Exploring the relationship between personality and cognitive bias to enhance user performance in adaptive HCI

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Abstract

The way interaction designers deal with intuition affects the ability to accurately predict users’ individual differences in decision-making patterns. Cognitive biases are written off as insidious to performance and are thereby targeted as interactive patterns one must avoid or mitigate, which greatly affects user experience and performance. The goal was to assess individual susceptibilities to bias and if biased decision-making patterns could be empowered by applying nudge theory and choice architecture to adaptive interfaces. The Adult Decision-Making Competence and Neuroticism-Extraversion-Openness Personality Inventory Revised were used to gather personality and decision-making profiles from 51 students (28 males, 23 females), in an attempt to predict susceptibilities to sunk cost fallacy, overconfidence and framing effect from their personality traits. Preliminary results showed positive correlations between Openness to Experience and resistance to sunk costs. It also showed positive correlations between resistance to framing effects and Openness To Experience, Agreeableness and Extroversion traits. Fantasy, Tender-mindedness, Modesty and Deliberation were found to be significant predictors of susceptibility. The second phase attempted to propose a set of guidelines that adapted to sunk cost susceptibilities by applying concepts of digital nudging and choice architecture that targeted individual differences in the Deliberation facets. These design guidelines were evaluated through differences in quantitative performance and usability metrics in a learning platform environment. Results from the within-subjects user studies suggested that adaptability yielded slightly higher performance rates but the comparative statistical tests results were non-significant. This is possibly due to sample size limitations during the validation phase (N = 30).

Keywords: personality, cognitive bias, individual differences, decision-making competence, adaptive design, user performance
Resumo

Na área de Interação Pessoa-Máquina, estratégias de desenho em torno da intuição do utilizador afecta o poder de previsão dos seus padrões de raciocínio. Isto deve-se à tendência generalizada de priorizar raciocínio normativo, que é incompatível com os vieses cognitivos próprios dos mecanismos intuitivos. Estes vieses são vistos como obstáculos à boa performance e esta posição tem várias implicações para a experiência de utilizador. O objectivo desde estudo é aferir diferenças individuais na susceptibilidade a vieses cognitivos e avaliar se é possível aplicar estratégias de influência e noções de adaptabilidade ao desenho de interfaces, de modo a tornar os padrões naturalmente enviesados num factor positivo à performance. Foi criado um modelo de predição de susceptibilidades a enviesamento na tomada de decisões a partir de traços de personalidade. Foram encontradas correlações positivas entre níveis altos de abertura à experiência e maior resistência à falácia de custos irrecuperáveis. Facetas de personalidade como Fantasia, Sensibilidade, Modéstia e Deliberação foram identificadas como preditores eficientes de susceptibilidade dessa falácia. As directivas de desenho adaptativo criadas a partir destas facetas foram avaliadas através de um protótipo de plataforma de ensino para averiguar diferenças em performance estudantil através de estratégias de influência positiva. Apesar dos resultados implicarem tendências a favor do design adaptativo, o estudo comparativo não demonstrou diferenças estatisticamente significativas de performance em relação à interface de controlo. Devido ao tamanho limitado do estudo (N = 30), recomenda-se repetir o processo de validação com uma amostra maior para corroborar as hipóteses propostas.

Keywords: diferenças individuais, personalidade, viés cognitivo, competências de tomada de decisão, design adaptativo, performance de utilizador
Contents

List of Tables ix

List of Figures xi

Acronyms 1

1 Introduction 3

1.1 Goals and Contributions .................................................. 5
1.2 Document Structure ......................................................... 5

2 Theoretical fundamentals 7

2.1 Individual Differences ...................................................... 7
  2.1.1 Personality ............................................................... 7
  2.1.2 Thinking Styles ......................................................... 9
  2.1.3 Decision-Making styles ................................................. 10

2.2 Human cognition ............................................................. 10
  2.2.1 The role of Heuristics .................................................. 10
  2.2.2 Cognitive Bias ......................................................... 11
  2.2.3 Error Management Theories ........................................... 13

3 Related Work 15

3.1 Modern Design solutions for Cognitive Biases ......................... 15
  3.1.1 Modification strategies ................................................ 15
  3.1.2 Nudge strategies ...................................................... 16

3.2 Links between Personality, Thinking Style and cognitive bias ....... 17
  3.2.1 "Personality - Cognitive Style"dynamics .......................... 17
  3.2.2 "Personality - Cognitive Bias"dynamics .......................... 18

3.3 Implications of adapting to individual differences ................. 18
  3.3.1 Personality-focused user experiences ............................. 18
  3.3.2 Cognition-focused user experiences ............................... 19
  3.3.3 Bias-focused user experiences ...................................... 19

3.4 Discussion ........................................................................... 20

4 Researching the role of personality in decision-making biases 23

4.1 Correlation study .............................................................. 23
  4.1.1 Research questions ..................................................... 23
  4.1.2 Assumptions and operating definitions ............................ 23
  4.1.3 Instruments ............................................................... 24
A. Forms created for the studies

A.1 Consent Forms .................................................. 65
A.2 User Guides ...................................................... 66
A.3 Demographic and Technological Familiarity Surveys .................................. 67
A.4 Vocabulary Diagnostic Test ....................................... 70
A.5 Official Portuguese SUS scale ..................................... 77
A.6 Adult Decision Making Competence questionnaire in Portuguese .................. 78
## List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>“Major perspectives in personality”, from Cambridge Handbook of Personality [42]</td>
<td>8</td>
</tr>
<tr>
<td>4.1</td>
<td>Results from the Shapiro-Wilk test on Adult Decision Making Competences (A-DMC) data</td>
<td>26</td>
</tr>
<tr>
<td>4.2</td>
<td>Cut-off Values for the A-DMC scores in each tested component.</td>
<td>27</td>
</tr>
<tr>
<td>4.3</td>
<td>Descriptive statistics of the NEO-PI-R results.</td>
<td>28</td>
</tr>
<tr>
<td>4.4</td>
<td>Correlations found between A-DMC components and the five personality traits in the NEO-PI-R</td>
<td>29</td>
</tr>
<tr>
<td>6.1</td>
<td>Descriptive statistics for predicted SC scores (using a prediction model) and actual SC scores (using the A-DMC)</td>
<td>41</td>
</tr>
<tr>
<td>7.1</td>
<td>Descriptive statistics of the main performance metrics targeting effectiveness and efficiency, regardless of susceptibility factor</td>
<td>45</td>
</tr>
<tr>
<td>7.2</td>
<td>Shapiro-Wilk normality tests for all four performance metrics across both groups.</td>
<td>49</td>
</tr>
<tr>
<td>7.3</td>
<td>Wilcoxon Signed Ranks test results on overall sample.</td>
<td>50</td>
</tr>
<tr>
<td>7.4</td>
<td>Levene’s test of homogeneity across the subjective metrics.</td>
<td>52</td>
</tr>
</tbody>
</table>
List of Figures

2.1 "Examples of some cognitive biases", taken the Cognitive Bias chapter of the Encyclopaedia of Human Behavior [91]. ......................................................... 12

3.1 Distribution of items per component on each trait dimension in the Big Five Inventory, as discovered by Revelle and Will [110]. ......................................................... 17

3.2 Interfaces Designed for Neuroticism and Extra-Conscientiousness. [118]. ................................. 19

4.1 Descriptive Statistics of Nonstandardized A-DMC Components in original study [39]. ............... 26

4.2 Box plot data distributions in each A-DMC component. .......................................................... 27

5.1 The five stages of ISD (or ADDIE), plus optional plugins [130]. ................................................. 33

5.2 User journey in the personality-adapted interface. UI Components catalogued from A to C are common to both interfaces while UI components from E to G are exclusive to the “Per Module mode (PMM).” .......................................................... 36

7.1 Box Plots for Lesson Completion Rates: a side by side comparison for Sunk Cost Resistant and Susceptible groups. .......................................................... 46

7.2 Box Plots for Module Completion Rates: a side by side comparison for Sunk Cost Resistant and Susceptible groups. .......................................................... 47

7.3 Box Plots for Answer Effectiveness: a side by side comparison for Sunk Cost Resistant and Susceptible groups. .......................................................... 47

7.4 Box Plots for Vocabulary tests Grade Improvement Rates: a side by side comparison for Sunk Cost Resistant and Susceptible groups. .......................................................... 48

