significant. This suggests that if the anchors were placed further apart, we would be able to achieve significant differences.

Apart from the anchoring effect, the differences between groups might also be attributed to social comparison. According to Adams' motivational theory, people evaluate their salary based on what their peers earn for the same input (Adams, 1963). Therefore, the participants might have felt the pressure to state that their expected salary is greater than the provided anchor, which represents what their peers will earn.

Another noteworthy finding was that male participants projected a salary of EUR 889.40 (45.41%) higher than female participants, despite the fact that women in Slovenia earn "only" 7.90% less than men. In comparison, the average for the European Union (EU27) is 14.10%. (Statista, 2021). This could indicate that women were more susceptible to the anchoring effect when it came to salary questions.

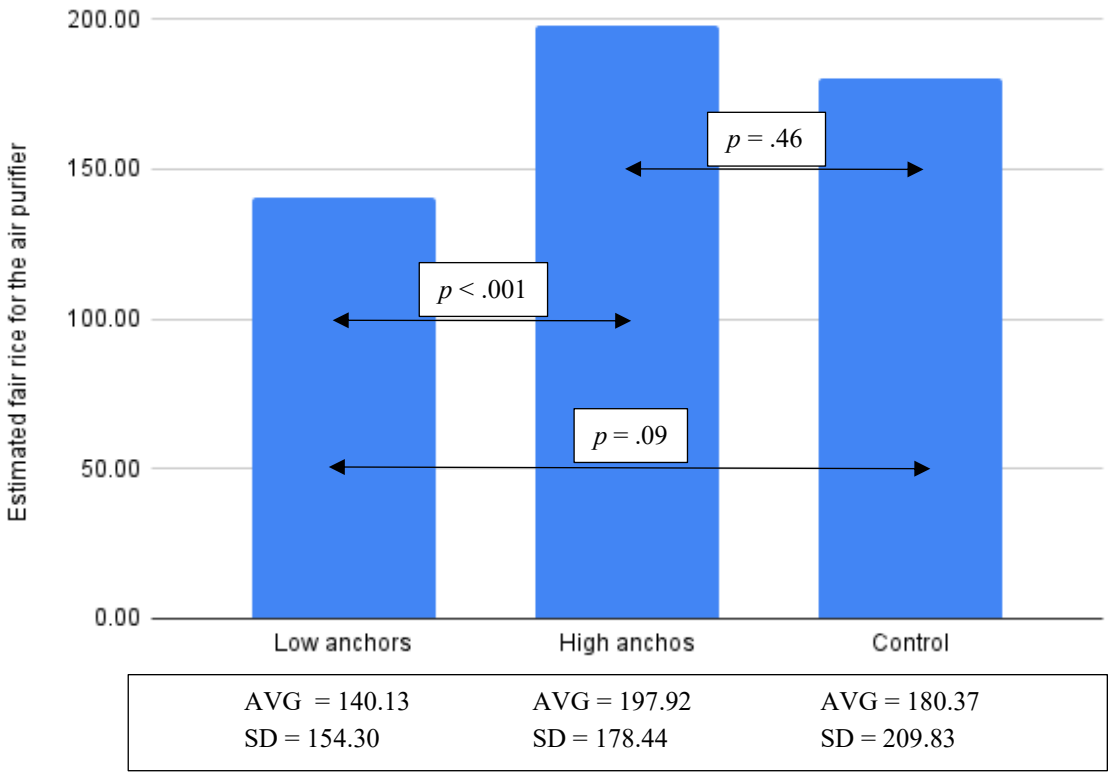
- *A fair price for the air purifier*

Based on our research, the average retail price for the Sinclair SP-45A air purifier is approximately EUR 240. The average estimate of a fair price for the entire sample was EUR 172.71. The control group's average estimate was EUR 180.37, *SD* = EUR 209.83. The low-anchor group's average estimate was EUR 140.13, *SD* = EUR 154.30, whereas the high-anchor group's average estimate was EUR 197.92, *SD* = EUR 178.44 (see Figure 11).

One-way ANOVA showed significant differences in average estimates between groups, $F(2,382) = 3.627$, $p < .05$. However, the t-test did not show any significant differences between the low-anchor group and the control group, $t\ (242) = –1.70$, $p = .09$, nor between the high-anchor group and the control group, $t\ (250) = .743$, $p = .46$. The average estimates of the two experimental groups are significantly different, $t\ (269) = –2.87$, $p < .001$. Kahneman's anchoring index equals 14.45. (For comparison of the anchoring indices by variables, see Figure 15.) There was also a significant gender difference , $t\ (343) = 2.42$, $p < .05$. On average, men estimated a price of EUR 144.95, while women estimated a fair price would be EUR 188.40.

Even though the participants did not write down the name of the device (with the number — anchor), the effect still occurred. As seen in the question about how much the participants would pay for dinner, on average, female participants would also estimate the air purifier as more expensive.