7.5 Box Plots for Systematic Usability Score: a side by side comparison for Sunk Cost Resistant and Susceptible groups. .......................................................... 51
Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-DMC</td>
<td>Adult Decision Making Competences</td>
<td>xi, xiii, 4, 10, 24, 26, 28, 29, 31, 41</td>
</tr>
<tr>
<td>APA</td>
<td>American Psychological Association</td>
<td>7</td>
</tr>
<tr>
<td>CAL</td>
<td>Overconfidence Assessment</td>
<td>24</td>
</tr>
<tr>
<td>CBM</td>
<td>Cognitive Bias Modification</td>
<td>15, 20</td>
</tr>
<tr>
<td>EMT</td>
<td>Error Management Theory</td>
<td>13</td>
</tr>
<tr>
<td>FFM</td>
<td>Five-Factor Model</td>
<td>4, 8, 17, 18, 20</td>
</tr>
<tr>
<td>FR</td>
<td>Resistance to Framing</td>
<td>24</td>
</tr>
<tr>
<td>GDMS</td>
<td>General Decision Making Styles</td>
<td>10</td>
</tr>
<tr>
<td>HCI</td>
<td>Human-Computer Interaction</td>
<td>3–5, 9, 12, 56</td>
</tr>
<tr>
<td>IPIP</td>
<td>International Personality Item Pool</td>
<td>32</td>
</tr>
<tr>
<td>ISD</td>
<td>Instructional System Design</td>
<td>33, 34, 56</td>
</tr>
<tr>
<td>MBTI</td>
<td>Myers-Briggs Type Indicator</td>
<td>19</td>
</tr>
<tr>
<td>NEO-PI-R</td>
<td>Neuroticism-Extraversion-Openness Personality Inventory Revised</td>
<td>9, 18, 24, 25, 28, 32, 41</td>
</tr>
<tr>
<td>PAQ</td>
<td>Performance Analysis Quadrant</td>
<td>33</td>
</tr>
<tr>
<td>PMM</td>
<td>Per Module Method</td>
<td>37, 40</td>
</tr>
<tr>
<td>PQM</td>
<td>Per Question Method</td>
<td>37, 40</td>
</tr>
<tr>
<td>SAPA</td>
<td>Synthetic Aperture Personality Assessment</td>
<td>17, 20</td>
</tr>
<tr>
<td>SC</td>
<td>Resistant to Sunk Costs</td>
<td>24</td>
</tr>
<tr>
<td>SUS</td>
<td>System Usability Scale</td>
<td>39, 40</td>
</tr>
<tr>
<td>TSI-R2</td>
<td>Thinking Styles Inventory Revised II</td>
<td>9</td>
</tr>
</tbody>
</table>
1 Introduction

In the field of Interaction and User Experience Design, the questions "Who are our users?" and "What do they need?" are the starting point for most professionals at the very beginning of any design project. Designers ponder daily on the way that humans think, feel and behave to maximize their experience. They often take on a Design Thinking approach to find elegant solutions for their users. This approach has 5 fundamental stages: empathize, define, ideate, prototype and test. As they identify their users' pain points by focusing on user empathy [1] to define the problem they want to solve, the solution is shaped by notions of cognitive load [2] [3] and mental models [4]. However, most design thinking initiatives happen in a corporate environment, where business goals focus on scalable over adaptive solutions. Designing through the lens of product development methodologies such as Agile and Lean, which invest in the Minimum Viable Product (MVP) [5], produces digital products whose features are able to solve surface-level pain points and needs without necessarily investing in the construction of detailed user models that reflect individual differences.

But is there an argument for designing to such a level of granularity? Digital-era technology has already had an unprecedented impact on humanity [6] [7]. The nature of this influence is widely recognized and formally studied under the field of digital anthropology – the study of the relationship between humans and the digital era [8]. It has influenced the way we learn [9], the way we communicate [10] even the way we think [11].

It has been argued that technology has had an active role in human evolution [12]. The Internet alone has been the propeller of drastic changes in our cognitive landscape [11]. Prensky was the one of the first to comment on how his students' profiles had shifted throughout his teaching career - "Our students have changed radically. Today's students are no longer the people our educational system was designed to teach." [13]. To fully describe this dichotomy, he created the terms “digital native” – referring to those born into our modern digital environment, never having to experience a world without digital media – and “digital immigrant” – referring to those that adopted the use of ubiquitous digital media later in life. The cognitive profiles of both groups differed quite drastically and consistently, from the way the brain manages memory to its information processing strategies [14]. So, in a way, the methods one uses to design technology today are retroactively designing the humans of tomorrow.

Moreover, several studies have found that systematically profiling how individuals think has shown important correlations in performance [15], perception [16] and empathy [17]. In Human-Computer Interaction (HCI) mental models are constructed to capture how users solve problems and make decisions, among other cognitive processes [18]. However, they leave biased thinking patterns undocumented. Cognitive biases are especially important in the area of human-centered design, considering that the way designers choose to handle them may have a dramatic impact on user experience [19] and performance [20]. A cognitive bias is broadly defined as "a systematic deviation from rational thinking" and was first identified in the early seventies by Daniel Kahneman and Amos Tversky [21], whose collaboration extensively contributed to a deeper comprehension of human decision-making and judgment. Their work inspired an academic effort to discover, define and categorize hundreds of instances of bias in human mem-
ory, decision-making and perception\textsuperscript{22}, which in return have been explored in a multitude of areas, such as business \textsuperscript{23}, medicine \textsuperscript{24} and design \textsuperscript{25} \textsuperscript{26}. In recent years, the topic of overcoming cognitive biases has gained popularity, be it in books about business \textsuperscript{27}, web articles about user experience \textsuperscript{28} \textsuperscript{29} \textsuperscript{30} and scientific papers on experimental behavior modification \textsuperscript{31} \textsuperscript{32} \textsuperscript{33} that correct these biased patterns.

This stems from the pervasive economist view that normative reasoning, which emphasizes the use of logic and rationality, is the key to optimal problem solving and decision making across all areas of life \textsuperscript{34}. The position one chooses regarding biases has its implications. On one hand, when biases (and other cognitive or psychological mechanisms) are seen as exploitable assets, we enter the realm of \textit{Dark Design Patterns} \textsuperscript{35} where design is unethically used to manipulate natural thought processes and forcefully create interaction paths that greatly favor corporate value at the expense of their users. On the other hand, when the approach is ethical yet spirited towards user supportive systems based on a standard of normative reasoning, designers will engage in cognitive bias avoidance efforts, where cognitive bias is regarded as an undesirable error or flaw that must not be triggered at any cost. And in that mindset of restricting biased patterns and avoiding triggering biases or atypical decision making processes, user interaction is continuously limited. This can severely alienate groups of users who systematically think in specific patterns that are discarded in the user experience as atypical, biased or even irrational.

In an attempt to address this issue, this study assesses the role of individual differences in profiling a subject’s decision-making competences and proposes adaptive design solutions to diverse thinking patterns and cognitive bias. The solutions include notions of nudge theory \textsuperscript{36} and evolutionary error management theories \textsuperscript{37}. Evolutionary error management theories try to explain where cognitive biases in reasoning came from and how they might have developed throughout evolution with very specific purposes. Nudge theory presents the concept of ethically influencing one’s behavior through environment architecture. By taking this approach, we hope to understand the purpose of bias in decision making and how it might be optimally triggered to enhance human ability in HCI.

Dynamics between personality and decision-making competences will be explored in a correlational study using the \textit{Five-Factor Model} (FFM) of personality \textsuperscript{38} and the \textit{A-DMC} questionnaire \textsuperscript{39}. The FFM is a personality model that assesses personality traits (Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism) and has been used in studies regarding HCI \textsuperscript{40}. The \textit{A-DMC} is a questionnaire that assesses how well adults make decisions and allows to extrapolate susceptibilities to certain biases such as the framing effect, overconfidence and the sunk cost fallacy \textsuperscript{39}. Collected data will then be analyzed to aid in the construction of prototypes that embody ideals of adaptability and bias empowering design.

Proof of concept will entail conducting user studies with said prototypes in order to detect significant improvement on objective performance metrics such as effectiveness and efficiency, and subjective metrics surrounding perceived usability.
1.1 Goals and Contributions

The primary objective of this study is to assess whether user performance in HCI can be optimized through the investment in user-adaptive interfaces and the adoption of an evolutionary perspective regarding the handling of decision-making biases in human-computer interaction. To accomplish this objective, the following intermediary steps were taken towards the resolution of these conjectures:

1. Extensive review of current design methodologies and how they handle user adaptability and individual differences in personality and decision-making;
2. Assessment of the relationship between personality, decision making skills and susceptibility to cognitive biases;
3. Application of novel strategies regarding adaptability to individual differences in personality and susceptibility to decision-making biases to a user-centered design process;
4. Construction of an interface prototype that embodies said strategies in one of two interaction environments: the control environment and the personality-adaptive environment.

This study aims to contribute with a set of design guidelines that adapt to personality traits and cognitive susceptibilities in order to optimize user performance in a learning platform environment. In doing so, it also contributes with several sets of psychological data regarding personality traits and decision making competences in the context of HCI and the ongoing publication of an extensive journal article addressing the implications of personality-adaptive design in society at large [41].

The validity of the study will render a pertinent argument towards further research into adaptive design and new approaches to handling cognitive bias.

1.2 Document Structure

In order to adequately explain the concepts discussed in the realm of this study, Chapter 2 includes an overview of personality, decision-making and cognitive processing theories. The literary review also introduces fundamental concepts of heuristics, cognitive biases and their role in error management. Subsequently, Chapter 3 delves into modern strategies when dealing with cognitive biases. It also presents pertinent studies conducted in the field of psychology that attempt to pinpoint the dynamics between personality, cognitive styles and cognitive biases. It closes with accounts of how adapting to personality, cognition styles and bias influenced the overall user experience.

Chapter 4 contains the preliminary study to collect data for the ensuing design effort. This chapter includes the definition of the research scope, a detailed description of the instruments and procedures that took part in the data collection process and the analytic report of the findings. Those findings were directly incorporated into the design process documented in Chapter 5. This chapter highlights the strategies that were followed, the design decisions that were made and the prototypes that were constructed to evaluate the effects of those strategies on the users.