*Figure 11: Average estimated fair price for the air purifier, by group*




*Source: Own work.*

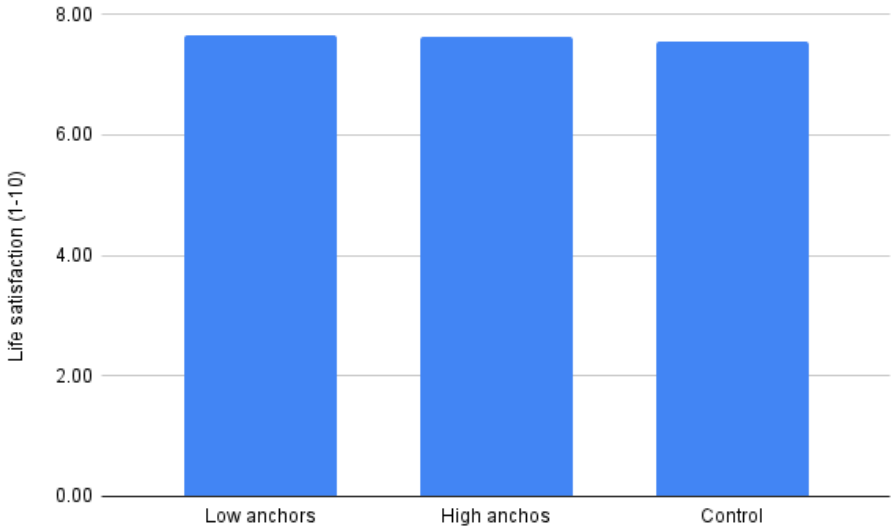
Even though the three estimates were lower than the actual value, the high-anchor group was the closest to real value. This question has a very similar concept to the one about the price of a dinner. However, in the case of the price of the air purifier, the effect was significant. A potential explanation for the difference between the two results is that in the case of the air purifier, the participants did not have any other information, while in the case of the dinner, there was also a short description of the restaurant available. Moreover, the first price is for a service, whereas the second one refers to a product. Finally, yet importantly, we expect that most of the participants have more experience paying for dinner than buying an air purifier. This means that, in the case of the price of a dinner, they have a stronger reference frame and thus rely less on anchoring.

- *Life satisfaction*

This was the only estimate that was not influenced by any numerical priming and, at the same time, the only variable where we did not perceive any effect. The average estimate of the entire sample was 7.61, *SD* = 1.69. On average, the low-anchor group, the high-anchor group, and the control group answered 7.64, 7.63, and 7.54, respectively (see Figure 12). The *SD* was 1.62, 1.65, and 1.70, respectively.

One-way ANOVA did not show significant differences in average estimates between groups; $F(2,382) = .148$, $p = .862$. A potential reason for the insignificant effect of priming might be that the priming stimulus was not strong enough. Life satisfaction is such a deep concept that one image might not be enough to prime people to evaluate it differently.

*Figure 12: Average life satisfaction (1–10), by group*

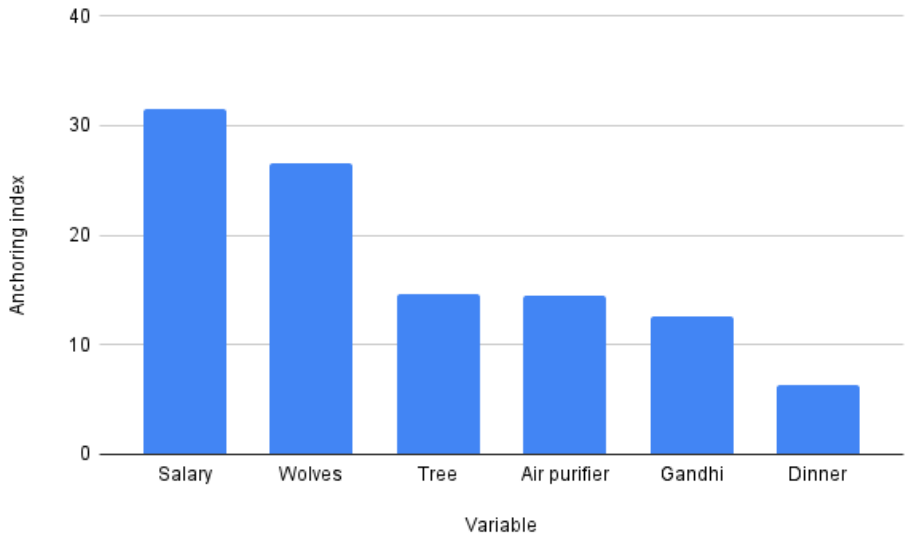



| | | |
|---|---|---|
| AVG = 7.64<br>SD = 1.62 | AVG = 7.63<br>SD = 1.65 | AVG = 7.54<br>SD = 1.70 |

*Source: Own work.*

- Kahneman's anchoring indices

Figure 13: The magnitude of anchoring effects, measured with Kahneman's anchoring index, by varia




*Source: Own work.*

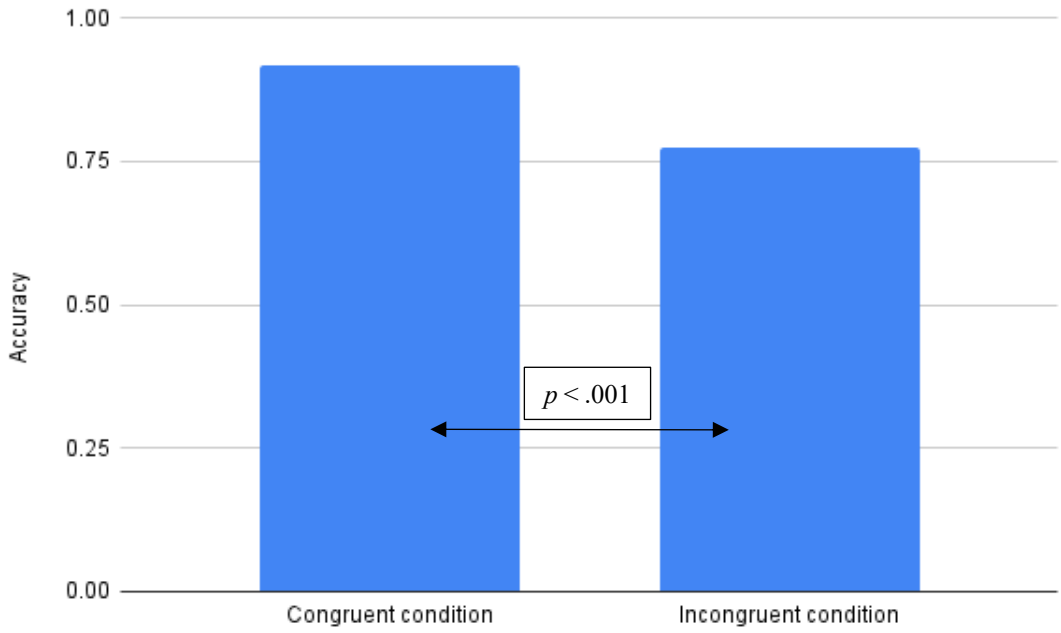
Additionally, we calculated Kahneman's anchoring indices to be able to compare the anchoring effect across questions. It shows the strongest anchoring effects on the questions about the expected salary at the age of 30 and about the number of wolves living in Slovenia. The weakest effect was achieved with the question about how much the participants would pay for dinner (see Figure 13).

### 3.1.2 Cognitive control

We tested two different measures of cognitive control: reaction time and accuracy. Reaction time measures how much time the participants need before reacting to the stimulus on their screen. Accuracy measures how many of the participants' answers were correct. For each of the measures, we got two different results based on the trial type: one in the congruent condition where all arrows pointed in the same direction, and one in the incongruent condition where the middle arrow pointed in the opposite direction.

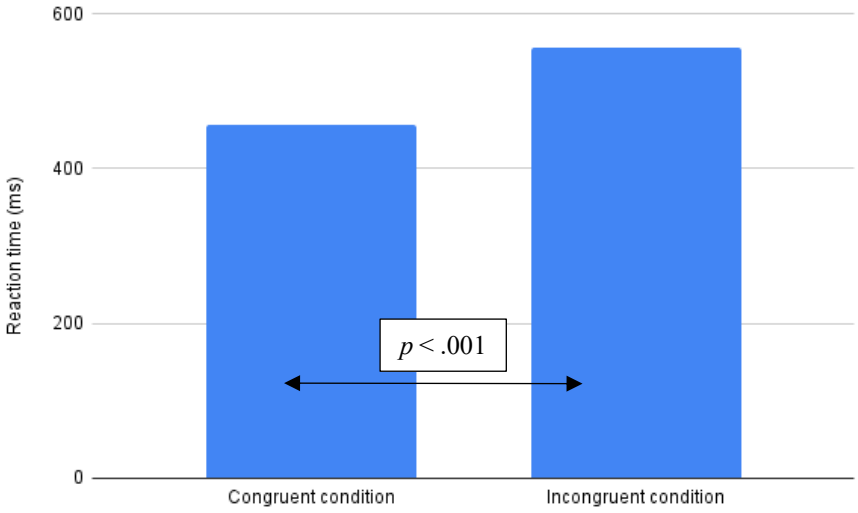
Our sample for analyzing cognitive control included 186 people. In the congruent condition, the average accuracy rate was 0.92, $SD = 0.15$, and in the incongruent condition, it was 0.77, $SD = 0.23$ ; $t\,(186) = 10.31$, $p < .001$ (see Figure 14). The average reaction time for congruent tasks was 456 ms, $SD = 74$ ms, and 558 ms, $SD = 122$ ms for incongruent tasks, $t\,(186) = -18.02$, $p < .001$ (see Figure 15).

*Figure 14: Average accuracy in congruent and incongruent conditions*




*Source: Own work.*

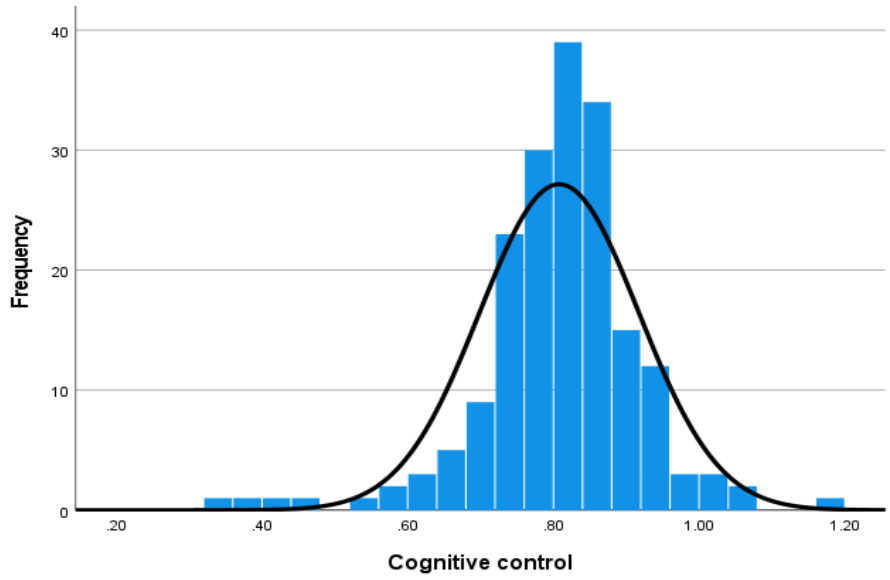
*Figure 15: Average reaction time in milliseconds under congruent and incongruent conditions*




*Source: Own work.*

The measures of reaction times and accuracy in congruent and incongruent tasks were combined into the reaction time cognitive control index and the accuracy cognitive control index. Since the reaction time cognitive control index correlated better with the magnitude of the anchoring effect in our study, we chose that measure in our further analysis. The shorter the reaction time is with minimal difference between congruent and incongruent conditions, the higher the index is. This means the participant similarly quickly responded in both conditions, indicating stronger cognitive control.

*Figure 16: The distribution of the cognitive control index, compared to a normal distribution*




*Source: Own work.*

The mean of the reaction time cognitive control index was 0.81, with a minimum of 0.33 and a maximum of 1.16, *SD* = 0.11, and the skewness was –0.87. The distribution was slightly asymmetric to the left (see Figure 16).