Chapter 6 presents the evaluation method. It presents the method by which hypotheses, metrics and protocols were defined for the user studies to enable proof of concept. In succession, a methodical report of all the results is presented and discussed in Chapter 7, followed by closing statements discussing the limitations and future directions for this endeavor in Chapter 8.
2 | Theoretical fundamentals

In order to serve the goals defined in the last chapter, one must get acquainted with the theories and models that are adjacent to this study. This chapter encapsulates the history and literary review of topics regarding individual differences and evolutionary perspectives of human cognition and decision-making.

2.1 Individual Differences

This section will review the underlying notions on how individual differences are defined within personality, cognition and decision-making.

2.1.1 Personality

To engage in efforts to design more adaptive experiences, one must revisit the concept on which adaptability is centered: the concept of individual difference. Personality theory is specifically aimed towards this concept [42]. In fact, according to the American Psychological Association (APA) [43], personality may, in a rather simplified sense, be defined as "individual differences in patterns of thinking, feeling and behaving." This definition is, however, endlessly tricky.

As shown in Table 2.1, there is a wide range of personality theories, each with differing perspectives on particular topics when defining the constructs of personality. Whether scholars debate over personality being a stable or malleable construct, a whole entity or a connected system of psychological parts, or it being innate or a product of social experience, one of the theories that has stood the test of time is personality trait theory. Gordon Allport, one of the founding fathers of modern personality psychology, introduced this theory in the late 1930's to offset behaviorist and psychoanalytical views on personality that were popular at the time [44].

He first defined personality traits as "generalized and personalized determining tendencies - consistent and stable modes of an individual's adjustment to his environment" [45] and built a vast lexical collection of adjectives that could be used to describe these traits. He then categorized them in a hierarchical structure with three distinct levels: cardinal, central and secondary traits. While central traits were considered to be the building blocks of a person's personality that remain consistent regardless of the environment they were in, he believed in the existence of secondary traits that could only become apparent in specific situations. Cardinal traits were described as rare but rather dominant. If they were ever developed in a later stage in life, they would begin to shape the entire aspect of the person's behavior, motivation, attitude and even identity. A number of trait theorists such as Eysenck, Cattell and Goldberg [42] developed different personality models that reduced, arranged and categorized the vast collection of traits to identify the minimum necessary trait dimensions to predict an individual's personality. Recurring investigation showed the prevalence of five basic trait dimensions, which led to the general acceptance of the Five-Factor Model. Developed over time with the contribution of by Digman Norman, Goldberg
Table 2.1: "Major perspectives in personality", from Cambridge Handbook of Personality [42]

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Major Concepts</th>
<th>Contributors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological</td>
<td>Temperament, evolution, adaptation, altruism, sexual jealousy, heredity, neurotransmitter pathways, cerebral hemisphere function</td>
<td>D. Buss [46], Eysenck [47], J.A. Gray [48], C. R. Cloninger [49], Kagan [50]</td>
</tr>
<tr>
<td></td>
<td>Expectancy, self-efficacy, outcome expectation, schema, cognitive person variable, personal construct, reciprocal determinism, modelling, constructive alternativism, life narrative</td>
<td>Mischel [51], Bandura [52], Kelly [53], Beck [54]</td>
</tr>
<tr>
<td>Cognitive</td>
<td>Self-actualization, creativity, flow, spirituality, personal responsibility, freedom, choice, openness to experience, unconditional positive regard, acceptance, empathy, real self, hierarchy of needs, peak experience, positive psychology</td>
<td>Maslow [55], Rogers [56], Seligman and Csikszentmihalyi [57]</td>
</tr>
<tr>
<td>Humanistic</td>
<td>Libido, conflict, id, ego, superego, defence mechanisms, Oedipal conflict, fixation, repression, attachment, object-relations</td>
<td>Freud [61], Jung [62], Adler [63], Erikson [64], Horney [65], Klein [66], Sullivan [67], Chodorow [68], Westen [69], Kohut [70], Kernberg [71]</td>
</tr>
<tr>
<td>Learning</td>
<td>Trait, type, facet, factors, Neuroticism/Emotional Stability, Extraversion</td>
<td>Allport [45], Cattell [72], McCrae and Costa [73]</td>
</tr>
</tbody>
</table>

and McCrae and Costa [42], the FFM of personality (also known as the OCEAN model) considers the following fundamental dimensions [38]:

- **Extraversion** - related with social energy levels, this dimension refers to one’s approach to a social environment. It includes traits such as sociability and assertiveness. Highly extraverted individuals actively seek social interaction to feel more energized and have been predicted to have a higher number of friends and/or sexual partners. Low extraversion, or introversion, is characterized by the expenditure of energy in social interactions, thus requiring more isolation to recharge, which in return as been associated with higher rejection rates by peers, specially if they are extraverted.

- **Agreeableness** - related to communal orientations, agreeableness refers to one’s approach to social order and collective good. It includes traits such as altruism, trust and modesty. Highly agreeable individuals prefer to engage in positive relations towards others and have been associated with having increased performance in group settings. Low agreeableness however, can be factored with lack of empathy and as been used to predict juvenile delinquency.

- **Conscientiousness** - related with awareness of social restraints and self-control, this dimension describes the degree of mindfulness within task-driven behaviors such as planning, deliberated actions, delayed gratification and adherence to norm. It includes traits such as impulsiveness and consistency. Highly conscientious individuals are more likely to be well organized, to adhere to personal regimens and have been predicted to have better performance, both in academia and in the workplace. Low conscientiousness can be expressed as more spontaneous, having a more flexible demeanor and has been correlated with susceptibility to substance abuse and attention disorders.
• **Neuroticism** - related with emotional stability and temperance, neuroticism refers to the balance of positive and negative emotionality. Highly neurotic people experience more stress, mood swings and have shown decreased ability to cope with illness. Low neuroticism is associated with a better self-confidence, a calmer demeanor and has been correlated with increased relationship satisfaction.

• **Openness to experience** - related to originality and mental complexity, openness to experience describes how one seeks to widen their world view and their willingness to partake in complex experiences. It includes traits such as imagination, curiosity and open-mindedness. Highly open individuals tend to be more creative and are predicted to complete more years of education and be more successful in artistic jobs. Low openness is associated with close-mindedness and conservative attitudes.

In order to assess the intensity of each dimension on a given test subject, Costa and McCrae developed and validated the [**Neuroticism-Extraversion-Openness Personality Inventory Revised (NEO-PI-R)**](#) [73]. Each item in the inventory presents the variables as simple assertions regarding feelings, thoughts and behaviors that the subject must either agree or disagree with through a five-level Likert scale (Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree). The results are displayed as high or low scores for each of the dimensions, which in their sum predict the subject's personality.

This particular model describes individual differences as a collective pattern of feelings, thoughts, actions and motivations, which seems ideal as a baseline test for this study, in order to then bring focus to the cognitive aspect of individuality. The cognitive perspective of personality focuses heavily on the link between personality traits and performance. Early research began with insights on the idea that emotional pathology could be related to cognitive impairments and distortions. Performance studies have since been integrated with topics such as neuroscience, neuroimaging and information-processing models [42].

### 2.1.2 Thinking Styles

Thinking styles refer to an individual’s approach to organizing and processing information. While cognitive approaches to personality have one of the largest bodies of evidence, it has been rendered almost unapproachable as lack of research integration, consolidation and heavy criticism has made any intention of looking into cognitive and thinking styles a somewhat controversial matter [74] [42]. Despite this, we shall attempt to review the literature, with the help of the *Handbook of Intellectual Styles* [75]. The totality of research has no consolidation on the terms that refer uniquely to the style of thinking. Depending on decade, researcher and approach, terms like cognitive, intellectual, thinking, learning and teaching styles were used somewhat interchangeably [75]. Stenberg's Mental Self-Government Model [76] wanted to bridge personality and intelligence, presenting 13 distinct styles, divided by five different dimensions of thinking. It is the basis for the [**Thinking Styles Inventory Revised (TSI-R2)**](#) and has been useful in establishing a distinction between personality and thinking style [77]. The Decision Making Styles model developed by Scott & Bruce [78] describes how an individual makes choices and has five styles: rational, intuitive, dependent, avoidant and spontaneous. Del Campo et al [79] used this model to understand how different styles influenced the use of heuristics in the decision making process. Numerous instances of dual thinking styles have also been proposed and studied in HCI-related tasks, such as the visualizer-verbalizer model [80], intuitive-rational model [81], among many others [75]. An an attempt to deal with the great volume of articles within this topic, this project scope was reduced to include differences in decision-making only.
2.1.3 Decision-Making styles

Decision theory pertains to goal-directed behaviours when one is presented with options [82]. It studies aspects of reasoning underlying choices. Decisions can be studied from two distinct perspectives: normative and descriptive. Normative decision theories focus on how decisions should be made while descriptive theories (the focal point of this section) reflect on how decisions are actually made by human beings. In the field of economics, discussing these perspectives is often referred to as the "Humans vs. Econs" debate [34]. Normative theories propose decision-making strategies that assume a perfect logical-rational reasoning model within the decision-making agent. The notion that humans satisfy this assumption defines the theoretical concept of an Econ, or a perfectly rational human. However, we are not Econs. Descriptive decision theories describe the various strategies used by real humans in decision-making processes. Individual differences in decision-making style account for strategy selection patterns. To assess these differences, Scott & Bruce [78] defined 5 different decision-making styles and created the General Decision Making Styles (GDMS) to identify them. Those styles were conceptualized as follows:

- Rational, where the subject focuses on thoroughly researching all possible alternatives and evaluating them logically;
- Intuitive, where the subject relies primarily on intuitive, surface-level thought processes;
- Spontaneous, where the subject focuses on making decisions as quickly as possible;
- Dependent, where the subject relies on external sources to aid the decision-making processes;
- Avoidant, when the subject tends to prolong the decision-making process in order to postpone the final decision.