### 3.2 Hypotheses testing

The above results show and mainly confirm the effect of anchoring on judgement, which is in line with previous research. Going one step further, the aim of this research is to try to understand how this susceptibility to cognitive biases is related to individual cognitive control.

With H1, we hypothesize that a higher level of cognitive control is related to a lower level of susceptibility to the anchoring effect. We quantified the magnitude of the anchoring effect using two calculations. The first one expressed the percentile deviation of the estimate from the real value. The second one expressed the percentile deviation of the estimate from the anchor. A higher first value and a lower second value indicate higher susceptibility to the anchoring effect.

In the low-anchor group, there was no significant correlation between cognitive control and any of the anchoring effects that we had measured using the deviation of the estimate from the real value (index 1). However, when we considered the deviations from the anchors at the variable fair price for the air purifier (Anchoring Air Purifier 2), there was a significant positive correlation between the magnitude of the anchoring effect and the level of cognitive control, $r = .268$, $p < 0.05$. There was no significant correlation between cognitive control and any other measured anchoring effect using the deviation of estimates from the anchor as the measure (see Table 2 or Appendix 10).

Additionally, when we calculated a combined index that incorporated the anchoring effects for the variables wolves living in Slovenia, Mahatma Gandhi's age when he died, the tallest tree in the world, and a fair price for the air purifier (Anchoring Index 2), we got a significant correlation between the index and the cognitive control measures, $r = .251$, $p < .05$ (see Table 2 or Appendix 10).

According to the results, a higher level of cognitive control is positively correlated with a higher deviation from the anchor. In other words, the judgement of those with stronger cognitive control when exposed to low anchors is less likely to be affected by them.

In the high-anchor group, we did not find a significant correlation of cognitive control with any measure of anchoring effect (see Table 3 or Appendix 11).

*Table 2: Correlations of anchoring and priming effects with cognitive control, low-anchor group*

| **Low-anchors group** | **Cognitive control** | | |
|---|---|---|---|
| | Pearson Correlation | Sig. (2-tailed) | N |
| Anchoring wolves 1 | 0.104 | 0.416 | 63 |
| Anchoring wolves 2 | 0.032 | 0.801 | 63 |
| Anchoring Gandhi 1 | –0.158 | 0.215 | 63 |
| Anchoring Gandhi 2 | 0.092 | 0.472 | 63 |
| Anchoring tree 1 | –0.118 | 0.356 | 63 |
| Anchoring tree 2 | –0.021 | 0.872 | 63 |
| Anchoring air purifier 1 | 0.036 | 0.782 | 63 |
| Anchoring air purifier 2 | .268* | 0.033 | 63 |
| Anchoring index 1 | 0.023 | 0.856 | 63 |
| Anchoring index 2 | .251* | 0.047 | 63 |

*Note: * $p < .05$*

*Source: Own work.*

*Table 3: Correlations of anchoring and priming effects with cognitive control, high-anchor group*

| **High-anchors group** | **Cognitive control** | | |
|---|---|---|---|
| | Pearson Correlation | Sig. (2-tailed) | N |
| Anchoring wolves 1 | 0.094 | 0.429 | 73 |
| Anchoring wolves 2 | 0.056 | 0.638 | 73 |
| Anchoring Gandhi 1 | 0.086 | 0.469 | 73 |
| Anchoring Gandhi 2 | –0.141 | 0.234 | 73 |
| Anchoring tree 1 | 0.064 | 0.593 | 73 |
| Anchoring tree 2 | –0.036 | 0.764 | 73 |
| Anchoring air purifier 1 | 0.033 | 0.779 | 73 |
| Anchoring air purifier 2 | –0.185 | 0.117 | 73 |
| Anchoring index 1 | 0.124 | 0.294 | 73 |
| Anchoring index 2 | –0.186 | 0.115 | 73 |

*Source: Own work.*

Furthermore, we also performed a linear multiple regression analysis. Results do not show any variable that could reliably predict the value of cognitive control (see Tables 4 and 5). We can partially confirm our hypothesis H1 that a higher level of cognitive control is related to a lower level of susceptibility to anchoring, but only when exposed to low anchors, based

on correlation and regression analysis. The results for the high-anchor group, on the other hand, are inconclusive.

*Table 4: Linear multiple regression analysis, coefficients, low-anchor group*

| Variable | Standardized coefficients beta | t | Sig. |
|---|---|---|---|
| Gender | .003 | .020 | .984 |
| Age | .087 | .606 | .547 |
| Anchoring wolves | .187 | .933 | .355 |
| Anchoring Gandhi | –.111 | –.636 | .528 |
| Anchoring tree | –.112 | –.834 | .408 |
| Anchoring air purifier | –.169 | –1.117 | .269 |
| 2 Anchoring wolves | –.228 | –1.094 | .279 |
| 2 Anchoring Gandhi | –.069 | –.410 | .683 |
| 2 Anchoring tree | –.125 | –.887 | .379 |
| 2 Anchoring index | .374 | 1.945 | .057 |

*Source: Own work.*

*Table 5: Linear multiple regression analysis, coefficients, high-anchor group*

| Variable | Standardized coefficients beta | t | Sig. |
|---|---|---|---|
| Gender | .063 | .470 | .640 |
| Age | .092 | .721 | .473 |
| Anchoring wolves | .062 | .476 | .635 |
| Anchoring Gandhi | –.069 | –.318 | .751 |
| Anchoring tree | .059 | .385 | .701 |
| Anchoring air purifier | .031 | .242 | .810 |
| 2 Anchoring wolves | .171 | 1,154 | .253 |
| 2 Anchoring Gandhi | –.128 | –.585 | .560 |
| 2 Anchoring tree | .087 | .573 | .569 |
| 2 Anchoring index | –.284 | –1,886 | .064 |

*Source: Own work.*

With H2, we hypothesized that a higher level of cognitive control is related to a lower level of susceptibility to the priming effect. The only variable in our experiment where participants were exposed to non-numerical priming was life satisfaction. For this variable, we did not find any priming effect, $F(2,382) = .148$, $p = .862$, which does not allow us to conduct further analysis. Thus, we cannot confirm nor discard our proposed hypothesis H2 regarding the relationship between cognitive control and the priming effect.

# 4 DISCUSSION

We achieved a significant anchoring effect on four out of six questions that were expected to provoke it. We considered the effects significant if the average estimates between the experimental groups were statistically different based on an independent-samples t-test. These were the number of wolves living in Slovenia, the age of Mahatma Gandhi when he died, the height of the tallest tree in the world, and a fair price for the air purifier. We also perceived differences in average estimates for the price of dinner and the expected net salary at age 30, but those were not statistically significant. We did not perceive any effect on the only question that contained non-numerical priming.

Using tasks by other authors enabled us to compare some of our results to theirs. At the task where the participants had to estimate Gandhi's age on the day when he died the anchoring effect was similarly strong as in the study by Strack & Mussweiler (1997) while the estimates of our respondents were considerably more accurate. In the low-anchor group they reported an average estimate of 50.10 while our low-anchor group's average estimate was 74.98. In the high-anchor group they reported an average estimate of 66.7 while our high-anchor group's average estimate was 90.64. They got Kahneman's anchoring index of 13% while ours was 11%. This shows that our participants were slightly less susceptible to anchoring compared to the participants of the study by Strack & Mussweiler (1997).

At the task where participants had to estimate the height of the tallest tree in the world, we used slightly different anchors than Kahneman since we adopted them from feet to meters and rounded them. Therefore, we used 60 meters instead of 180 feet (54.86 meters) and 400 instead of 1,200 feet (365.76 meters). However, our results were by far less extreme than Kahneman's. Kahneman reported that the average estimate of their low-anchor group was 282 feet (85.95 meters while our low-anchor group's average estimate was 100.92. In the high-anchor group, Kahneman reported an average estimate of 844 feet (257.25 meters) while our high-anchor group's average estimate was 150.42 meters. Kahneman achieved an anchoring index of 55% while ours was 14%. This shows that our respondents might be less susceptible to the anchoring effect compared to the attendees in his research.

At the question where the participants had to suggest how much they would pay for dinner our average result in the low-anchor group was EUR 53.73 while in the original study by Critcher and Gilovich (2008) it was USD 24.58 (EUR 21.62). In the high-anchor group our average response was EUR 58.82 while the average result in the original study was USD 32.84 (EUR 28.88). We might have got higher results due to different image and description of the restaurant. Further, there is a time gap between the researches and USD and EUR have lost some value meanwhile. However, we can compare absolute differences between the groups and Kahneman's indices. We got the absolute difference of EUR 5.09 while Critcher and Gilovich (2008) got the difference of EUR 7.26. In the original study kahneman's anchoring index was 9% while our was 6%. Again, our respondents were less susceptible to the anchoring effect than the participants of the original study.

We hypothesized that a higher level of cognitive control is related to lower susceptibility to the priming and anchoring effects. We measured the anchoring effect as the percentile deviation of the estimates from the real values or the anchors. In the case of the first formula, we did not find any correlations between the anchoring effects and cognitive control. In the case of the second formula, we found significant correlations in the low-anchor group. The deviation from the anchors on the question about a fair price for the air purifier was correlated with the level of cognitive control. Since the question about the fair price for the air purifier showed one of the most robust and clear anchoring effects in our research, the correlation with cognitive control should not be overlooked.

Even more importantly, the deviation from the anchoring index, which was composed of anchoring effects, correlated with cognitive control in the low-anchor group. This means that the participants with a higher level of cognitive control were less susceptible to anchoring in that group. Even though this phenomenon did not occur in the high-anchor group, we can still partially confirm our proposed hypothesis H1.

On the other hand, we could not confirm our second hypothesis because we did not achieve any non-numerical priming effect. As discussed, we might have achieved it with stronger stimuli that would be easier to present in a face-to-face environment.

One potential reason why the experiment could not fully confirm our hypotheses was its limitations. First, our research tested the differences between subjects, not within subjects, which reduced the reliability of the results. If the same subject could answer the same question with a low anchor, a high anchor, and with no anchor without remembering the question from the previous trials, the results might be more accurate.

Another limitation was that one group was presented to high anchors only, whereas the other group was presented only to low anchors. It is possible that the participants observed the trend and responded differently as a result. The results might be more precise if the high and low anchors were evenly distributed among the surveys.

Furthermore, we used only the Flanker task to measure cognitive control. We tested how accuracy and reaction times correlate with the perceived anchoring effects, but perhaps other ways of measuring cognitive control could correlate with the magnitude of the anchoring effect better. The Flanker task is useful for evaluating how fast and how accurately people can process and react to what they see, but there might be better ways to measure cognitive control that would not depend on the sensory capabilities of the participants.

Moreover, a larger number of more systematically designed priming and anchoring tasks could help measure the effects more accurately. A larger number of tasks would allow more freedom and possibilities to join the correlating effects into indices that could show a stronger correlation with cognitive control.

A potential enhancement would also be to preliminarily test the anchors on a smaller sample size so that they would be harmonized with general public perception about the occurrences. In some questions, the participants in the control group gave the most extreme answers, which means that in those cases, anchoring was a smart decision. There would have been fewer chances of this happening if the anchors had been tested beforehand. Our results could help future research better locate the anchors. Finally, a larger sample size could increase the reliability of the results.

The limitations of our research can be used to guide future research in this area. The main guidelines for future research would be to more thoroughly measure priming and anchoring effects, as well as cognitive control. A larger number of systematically designed tasks with pre-tested anchors could be used to more accurately measure priming and anchoring. Other existing or future cognitive control tests with higher validity could be used to measure cognitive control.