Rational and Intuitive styles are a direct result of favoring a particular system within the dual-system construct presented in Section 2.2.1. The strategies one selects is a direct result of individual preference for one system over the other, which in return influences decision outcome. Therefore, individuals also differ in decision-making competence. Bruine de Bruin [39], proposed the A-DMC to assess decision-making competence in function of one’s resistance to systematic deviations in rationality. These systematic deviations in human thought processes can lead to poor decision-making. Such deviations are known as cognitive biases and will be further discussed in section 2.2.2.

2.2 Human cognition

Cognition as a theoretical concept can be analyzed through a plethora of distinct fields such as linguistics, neuroscience, philosophy, biology, computer science and psychology [83]. To limit the scope, aspects of cognition shall be explored from the perspective of cognitive psychology. This section elaborates on the multitude of models proposed over time to describe the underlying constructs of human reasoning and decision making, exploring the concept of cognitive bias as both an error and a cognitive feature.

2.2.1 The role of Heuristics

The core body of research regarding reasoning in the realm of psychology and social cognition has been molded by what is generically referred to as dual-process theories [83] - theories that lie on the principle that mental processes can be divided into two categories, automatic processes and controlled processes. Establishing the operating conditions of automatic processes, they are necessarily elicited
unintentionally, require little amounts of cognitive resources, cannot be stopped voluntarily and they occur outside of conscious awareness [84]. Consequently, controlled processes are the opposite, they are initiated intentionally, require considerable amounts of cognitive resources, can be stopped voluntarily and operate within conscious awareness. Given this perspective, decision-making is molded by these two distinct forms of reasoning.

In “Thinking fast and slow”, Kahneman [85] emulates dual-process theories when describing the act of thinking as two separate mental systems operating simultaneously: System 1 (thinking fast) and System 2 (thinking slow). System 1 is most active and encompasses intuitive thought processes, feeding insights to the more complex and analytical System 2 that builds the core belief system of a given individual. He construed that cognitive biases are triggered by events that challenge the cohesion and integrity the System 1 created and stored in System 2. It’s an attempt to bring sense to the new unabridged information.

However, there are definite critics to these theories. Lieder et al [86] disagree with the sole existence of two systems. They argue the theories should reflect multiple systems that, depending on the structure of the environment, evaluate the time and effort of choosing between them. They further investigate what the optimal number of cognitive systems would be and found that it depends on the variability of the environment and the difficulty of deciding when which system should be used. Systems only worked as described by Kahneman [85] in instances where the optimal number of systems is necessarily two. Whether there are one, two or more systems, there is a consensus on the fact that efficient decision making processes are characterized by heuristics [21].

Heuristics are rules we apply to problem solving which, without guaranteeing optimal results, are deemed sufficient for reaching a satisfactory solution. They are considered to be mental shortcuts that are primed in system 1 reasoning as being efficient and overall effective. They may be direct consequences of bounded rationality - the notion introduced by Simon [87] that human rationality is limited by the complexity of the decision problem, the mind’s cognitive limitations, and the time one has to make the decision. Tversky and Kahneman [21] studied the impact of our most common heuristics in uncertain scenarios, which gave arise to the identification of cognitive biases, which shall be the theme of the next section.

2.2.2 Cognitive Bias

Cognitive biases have been thoroughly documented [88] [89] and have a well-known impact on usability [90] and user experience [19]. Considering that any form of interaction involves complex cognitive processes that deeply influence the users’ perception and judgments, it would make sense that we design the parameters of these interactions with the knowledge of which biases are being stimulated and how. To do so, one must first understand the nature of cognitive biases and their realms of influence on the user's perception.

Cognitive bias was a term first introduced in 1972 by Amos Tversky and Daniel Kahnemann [21], as they demonstrated the existence of a systematic deviation from normative standards in human assessments of probabilistic theory and logic. They arose in situations where subjects relied on common heuristics to fill in the blanks when asked to make decisions under great levels of uncertainty. Biases were then characterized either as limitation in cognitive power or systematic logical errors. For the purpose of this study, we shall settle on the definition that a cognitive bias is “any instance in human cognition [that] reliably produces representations that are systematically distorted compared to some aspect of objective reality.” [37]. Thus, one can define biases without constructing judgments on their implications in other areas.

A cognitive bias is an unconscious phenomenon, meaning the subject is not aware of their distorted
leaps in logic when constructing their thought process and the question of forcing that awareness is still debatable [92]. There are over a hundred documented biases [22] that affect several different cognitive processes (see Fig.2.1). They can be divided into four main categories: memory biases, decision-making biases, social biases and probability biases.

Memory bias are standard deviations in how data is selected when retrieved from memory. The most common within this group is the hindsight bias, which is responsible for the "I knew it all along" effect. Social bias are deviations that occur in social settings, where the subject evaluates and attempts to justify their or others' behaviors in a way that regulates their perception of self according to the perception of other [93]. The Halo Effect, for example, has been extensively studied in HCI for its impact in user perception of usability [94] and overall user experience [19].

Probability biases such as the conjunction and gambler's fallacies correspond to the inability to assess the probability of different events without the intervention of one's belief system [21]. A well-known example is when flipping a coin, if it has come up tails 4 times in a row, the subject tends to believe it is less likely that it will turn up tails a 5th time. Since flipping a coin is always random, it could in fact be possible to come up with tails an infinite number of times in a row, but the gambler's past experiences taint the notion of equal probability, thus tricking them into believing there is a streak in process.

Decision making biases are those that cause one to consider otherwise irrelevant data as being an important factor in the decision making process. The most popular popular biases within this category are the sunk cost fallacy and the framing effect. The sunk cost fallacy emphasizes past investments over future costs and benefits. It causes individuals to be unable to walk away from projects and activities they already feel invested in. This fallacy is present when, for example, one pays for a movie ticket and stays until the end even if, 20 minutes in, they found the plot line to be terrible. The sunk cost of the ticket makes them stay and endure so it does not feel like a waste of money.

The framing effect causes decisions to vary according to how the information surrounding the problem is presented. For example, asking for public feedback when presenting a new eye treatment with a 90% success rate would elicit different responses from presenting a new eye treatment with a 10% failure rate. The information is the same, but positively or negatively framing it shifts cognitive focus and manipulates decision-making. This study chose to focus on this type of biases as they are the most well-documented and the ones that present more design implications regarding content framing and information architecture.

While there are several methods to identify one's susceptibility to a specific cognitive bias, there are

<table>
<thead>
<tr>
<th>Cognitive bias</th>
<th>Short description</th>
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<tbody>
<tr>
<td>Confirmation bias</td>
<td>The tendency to selectively search for or interpret information in a way that confirms one's preconceptions or hypotheses</td>
</tr>
<tr>
<td>Conjunction fallacy</td>
<td>The tendency to assume that specific conditions are more probable than a single general one</td>
</tr>
<tr>
<td>Endowment effect</td>
<td>The tendency that people often demand more to give up on an object than they would be willing to pay to acquire it</td>
</tr>
<tr>
<td>Fundamental attribution error</td>
<td>The tendency to overemphasize personal factors and underestimate situational factors when explaining other people's behavior</td>
</tr>
<tr>
<td>Gambler's fallacy</td>
<td>The tendency to think that future probabilities are changed by past events, when in reality they are unchanged (e.g., series of roulette wheel spins)</td>
</tr>
<tr>
<td>Halo effect</td>
<td>The tendency for a person's positive or negative traits to extend from one area of their personality to another in others' perceptions of them</td>
</tr>
<tr>
<td>Hindsight bias*</td>
<td>A memory distortion phenomenon by which with the benefit of feedback about the outcome of an event, people's recalled judgments of the likelihood of that event are typically closer to the actual outcome than their original judgments were</td>
</tr>
<tr>
<td>Hot-hand fallacy*</td>
<td>The expectation of streaks in sequences of hits and misses whose probabilities are, in fact, independent (e.g., coin tosses, basketball shots)</td>
</tr>
<tr>
<td>Illusory correlation</td>
<td>The tendency to identify a correlation between a certain type of action and effect when no such correlation exists</td>
</tr>
<tr>
<td>In-group bias</td>
<td>The tendency for people to give preferential treatment to others they perceive to be members of their own group</td>
</tr>
<tr>
<td>Mere exposure effect</td>
<td>The tendency by which people develop a preference for things merely because they are familiar with them</td>
</tr>
</tbody>
</table>

Figure 2.1: “Examples of some cognitive biases”, taken the Cognitive Bias chapter of the Encyclopedia of Human Behavior [91].
limited available tools to properly assess a multitude of them with a single instrument. Efforts to create proper cognitive bias detection instruments will be discussed in section 3.2.1.