# CONCLUSION

This master's thesis aimed to find out to what extent people are prone to priming and anchoring and whether people with a higher level of cognitive control are less susceptible to priming and anchoring effects.

Our goals were to conduct a systematic literature review to demonstrate priming and anchoring effects in our experiment in the relevant tasks and to test if the susceptibility to priming and anchoring effects depends on the available cognitive control resources.

In four out of six cases, we managed to achieve a significant anchoring effect. Two out of four tasks where we achieved the effect were our own, and the other two were adopted from Kahneman (2011) and Strack & Mussweiler (1997). Compared to the original studies our participants were less susceptible to the anchoring effects in all cases.

Based on our results, we can partially confirm our hypothesis, stating that a higher level of cognitive control is related to a lower level of susceptibility to the anchoring effect. In the low-anchor group, we found a weak but significant correlation between the deviations of the estimates from the anchor and the measured cognitive control. Moreover, we found a correlation between the second anchoring index—composed of deviations from the estimates from the anchors for four variables—and the measured cognitive control. Further research is required to confirm this. Speaking of priming, we did not achieve the effect and therefore could not test if the priming effect is related to cognitive control.

We also found some intriguing differences between genders: in both tasks where the participants had to evaluate the price of a product or service, women suggested a significantly higher price compared to men. On the other hand, when they had to specify their expected salary at the age of 30, women expected remarkably less.

Since we could not confirm our hypotheses, our suggestions for businesses can only refer to anchoring effects. As we have shown, higher anchors can provoke a higher number as a response when talking about estimates of random values as well as money. Therefore, customers might be more comfortable paying a higher price for a product if the number in the product's name was (significantly) higher than the current lower price. Our results also show why, in positional negotiations, it can be strategically important to make an offer first instead of waiting for the opposite side to make it.

Furthermore, our findings might be used as study materials for showing what the anchoring effect is and how it can appear in different situations. Our cases could be used in classes of marketing, entrepreneurship, behavioral economics, psychology, and others.

We might also be able to offer some advice to other researchers in this field of expertise. When planning an experiment that includes anchoring, we propose that they test the anchors on a smaller sample size first, or use (and adapt) the anchors from our study or any other prior study. As a result, they might be able to achieve greater anchoring effects. Further, we would recommend, that when trying to achieve the priming effect, they use more tasks and stronger stimuli.

We anticipate that new approaches to measuring cognitive control and other cognitive abilities will provide greater insight into the human brain's capacities, as well as the development of a measure that could better predict sensitivity to the priming and anchoring effect.

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# APPENDICES

## Appendix 1: Povzetek

Učinka naperjanja in sidranja sta del našega vsakdana. Navadno se ju ne zavedamo, kar je tudi vzrok, da nehote podcenjujemo njune posledice. Vplivata na preproste vsakdanje odločitve kot tudi tiste, ki bodo zaznamovale naša življenja ali uspešnost organizacij, v katerih delamo.

Zgodovinsko je bilo raziskovanje naperjanja in sidranja osredotočeno na učinke na ravni skupin, Robinson in von Hippel (2006), Yap, Hutchison & Tan (2015), Robinson (2010), Eroglu in Croxton (2010) ter McElroy in Dowd (2007) pa so pokazali, da je odziv posameznikov na naperjanje in sidranje odvisen tudi od osebnostnih lastnosti in zmožnosti. De Fockert, Mizon & D'Ubaldo (2010) ter Ortells, Noguera, Álvarez, Carmona & Houghton (2016) so predlagali, da bi bila lahko moč učinka naperjanja odvisna od posameznikovega kognitivnega nadzora.

Eden izmed stebrov kognitivnega nadzora je zaviranje procesiranja irelevantnih in zavajajočih informacij in s tem povezano izogibanje intuitivnim, a napačnim odgovorom. Ker so dražljaji pri sidranju in naperjanju lahko (niso pa nujno) irelevantne in zavajajoče informacije, predpostavljamo, da bi višja raven kognitivnega nadzora lahko prispevala k zaviranju procesiranja teh informacij in na ta način zmanjšala dovzetnost posameznikov za učinka naperjanja in sidranja. Tako smo postavili dve hipotezi: (1) višja raven kognitivnega nadzora je povezana z nižjo ravnjo dovzetnosti za učinek sidranja in (2) višja raven kognitivnega nadzora je povezana z nižjo ravnjo dovzetnosti za učinek naperjanja.

Želeli smo ugotoviti, do kolikšne mere so ljudje dovzetni za učinka naperjanja in sidranja ter kakšno vlogo ima kognitivni nadzor pri tem. V empiričnem delu smo uporabili kvantitativni pristop, naša raziskava pa je bila sestavljena iz Flankerjevega testa kognitivnega nadzora in eksperimenta, čigar namen je bil doseči učinka naperjanja in sidranja.

Naš vzorec je obsegal 386 študentov Ekonomske fakultete Univerze v Ljubljani. V eksperimentu smo statistično značilen učinek sidranja dosegli pri štirih od šestih nalog, kjer smo ga preučevali. Dve izmed teh nalog smo pripravili sami, dve pa sta bili prilagojeni po Kahnemanu (2011) in Strack & Mussweiler (1997). Pri vseh nalogah, ki smo jih priredili po predhodnih raziskavah, so bili naši udeleženci manj dovzetni za sidranje kot udeleženci v originalnih raziskavah. Učinka naperjanja nismo dosegli.

Odkrili smo statistično značilno povezavo med močjo učinka sidranja in ravnjo kognitivnega nadzora za eno spremenljivko in en indeks, sestavljen iz štirih spremenljivk. Na podlagi regresijske in korelacijske analize lahko delno potrdimo hipotezo, da je višja stopnja kognitivnega nadzora povezana z manjšo dovzetnostjo za učinek sidranja, ne moremo pa potrditi druge hipoteze, da je višja stopnja kognitivnega nadzora povezana z manjšo dovzetnostjo za učinek naperjanja.