2.2.3 Error Management Theories

Researchers attempted to understand not only the role of cognitive biases but, most importantly, how biases came to be an integrated part of thinking.

In this section, we will focus on the perspectives of Evolutionary Psychology, which view Cognitive biases as adaptive forms of problem solving that ultimately contributed to ancestral success. These perspectives refute the idea that cognitive features need be absolutely accurate or logical if they ultimately enable problem solving. According to Haselton & Nettle [37], there are three main hypotheses for the origin of biases:

1. **Heuristics**, Where evolution is positively affected by a selection of specific shortcuts that despite not being optimal, yield successful outcomes in most circumstances;

2. **Artifacts**, Where bias is fueled by the ineptitude of the mind towards solving a specific problem.

3. **Error Management Theory (EMT)** - Where using a bias view on a problem is reinforced by demonstrating lower error costs than the unbiased counterpart.

Heuristics, as mentioned in the previous section, have been the founding principle of Kahneman and Tversky’s narrative on cognitive bias [21]. These are selected based on the degree in which the current situation is similar to a past moment where that same rule produced a successful result.

Bias by artifact discusses the issue of problem formatting. Gigerenzer [95] believed that forcing the mind to operate in problem formats for which it was not designed will forcefully produce illogical results. In his example of ecological bayesian theory, he explained that the brain is optimized to deal with natural frequencies and not probabilities and percentages, which consist of mathematical abstractions that are hard to grasp through traditional sensory input. So this perspective defends the need to design for what one can expect from standard cognitive power and ability.

EMT was proposed by Haselton & Buss [96] and argued that biases evolve from actions with lower error costs, when favoring decisions of larger amounts of cheap errors than decisions with sparse, costlier errors. EMT predicts that biases may naturally spawn in human judgments where the environment in which a judgment is made is riddled with uncertainty, the outcomes of said judgment affect reproductive success, and the paths available have asymmetrical costs.

Studying the evolution of error is a pathway towards understanding how cognitive bias can improve decision making instead of hindering it. Johnson et al [97] consider cognitive bias as naturally adaptive to uncertainty and consider EMT a unifying framework for understanding the decisions made there are asymmetric costs between types of errors. Marshall et al [98] expressed how cognitive biases can actually lead to optimal results, given appropriate constraints. But because psychological studies focus on biased perceptions of the probability of events without taking cost/benefit factors into consideration, biases are continuously viewed as sub-optimal. These hypotheses collectively gravitate towards a more positive attitude toward cognitive biases, where one can argue that controlling the constraints and context of the situations in which biases are triggered might enable designers to guide users into optimal performance.
3 Related Work

In order to assess if creating interfaces that adapt to a user’s personality and decision-making susceptibilities can have a positive effect on their performance, there is a need to review what has been accomplished so far. This section seeks to introduce how biases are currently handled, studies on the relationships between personality, thinking styles and cognitive biases, and pertinent contributions to design that focus on adaptability.

3.1 Modern Design solutions for Cognitive Biases

Kahneman and Tversky \[21\] began by describing biases as potentially useful features of rapid thought processes, despite the possibility of also being detrimental to rational thinking. Nonetheless, cognitive biases gained a reputation for being insidious flaws in human reasoning that could compromise success in a multitude of endeavors \[27\]. This is considerably expected, since one of the most prominent biases humans tend to exhibit is the belief we are predominantly rational creatures \[99\]. In response to this need of purging ourselves of our biases, research trends on mitigating \[20\] \[90\] and modifying \[100\] \[101\] \[99\] biases emerged. The following sections explore the pros and cons of retraining versus empowering biases.

3.1.1 Modification strategies

The concept of Cognitive Bias Modification (CBM), which uses computer-based tasks to curb unhealthy behavior by retraining underlying cognitive biases, has been used to treat depression \[102\], anxiety \[33\] and addictive behaviors such as excessive gaming \[31\] and alcohol consumption \[99\]. Rabinovitz & Nagar demonstrated a link between approach bias and urges produced by game-related cues in Internet Gaming Disorder (IGD) \[31\], where retraining through an Approach Avoidance Task (AAT) reduced said urges and even the subjects’ intention to play Massive Multiplayer Online Role-Playing Games (MMORPGs).

This form of therapy is being increasingly applied to interactive products such as games \[99\], smartphones \[32\] and apps \[103\] as a way to encourage users to undergo cognitive modification. Boendermaker et al \[104\] applied the gamification principle to screen-based tasks in an attempt to entice teenagers into substance abuse treatment.

While published studies using CBM therapy seem to ensure positive results, reviews such as conducted by Liu et al \[33\] addressed, ironically, the possibility of a publication bias on this newfound technique, where “positive and statistically significant studies are likely to be published more rapidly than are studies with negative and statistically non-significant results”.

Cristea et al \[102\] analyzed 49 separate trials with the objective to treat anxiety and depression and verified that once adjusted for publication bias and removing extreme outliers, most results were non-
significant. Taking this into consideration, some studies were found that displayed difficulty in maintaining the effects of retraining after therapy, as subjects seemed to easily revert back to their normalized patterns. Considering healthy population samples, Wiers [99] demonstrated that the bias blind spot, which makes subjects unable to detect their own biased behaviors despite recognizing them in others, suffered no alteration based on one’s cognitive sophistication. In fact, they found a positive correlation between higher cognitive ability and blind spot magnitude, meaning that those with better cognitive skills still displayed classic cognitive biases and a lack of ability to admit them. However, this demonstration is limited by the construction of the self-assessment tool, which could have predisposed certain responses from the test subjects.

3.1.2 Nudge strategies

Nudge theory is a concept in behavioural economics that disagrees with the notion that humans are Econs (as defined in Section 2.1.3) [34] and highlights the benefit from being “nudged” into making the best choice, all things considered. A nudge is defined as “any aspect of the choice architecture that alters people’s behavior in a predictable way without forbidding any options or significantly changing their economic incentives.” [36]. It is important to note that nudge theory is grounded on the notion of libertarian paternalism, where influences on decision-making are designed to make the individual better off (paternalistic movement), without being so restrictive or disruptive to the decision-making process that it could compromised one’s freedom of choice (libertarian movement) [36].

The application of this theory to design is referred to digital nudging, where the design of a digital environment influences the user’s decision-making [105] [108]. On this front, studies such as the one conducted by Turland et al researched the effects of color coding and presentation order in promoting cyber-security [107]. With the intent of nudging users to choose safer wi-fi networks, they used color and order to present the different wi-fi connections from most to least secure. They found that while order alone did not influence decision-making, color coding was quite effective in influencing users to choose the safest connections. More so when both nudges were combined.

While approaches surrounding the concept of digital nudging to frame one’s cognitive susceptibilities in a positive way are significantly novel, there has been an increased non-academic discussion of the idea of designing for cognitive bias. Designing for bias refers to creating a controlled interactive environment where biased behavior leads to positive outcomes.

David Dylan Thomas gave a talk at the UX Copenhagen Conference on this particular topic [108]. He began by stating how hard it is to combat bias since most of cognition happens unconsciously. He then emphasizes the importance of choice architecture in directing human reasoning. Designers have a primary role in identifying the decisions the user needs to make and particularly, how they make them. He presents an example where users are influenced to complete a task (following a recipe) by influencing a common bias that makes them associate readability with task complexity. By decreasing the amount of text and adding more visual cues to each step, the user is led to believe that the recipe is easy to make.

Another example was how Amazon ordered and displayed product reviews to improve their customers’ decision-making. They created the concept of review usefulness and presented the two most useful positive and negative reviews side by side. This enabled the consumer’s recency bias to occur in a choice-supportive environment.
3.2 Links between Personality, Thinking Style and cognitive bias

As highlighted by Fan et al, while personality and thinking styles might be closely related when discussing what embodies individual differences, there is no consensus on whether one is subordinate to the other [77]. Several studies have explored how different aspects of personality can predict patterns in cognitive processes and vice-versa.

3.2.1 “Personality - Cognitive Style” dynamics

Revelle et al proposed the use of the Synthetic Aperture Personality Assessment (SAPA) tool to explore cognitive (and non-cognitive) aspects of personality in order to predict individual differences in cognition [109]. They presented personality has “an abstraction used to explain consistency and coherency in an individual’s pattern of Affects, Cognitions, Desires and Behaviors.”, escaping pure trait theories of personality. As it is difficult to conduct studies in personality that require such immense sample sizes, SAPA is used as a web-based data collection technique that given a large set of personality and ability items, distributes smaller subsets of said across the Internet to individual subjects in order to collect incomplete portions of the survey and synthesize them in a larger, complete sample. They used this technique in several proof of concept studies, in particular when examining the relationship between the Big Five (FFM) scale and IQ items, which found a positive correlation between Openness to Experience and intellectual ability in conventional standardized tests.

When later addressing affects, behaviors, cognitions and desires in the Big Five traits, Revelle & Wilt pointed out the lack of proper operationalization of these components in current trait inventories, which could have introduced practical limitations to their past attempts to correlate personality and cognition [110]. They set out to determine the ABCD composition of traits and identify inventory items that were significantly high in a particular component of the ABCD in order to obtain pure scales of cognition-related personality traits. As illustrated in Fig. 3.1, they found that the traits themselves differed in their emphasis toward different components, where one trait seems to represent one component in neglect of the others. For example, neuroticism was being assessed with items focused primarily on Affective content with a low number of items representing Behavior and Cognition, creating asymmetric evalua-

<table>
<thead>
<tr>
<th>Traits \ Scale</th>
<th>A (Affect)</th>
<th>B (Behavior)</th>
<th>C (Cognition)</th>
<th>D (Desire)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agreeableness</td>
<td></td>
<td></td>
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<tr>
<td>Conscientiousness</td>
<td>≤</td>
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<tr>
<td>Extraversion</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Neuroticism</td>
<td>≤</td>
<td>≤</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Openness</td>
<td>≤</td>
<td>≤</td>
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</tbody>
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Figure 3.1: Distribution of items per component on each trait dimension in the Big Five Inventory, as discovered by Revelle and Wilt [110].
tions of neuroticism despite its known effects on cognition and behavior. The studies they implemented culminated in valid ABCD scales extracted from the Big Five Inventory, that would allow for an easier path when addressing the study of correlations with topics such as cognition, cognitive style and bias. Nevertheless, relationships between cognitive style and FFM of personality can be produced in segmented studies that address particular aspects of cognitive style. Barakat et al successfully correlated higher levels of agreeableness, conscientiousness and openness to prudence, a cognitive characteristic that affects how one deals with information, situations and events [15].

3.2.2 "Personality - Cognitive Bias" dynamics

As seen in the last topic, there is a significant amount of research on the topic of individual differences in cognition ability and thinking styles. Given these relationships, could one predict a predisposition for certain cognitive biases through personality traits?

Long set out to answer this exact question, applying the NEO-PI-R questionnaire with a Confirmation Inventory to assess if different personalities differed in level of confirmation bias [111]. Alas, the results were inconclusive has the sample size was far too small. Outside human-centered research, a study with parrots [112] successfully determined personality as a predictor of level of attentional bias, suggesting that high neuroticism led to greater attention bias to environmental stimuli. Considering this biologically relevant individual difference in cognition, fitness implications of said bias were also discussed in regards to the benefits of high neuroticism for survival in high-threat environments.

While there is certainly an interest in research of individual differences in susceptibility to bias, most current literature on the subject faces methodological restrictions. Aczel et al demonstrates the difficulty of producing a valid multiple-bias questionnaire based on previous Heuristic and Bias research, as efforts of consolidating multiple tasks ultimately produces severe internal inconsistencies [113]. Nevertheless, Sklad & Diekstra seemed successful in producing a psychometric scale to assess vulnerability for six different biases by involving undergraduate students in the process. So there is space to assume that comprehensive cognitive bias assessment inventories are not entirely out of reach [114].

In contrast to holistic reviews of susceptibilities to bias, studies exploring personality dynamics with a single, specific cognitive bias at a time enabled pertinent findings. Fujino et al studied the relationship between personality and the sunk cost bias. They found instances of high Agreeableness and Conscientiousness correlating to heightened susceptibility to this decision-making fallacy [115].

3.3 Implications of adapting to individual differences

Numerous initiatives to promote designing for individual differences in HCI have spawned from the implications of pertinent findings regarding the impact of adaptive design and novel approaches to thinking styles and cognitive bias on user performance, perception and overall satisfaction.

3.3.1 Personality-focused user experiences

It is rather common to find articles that juxtapose personality to personal preferences [116] [117]. A elegant example of so was conducted by Sarsam & Al-Samarraie in an attempt to optimize attention in a mobile learning app [118]. They collected, analyzed and clustered the personality and design preferences of 87 students into two personality types: neuroticism and conscientiousness. Each interface (see Fig. 3.2) was designed to the visual preferences of each group and setup to capture eye movement and pupil dilation in order to infer cognitive load and focus. Results showed that design adaptations favored increased user satisfaction and low cognitive loads.
Abrahamim et al were able to use the Myers-Briggs Type Indicator (MBTI) to enhance learning by exposing students to learning structures that best matched their personality. When controlling for differences in Sensing/Intuition and Introversion/Extroversion traits, they found that intuitive extroverts performed better in well-structured environments, while intuitive introverts were able to perform just as well in non-structured environments. This also reflects how personality and cognition seem intertwined.

### 3.3.2 Cognition-focused user experiences

Contributions from the early 2000’s explored the role of cognitive styles in aspects of visual design, interaction design and design thinking with the objective of addressing the need for future work in adaptive design and more cognitive approaches to user experience and performance. Mampadi et al demonstrated that adapting to cognitive styles improved student learning performance in hypermedia learning systems. Moreover, this adaptation resulted in significant improvement in the student’s perception of structure clarity and logical sequence in the system.

### 3.3.3 Bias-focused user experiences

Minge et al demonstrates that user experience is heavily affected not only by hedonic halo effects - emotionally charged cognitive biases where cues unrelated to functionality such as visual aesthetics influences overall perceived usability-, but also by pragmatic halo effects - where the overall appraisal of the object became conditioned to the level of usability they had just experienced. Thus, cognitive biases have not only the power to influence one’s performance, but their entire experience using a specific artifact. The concept of bias as an important interaction factor goes beyond traditional HCI. The field of social robotics contains contributions such that of Biswas & Murray where the hypothesis of constructing “biased” robots yields better human-robot interactions than with “unbiased” robots. When they first reviewed the subject of misattribution - a memory bias where the subject only remembers part of a memory accurately, attributing wrong facts to other details - in robots, they programmed an ERWIN
to engage in friendly conversations in separate sessions in order to gain insights on the participants. In the third study, they introduced misattributed statements such as “Last time you were wearing a blue shirt, am I correct?” and apologies when corrected by the participants. Participants demonstrated a keen sensibility in picking up these subtle imperfections and associated them with being more natural, more human, and therefore, more suitable for long-term interactions. While the impact of cognitive bias on interaction is present in current literature, there is a scarcity of initiatives that look into the manipulation of interaction context as a form of empowering (and not simply eradicating [26]) biased interactions with the objective of actually enhancing performance, perception or user experience. The closest arguments found were either present in scattered opinion pieces outside of academic interventions [123], or in the underlying ideology of “Nudge” [36], a literary piece on choice architecture and context reframing that inspires readers to take learn how to take advantage of their natural cognitive biases to induce better outcomes for biased behavior.

3.4 Discussion

Related approaches to individual differences and cognitive biases were presented. We began by introducing the trend of CBM therapies and their goal of retraining cognitive biases that are viewed as harmful to human beings. This form of therapy has been recently popularized and its extensive body of research has celebrated numerous successes. However, instances of failure to train biases and revert back to initial behaviors can be found in articles such as that of Cristea et al, that reviewed 49 instances of CBM therapy with no real positive effect to the participants in long term [102].

While the concept of curbing unhealthy behavior is enticing and can prompt positive effects for those who suffer from mental illness and addiction, bias modification might benefit from a more lenient approach to bias itself. Instead of viewing bias as insidious and promoting its modification, perhaps viewing bias as beneficial to thought processes and an opportunity to harness its adaptive qualities can yield longer lasting results. This particular perspective has been increasingly discussed in non-academic environments [108] [123], emphasizing the need to design for bias instead of investing in retraining or avoidance strategies. An interesting take on this perspective is the concept of nudge theory [36]. Thaler suggested that by simply controlling the context in which biases are triggered and employing pertinent choice architecture, one might be able to steer subjects into better performance and decision-making. David Dylan Thomas then recounts instances that operationalize these nudges to positively frame our biases into more optimal outcomes [108]. Given this novel perspective on bias, we then address notions of individual differences in susceptibility to such biases. We do so by exploring the body of work regarding the correlations found between personality traits, cognitive and thinking styles, and susceptibility to cognitive biases. Most agree that while there are definitely links between personality and thinking styles, they still constitute distinct entities in the realm of individual differences [77]. Revelle et al presented their work on personality organization as an entity comprised of four components, one of them being the cognitive component of personality [109]. Given this particular component, they used the SAPA tool to predict cognitive and non-cognitive differences from the Big Five personality traits. While they sought the extraction of pure component scales from the FFM studies like that of Barakat et al demonstrated that it is possible to study these relationships between personality and cognitive style without reforming the inventories [15]. In this particular article, they successfully correlated higher levels of agreeableness, conscientiousness and openness to prudence, in contrast to lower scores for impulsive styles of thinking and assessing the environment. Regarding bridges with cognitive biases and susceptibility to biased thinking, few holistic studies have found concrete evidence that demonstrate predictable differences in the types of cognitive biases one to which one is most susceptible, either due to small sample sizes or limitations in bias assessment. Initiatives to construct comprehensive measures of bias detection have
been pioneered by Sklad & Diekstra, who seemed to have successfully created a psychometrical tool that assesses six different cognitive bias [114]. Unfortunately, attempts such as that of Aczel et al struggles with internal consistency when composing larger number of heuristic and bias tasks scattered in the body of research on the topic [113]. This might be due to the conflicting nature of different biases, as they can be triggered simultaneously. When focused on a particular bias, Fujino found that Agreeableness and Conscientiousness traits had a significant effect on vulnerability to the sunk cost fallacy [115]. The solution seems to be to evaluate small subsets of biases who’s task presentation does not involve significant load on more than one aspect of cognition, such as simultaneously involving memory and decision-making. With this in mind, this study chose to focus on decision-making competences. Finally, implications for such an approach on cognitive biases in interface design is presented with the objective of demonstrating solutions that have found evidence of better performance and user experience in adaptive frameworks. Studies from the last two decades support the notion that adapting to individual differences such as cognitive style promoted better user performance, perceived usability and overall experience. Moreover, studies that looked into the impact of cognitive biases in interaction agree that it is a powerful force in interface evaluation [19] and relationships with technology [122]. We find that there are significant arguments to articulate this research initiative and given this collection of evidence, the next section will present the research portion of this project.
4 | Researching the role of personality in decision-making biases

Having found pertinent findings regarding the dynamics of personality, cognitive style and decision-making skills in the scientific community, this chapter presents the correlation studies that set to investigate the role of personality in individual levels of susceptibility to different decision-making biases. Here, main research questions, hypotheses and experimental procedures were rigorously defined to enable the data collection process.