Za boljše razumevanje vpliva kognitivnega nadzora na dovzetnost za učinka naperjanja in sidranja bodo potrebne nadaljne raziskave. Ključen bo večji nabor nalog, ki bodo merile učinka naperjanja in sidranja, pomembno vlogo pa bi lahko igrala tudi uporaba drugih že obstoječih ali pa novih pristopov k merjenju kognitivnega nadzora.

**Appendix 2: Restaurant, control group**


*Adapted from Varady (2016)*

**Appendix 3: Restaurant, low-anchor group**


*Adapted from Varady (2016)*

**Appendix 4: Restaurant, high-anchor group**


*Adapted from Varady (2016)*

**Appendix 5: Priming picture, low-anchor group**

*Source: Tecnotvhn (n.d.)*

**Appendix 6: Priming picture, low-anchor group**


*Source: Klevže (2013)*

**Appendix 7: Air purifier, control group**


*Adapted from Sinclair (n.d.)*

**Appendix 8: Air purifier, low-anchor group**


*Adapted from Sinclair (n.d.)*

**Appendix 9: Air purifier, high-anchor group**


*Adapted from Sinclair (n.d.)*

## Appendix 10: Correlations, entire sample

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | control/experimental group | 1.00 | | | | | | | | | | | | | | | | | |
| 2 | gender | 0.07 | 1.00 | | | | | | | | | | | | | | | | |
| 3 | age | 0.00 | 0.07 | 1.00 | | | | | | | | | | | | | | | |
| 4 | program | -0.04 | 0.06 | .165** | 1.00 | | | | | | | | | | | | | | |
| 5 | cognitive control | -0.04 | -0.04 | 0.14 | -0.01 | 1.00 | | | | | | | | | | | | | |
| 6 | anchoring_number of wolves 1 | -.265** | -0.08 | 0.05 | -0.09 | 0.08 | 1.00 | | | | | | | | | | | | |
| 7 | anchoring_Gandhi's age 1 | .170** | 0.00 | 0.04 | 0.03 | -0.02 | 0.08 | 1.00 | | | | | | | | | | | |
| 8 | anchoring_tallest tree 1 | 0.01 | .142** | 0.05 | -0.03 | -0.04 | 0.00 | .123* | 1.00 | | | | | | | | | | |
| 9 | anchoring_price for a dinner 1 | 0.04 | -0.01 | -0.04 | -0.09 | 0.08 | 0.02 | 0.01 | 0.06 | 1.00 | | | | | | | | | |
| 10 | priming satisfaction 1 | 0.04 | -0.03 | -0.05 | -0.03 | -0.08 | 0.02 | -0.02 | 0.04 | -0.05 | 1.00 | | | | | | | | |
| 11 | anchoring_sallary at the age of 30 1 | -.107* | -.140** | -0.08 | -0.09 | -0.01 | 0.08 | .105* | -0.03 | 0.06 | 0.03 | 1.00 | | | | | | | |
| 12 | anchoring_price for the air purifier 1 | -0.06 | 0.05 | -0.04 | 0.02 | -0.01 | 0.07 | -0.03 | .104* | 0.08 | 0.00 | 0.02 | 1.00 | | | | | | |
| 13 | anchoring index 1 | -.265** | -0.08 | 0.05 | -0.09 | 0.08 | 1.000** | 0.09 | 0.01 | 0.02 | 0.02 | 0.08 | 0.09 | 1.00 | | | | | |
| 14 | anchoring_number of wolves 2 | -.565** | -0.07 | 0.00 | 0.09 | 0.03 | .314** | -0.03 | -0.12 | -0.08 | -0.03 | 0.07 | 0.04 | .165** | 1.00 | | | | |
| 15 | anchoring_Gandhi's age 2 | -.958** | -0.01 | 0.03 | .170** | 0.02 | -0.11 | -.349** | -.240** | -0.09 | -0.05 | -0.05 | 0.07 | -.207** | .520** | 1.00 | | | |
| 16 | anchoring_tallest tree 2 | -.132* | 0.08 | -0.08 | -0.03 | -0.02 | 0.04 | -0.10 | 0.09 | -0.06 | 0.07 | 0.06 | -0.06 | 0.01 | .194** | .148* | 1.00 | | |
| 17 | anchoring_price for the air purifier 2 | -.341** | 0.01 | 0.01 | 0.05 | 0.16 | -0.05 | -0.04 | -.143* | 0.05 | -0.02 | 0.00 | .193** | 0.00 | .238** | .301** | .125* | 1.00 | |
| 18 | anchoring index 2 | -.873** | -0.01 | 0.02 | .142* | 0.09 | -0.02 | -.250** | -.229** | -0.05 | -0.04 | -0.01 | .129* | -0.09 | .655** | .873** | .273** | .683** | 1.00 |