4.1 Correlation study

Before starting to collect data, it is imperative to define the research questions, along with any assumptions and hypotheses that might be critical for posterior analysis. This section enumerates all the necessary formalities that preceded the study.

4.1.1 Research questions

This study attempts to answer the following questions:

- **Question 1.1 (Q1.1):** Is there a relationship between personality and the type of cognitive bias to whom one is most susceptible?
- **Question 1.2 (Q1.2):** Is it possible to predict one’s susceptibility to certain cognitive biases solely through personality test scores?

4.1.2 Assumptions and operating definitions

The main assumption throughout this document is that errors that occur in a systematic, predictable pattern can be defined as cognitive biases. While there are many different types of different cognitive biases, the focus of the following study is on decision-making biases - specifically biases that compromise the quality of a decision, whether it leads to an optimal outcome or not.

When assessing competence in decision-making, one assumes that a higher competence is associated with having a higher resistance to common cognitive biases associated with that certain type of decision. For example, a higher competence in making consistent decisions when a problem is framed in both positive and negative ways indicates a higher resistance to framing bias.

The final assumption is that a low competence for making a particular type of decision can be defined as a potential susceptibility to the cognitive biases that surround said decision. So a lower competence in making consistent decisions despite how a problem is framed would signify that the subject is more susceptible or vulnerable to the framing bias.
4.1.3 Instruments

The following instruments were chosen to best address the questions pertinent to this study and were adapted to be administered in European Portuguese.

- **NEO Personality Inventory.**
  The assessment of participants’ personality traits was made through the NEO-PI-R[73], composed of 240 items that are devised to evaluate personality according to the Big Five personality traits (Neuroticism, Extroversion, Agreeableness, Openness, Conscientiousness). The items displayed in this questionnaire are in the form of brief assertions to which one can express different levels of agreement (or disagreement) by the use of a Likert scale.

- **Adult Decision Making Competence Questionnaire.**
  The assessment of participants’ decision making skills will be made through the A-DMC[39] questionnaire, containing a total of 87 items divided in the following sub-scales: resistance to framing, recognizing social Norms, under/overconfidence, applying decision Rules, consistency in risk perception, resistance to sunk costs and path independence.

Since this study focuses on decision-making biases, the subjects will only be required to fill out the following components of the A-DMC:

- **Resistance to Framing (FR)** consisting of 28 items (14 positive frames + 14 negative frames) that measure the ability to maintain decision consistency despite the way a problem is framed;
- **Overconfidence Assessment (CAL)** consisting of 34 items that measure one’s level of confidence in their own perception of facts;
- **Resistente to Sunk Costs (SC)** consisting of 10 items that measure the subject’s ability to walk away from a situation that is no longer fruitful to them.

The FR and SC components have a six-degree Likert scale format while the CAL component requires the subject to answer if a statement is true or false and add a percentage of how confident they are of their answer on a scale of 50% to 100% certainty. These specific components were translated from English to European Portuguese and reviewed by three Portuguese reviewers and one British reviewer. All other components corresponding to social and probabilistic cognitive biases were left out and untranslated.

4.1.4 Software

- **Google Forms**, where all instruments but the A-DMC questionnaires were presented;
- **Excel**, used to process questionnaire scores;
- **IBM SPSS Statistics 25.9**, used to conduct statistical analysis on the scores.

4.1.5 Participants

Subjects in this data collection phase were merely required to be at least 18 years old due to the specificity of the age range of the A-DMC. The participants were invited through social media platforms and on sight (near the campus grounds) to apply to individual study sessions scheduled between 8:00 and 20:00. While 77 sessions were successfully recorded, 26 records were discarded due to the accidental printing of an outdated translation of the A-DMC questionnaires.
Therefore, the results from 51 participants were submitted to analysis, which included 28 males, 23 females and an age range between 18 and 36 ($M = 21.67; SD = 3.21$). Moreover, all participants were college students pursuing different degrees (Computer Engineering, Psychology, Biology, etc).

### 4.1.6 Procedure

As each participant arrived to their scheduled session, they were given an introduction on the motivation for this study and the data they would be providing. After signing a consent form that authorized the use of said data for academic purposes, they were presented a Google form with the following questionnaires to complete:

1. Demographic Survey (see Appendix A.3);
2. Technological Familiarity Survey;
3. Adult Decision-making Competence (A-DMC) (see Appendix A.6);
4. Personality (NEO-PI-R) test;

Participants were allowed a short 5 minute break between filling out the A-DMC and the NEO-PI-R, as the latter is quite extensive and could lead to answer fatigue.

### 4.2 Descriptive statistics

#### 4.2.1 Demographic data

The demographic survey recorded the participants’ gender, age, level of education, type of degree they are pursuing and how far along they are in said pursuit (academic year). As expressed in section 4.1.4, the study gathered data from a total of 28 males and 23 females ($M = 21.67; SD = 3.21$). No participants identified as non-binary in this study sample. In terms of level of education, the vast majority had a licentiate degree in Computer Engineering or were completing said degree with a complete high school education.

#### 4.2.2 Technological familiarity data

The technological familiarity survey recorded the participant’s most used operating system, browser and social media platform on their computer and mobile devices. The participants in this sample were most familiar to the use of Google Chrome as their main browser, Windows as their main operating system on a computer, Android as their main mobile operating system and Instagram as their main social media platform (although Facebook was a close second).

This survey also recorded how often they perform specific tasks on their computer such as checking their e-mail and shopping online and a self-reported estimate of daily hours spent interacting with each of their preferred products. The three most frequent tasks that participants do on a daily basis is check their e-mail, look for pictures/videos and do search queries on new concepts that are of interest to them (i.e., using the internet to obtain and learn new information). The least frequent task was online shopping (only once every few months). Participants spend on average 6 to 8 hours a day on the computer compared to an average of 2 to 4 hours on a smartphone.
4.2.3 Decision-making data

As mentioned in section 4.1.5, 26 questionnaires were discarded due to the incidental printing of an outdated translation of the A-DMC, which could potentially skew the participant’s answers and their subsequent validity.

To analyze the remaining 51 responses, one must recall one of the main assumptions of this study: “A lack of competence when making a particular type of decision can be defined as a potential susceptibility to the cognitive biases that surround said decision.” With this assumption in mind, low scores in the FR component were attributed to framing bias, the CAL component to overconfidence bias and the SC component to the sunk cost fallacy. Since susceptibility can occur in a spectrum, categorization in low, medium and high (or non-susceptible, potentially susceptible and highly susceptible) seemed most appropriate. Two possible classification strategies were considered: defining the cut-off values through the mean and standard deviation and defining through the 25th and 75th percentile.

At first glance, creating a percentile-based classification on the original population data [39] (see Fig. 4.1), seemed to be the best option. However, it was not possible to get access to the original raw data.

![Figure 4.1: Descriptive Statistics of Nonstandardized A-DMC Components in original study [39].](image)

To ensure that the collected data was normally distributed, box plots were analyzed along with Shapiro-Wilk normality tests (see Table 4.1). Despite the notion that Shapiro-Wilk test is reserved for trials up to 50 subjects (N < 50), it was considered that our sample (N = 51) would benefit from this test due to the rather small difference margin. The overconfidence component failed the normality test (D(51) = 0.916; p = 0.002) and was discarded from further analysis.

This test was not significant for data from the FR component (D(51) = 0.962; p > 0.05) and SC component (D(51) = 0.987; p > 0.05). This encouraged the use of mean and standard deviation to define the cut-off values. These values were then used to classify the current data sample as seen on Table 4.2.

![Table 4.1: Results from the Shapiro-Wilk test on A-DMC data.](image)

Drawing inspiration from the names of each component, Resistance to Framing and Sunk Costs scores determined if the subject was classified as Truly Resistant or Truly Susceptible to its given bias. Susceptible individuals were those who scored less than one standard deviation below the mean, while Resistant individuals were those that scores greater than one standard deviation above the mean. To
Figure 4.2: Box plot data distributions in each A-DMC component.

create a proper dichotomy, an additional cut-off value was placed directly on the mean to help place subjects that could be Potentially Resistant (scores above the mean) and Potentially Susceptible (scores below the mean) in one of the two main groups so as to avoid having a disproportionately large portion of inconclusive scores. The observed scores in FR ranged from 2.57 to 4.5 ($M = 3.61; SD = 0.41$).