*Note: * p < .05; ** p < .01; *** p < .001;*

## Appendix 11: Correlations, low-anchor group

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | gender | 1 | | | | | | | | | | | | | | | | |
| 2 | age | 0.015 | 1 | | | | | | | | | | | | | | | |
| 3 | program | .195* | 0.144 | 1 | | | | | | | | | | | | | | |
| 4 | cognitive control | -0.064 | 0.068 | -0.021 | 1 | | | | | | | | | | | | | |
| 5 | anchoring_number of wolves 1 | -0.048 | 0.037 | -0.132 | 0.104 | 1 | | | | | | | | | | | | |
| 6 | anchoring_Gandhi's age 1 | 0.051 | -0.092 | 0.03 | -0.158 | 0.07 | 1 | | | | | | | | | | | |
| 7 | anchoring_tallest tree 1 | .179* | 0.035 | 0.16 | -0.118 | 0.127 | -0.04 | 1 | | | | | | | | | | |
| 8 | anchoring_price for a dinner 1 | -0.075 | -0.11 | -0.064 | 0.167 | 0.049 | -0.034 | 0.015 | 1 | | | | | | | | | |
| 9 | priming satisfaction 1 | 0.044 | -0.069 | 0.046 | -0.018 | -0.049 | 0.006 | 0.056 | -0.072 | 1 | | | | | | | | |
| 10 | anchoring_sallary at the age of 30 1 | -.270** | -0.128 | -0.082 | 0.06 | 0.139 | 0.007 | -0.106 | 0.16 | 0.013 | 1 | | | | | | | |
| 11 | anchoring_price for the air purifier 1 | 0.098 | -0.105 | -0.049 | 0.036 | 0.069 | 0.03 | -0.093 | 0.126 | -0.065 | -0.045 | 1 | | | | | | |
| 12 | anchoring index 1 | 0.103 | -0.034 | -0.041 | 0.023 | .752** | .229** | .433** | 0.099 | -0.043 | 0.025 | .546** | 1 | | | | | |
| 13 | anchoring_number of wolves 2 | -0.092 | -0.05 | -0.023 | 0.032 | .711** | .205* | 0.081 | -0.042 | 0.002 | .178* | 0.026 | .547** | 1 | | | | |
| 14 | anchoring_Gandhi's age 2 | -0.029 | 0.036 | -0.053 | 0.092 | 0.051 | -.650** | 0.059 | 0.149 | -0.015 | -0.034 | 0.045 | -0.039 | -0.093 | 1 | | | |
| 15 | anchoring_tallest tree 2 | 0.128 | -0.165 | -0.071 | -0.021 | 0.107 | -0.123 | .423** | -0.037 | 0.149 | 0.098 | -0.037 | .199* | 0.147 | 0.077 | 1 | | |
| 16 | anchoring_price for the air purifier 2 | 0.041 | 0.01 | -0.019 | .268* | 0.003 | 0.053 | -0.114 | 0.127 | 0.007 | 0.016 | .278** | 0.113 | 0.06 | -0.096 | 0.091 | 1 | |
| 17 | anchoring index 2 | 0.013 | -0.024 | -0.055 | .251* | .295** | -0.139 | 0.026 | 0.139 | 0.027 | 0.082 | .253** | .312** | .401** | .262** | .326** | .841** | 1 |

*Note: * p < .05; ** p < .01; *** p < .001;*

## Appendix 12: Correlations, high-anchor group

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | gender | 1.00 | | | | | | | | | | | | | | | | |
| 2 | age | 0.08 | 1.00 | | | | | | | | | | | | | | | |
| 3 | program | -0.05 | .271** | 1.00 | | | | | | | | | | | | | | |
| 4 | cognitive control | 0.04 | 0.12 | 0.14 | 1.00 | | | | | | | | | | | | | |
| 5 | anchoring_number of wolves 1 | -0.12 | -0.16 | -.187* | 0.09 | 1.00 | | | | | | | | | | | | |
| 6 | anchoring_Gandhi's age 1 | -0.15 | 0.10 | 0.07 | 0.09 | 0.08 | 1.00 | | | | | | | | | | | |
| 7 | anchoring_tallest tree 1 | 0.13 | 0.08 | -0.02 | 0.06 | -0.02 | 0.14 | 1.00 | | | | | | | | | | |
| 8 | anchoring_price for a dinner 1 | 0.02 | 0.04 | -0.10 | 0.12 | 0.11 | -0.04 | 0.16 | 1.00 | | | | | | | | | |
| 9 | priming satisfaction 1 | -0.04 | -0.06 | -0.10 | -0.15 | 0.02 | -0.07 | 0.10 | -0.11 | 1.00 | | | | | | | | |
| 10 | anchoring_sallary at the age of 30 1 | -.324** | -0.12 | -0.13 | 0.05 | .230** | 0.11 | -0.06 | 0.14 | 0.08 | 1.00 | | | | | | | |
| 11 | anchoring_price for the air purifier 1 | 0.08 | -0.04 | -0.02 | 0.03 | -.179* | -0.13 | .288** | 0.00 | 0.11 | 0.02 | 1.00 | | | | | | |
| 12 | anchoring index 1 | 0.00 | -0.07 | -0.13 | 0.12 | .560** | .229** | .633** | 0.14 | 0.10 | 0.16 | .546** | 1.00 | | | | | |
| 13 | anchoring_number of wolves 2 | -.179* | 0.11 | -0.04 | 0.06 | .213* | 0.00 | -0.13 | 0.09 | 0.03 | 0.04 | -0.11 | 0.02 | 1.00 | | | | |
| 14 | anchoring_Gandhi's age 2 | 0.12 | -0.09 | -0.05 | -0.14 | -0.08 | -.812** | -0.13 | 0.03 | 0.03 | -0.13 | 0.04 | -.243** | -0.01 | 1.00 | | | |
| 15 | anchoring_tallest tree 2 | -0.05 | 0.09 | -0.02 | -0.04 | -0.07 | 0.03 | -.664** | -0.14 | -0.11 | 0.00 | -.283** | -.500** | 0.15 | -0.03 | 1.00 | | |
| 16 | anchoring_price for the air purifier 2 | -.212* | -0.04 | -0.12 | -0.19 | -0.12 | 0.08 | 0.10 | 0.15 | -0.13 | 0.14 | 0.16 | 0.07 | -0.01 | -0.06 | -0.12 | 1.00 | |
| 17 | anchoring index 2 | -.237** | 0.04 | -0.13 | -0.19 | -0.04 | -0.14 | -.298** | 0.11 | -0.12 | 0.09 | -0.04 | -.210* | .531** | .207* | .387** | .695** | 1.00 |

Note: * p < .05; ** p < .01; *** p < .001*;*