<table>
<thead>
<tr>
<th>Cut-off</th>
<th>FR</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truly Resistant</td>
<td>$&gt;M+SD$</td>
<td>$&gt;4.02$</td>
</tr>
<tr>
<td>Potentially Resistant</td>
<td>$[M; M+SD]$</td>
<td>$[3.61; 4.02]$</td>
</tr>
<tr>
<td>Potentially Susceptible</td>
<td>$[M-SD; M]$</td>
<td>$[3.2; 3.61]$</td>
</tr>
<tr>
<td>Truly Susceptible</td>
<td>$&lt;M-SD$</td>
<td>$&lt;3.2$</td>
</tr>
</tbody>
</table>

When applying the cut-off values, 25 participants were sorted into the Resistant group, where 5 were classified as Truly Resistant. In comparison, the Susceptible group contained 26 participants, where 7 were identified as being Truly Susceptible to the framing bias.

The observed scores in SC ranged from 3 to 5.3 ($M = 4.281; SD = 0.482$). When applying the cut-off values, 27 participants were sorted into the Resistant group, where 8 were identified as being Truly Resistant. In comparison, the Susceptible group contained 24 participants, where 8 were classified as Truly Susceptible to the framing bias.
4.2.4 Personality data

While the average percentiles for this data sample were lightly positively skewed in regards to the mean for a couple of personalit traits, no excess skewness or kurtosis was detected in the raw data (see Table 4.3). Participants were on average between the 60th and 70th percentile in Agreeableness and Openness to experience.

Table 4.3: Descriptive statistics of the NEO-PI-R results.

<table>
<thead>
<tr>
<th>Personality Traits</th>
<th>N</th>
<th>min</th>
<th>max</th>
<th>M</th>
<th>SD</th>
<th>Skewness (Stat. Error)</th>
<th>Kurtosis (Stat. Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuroticism</td>
<td>51</td>
<td>50</td>
<td>158</td>
<td>104,29</td>
<td>25,277</td>
<td>-0,056</td>
<td>0,333</td>
</tr>
<tr>
<td>Extroversion</td>
<td>51</td>
<td>57</td>
<td>157</td>
<td>116,80</td>
<td>20,120</td>
<td>-0,651</td>
<td>0,333</td>
</tr>
<tr>
<td>Openness</td>
<td>51</td>
<td>90</td>
<td>160</td>
<td>130,24</td>
<td>17,876</td>
<td>-0,195</td>
<td>0,333</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>51</td>
<td>89</td>
<td>170</td>
<td>127,98</td>
<td>17,538</td>
<td>0,175</td>
<td>0,333</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>51</td>
<td>59</td>
<td>155</td>
<td>115,37</td>
<td>23,262</td>
<td>-0,411</td>
<td>0,333</td>
</tr>
</tbody>
</table>

4.3 Results

With the findings from the previous sections, we calculated Pearson correlations and multivariate regression models between the A-DMC and NEO-PI-R scores.

4.3.1 Correlation studies

The goal for this study phase was to find correlations and interesting relationships between different decision-making competences and personality traits. Having performed a Pearson’s correlation test on a sample of $N = 51$ (see Table 4.4), it was found that the Resistance to Framing component ($M = 3.61$; $SD = 0.41$), had significant correlations with the following personality traits:

- Extraversion ($M = 116.8$; $SD = 20.12$), $r = 0.297$, $p < 0.05$
- Openness to experience ($M = 130.24$; $SD = 17.88$), $r = 0.307$, $p < 0.05$
- Conscientiousness ($M = 115.37$; $SD = 23.26$), $r = 0.313$, $p < 0.05$

The Resistance to Sunk Costs component ($M = 4.28$; $SD = 0.48$) also had a significant correlation with Openness to experience ($M = 130.24$; $SD = 17.88$; $r = 0.377$; $p < 0.01$). In an effort to deepen the understanding of these correlations, another Pearson test was also conducted on the 30 different facets that characterize these personality traits. For the FR component, there were positive correlations with:

- Achievement Striving facet of Conscientiousness ($M = 19.92$; $SD = 5.25$), $r = 0.337$, $p = 0.016$
- Competence facet of Conscientiousness ($M = 20.67$; $SD = 4.175$), $r = 0.334$, $p = 0.016$
- Ideas facet of Openness to experience ($M = 23.61$; $SD = 5.250$), $r = 0.285$, $p = 0.043$.

The SC component had positive correlations with Fantasy ($M = 22.65$; $SD = 4.556$), $r = 0.335$, $p = 0.016$ and Ideas ($M = 23.61$; $SD = 5.250$), $r = 0.334$, $p = 0.017$ from the Openness to experience trait. In the conscientiousness trait, there were positive correlations between resistance to sunk costs and both the
Table 4.4: Correlations found between A-DMC components and the five personality traits in the NEO-PI-R.

<table>
<thead>
<tr>
<th>A-DMC Component</th>
<th>FR</th>
<th>CAL</th>
<th>SC</th>
<th>N</th>
<th>E</th>
<th>O</th>
<th>A</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to Framing (FR)</td>
<td>Pearson’s r</td>
<td>Sigma (p)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under/Overconfidence (CAL)</td>
<td>-0.187</td>
<td>0.189</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance to Sunk Costs (SC)</td>
<td>0.235</td>
<td>-0.102</td>
<td>0.097</td>
<td>0.476</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neuroticism (N)</td>
<td>-0.137</td>
<td>0.039</td>
<td>-0.216</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extroversion (E)</td>
<td>0.338</td>
<td>0.788</td>
<td>0.127</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Openness (O)</td>
<td>0.297*</td>
<td>-0.076</td>
<td>0.061</td>
<td>-0.156</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agreeableness (A)</td>
<td>0.028</td>
<td>0.911</td>
<td>0.006</td>
<td>0.098</td>
<td>0.022</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conscientiousness (C)</td>
<td>0.307*</td>
<td>0.016</td>
<td>0.577**</td>
<td>0.234</td>
<td>0.321</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The correlation is significant at a 0.05 level (2 tailed).
** The correlation is significant at a 0.01 level (2 tailed).

Competence facet (M = 20.67; SD = 4.175; r = 0.324; p = 0.021) and the Deliberation facet (M = 17.8; SD = 4.682; 0.335; p = 0.010). The Pearson test also detected a negative correlation with the Hostility facet from the Neuroticism trait (M = 13.59; SD = 5.21; r = -0.305; p = 0.030), which was unexpected. This would mean that, in theory, achievement driven individuals that are more comfortable exploring abstract scenarios and display more confidence in their decision-making abilities tend to be more resistant to framing effects. Likewise, more deliberative individuals that enjoy thinking about a problem and consider more angles when entertaining fictitious scenarios in their mind would potentially be more resistant the sunk cost fallacy. No correlations were found between A-DMC scores and the demographic data.

4.3.2 Prediction models

Having found some interesting correlations between decision-making competences and personality traits, the next step was to ascertain if there was a comprehensive model that could, through the results of any NEO-PI-R test, accurately predict the subject’s susceptibility to specific decision-making biases. Multiple regression analysis was used for this effect. While there were no adequate predictions found for resistance to framing effect, a regression model for resistance to the sunk cost fallacy presented eight predictors that explained 57.3% of total variance ($F(8, 42) = 7.045, p < 0.000007, R^2 = 0.573$). Its respective equation is as shown below:

$$\text{SunkCostResistance} = 3.022 - 0.02 \cdot \text{Hostility} - 0.027 \cdot \text{Depression} + 0.031 \cdot \text{Vulnerability}$$
$$+ 0.05 \cdot \text{Fantasy} + 0.03 \cdot \text{Actions} + 0.023 \cdot \text{Modesty}$$
$$- 0.063 \cdot \text{TenderMindedness} + 0.053 \cdot \text{Deliberation} \quad (4.1)$$
Within this model, the following facets significantly predicted SC scores:

- Fantasy ($\beta = 0.05, p < 0.001$)
- Tender-mindedness ($\beta = 0.063, p < 0.001$)
- Modesty ($\beta = 0.023, p < 0.01$)
- Deliberation ($\beta = 0.053, p < 0.001$)

### 4.3.3 Discussion

Revisiting the research questions at the beginning of this chapter, there was enough evidence to answer Q1.1. Several personality traits and facets showed significant correlations to decision-making competences in this particular population sample. While one cannot infer causality, there is enough evidence that personality is a preponderant factor in characterizing individual differences in susceptibility to bias. While the Sunk Cost Resistance prediction model obtained in Section 4.3.2 was not robust enough to definitively answer Q1.2, the $R^2$ was still impressive given that it deals primarily with psychological data. There is room to speculate that modeling regressions from data collected through different instruments can deliver even more powerful predictors.

Moreover, there is still the possibility that other predictors outside of personality might also contribute to this independent variable. All of these factors will be taken into consideration when analyzing the implications and limitations of employing the current model in subsequent chapters.

Given the results and closing considerations within this chapter, this study phase was deemed successful. More importantly, it validated the decision of investigating the effects of design strategies that focus on individual differences in personality traits associated with susceptibility to the sunk cost fallacy. This process will be fully documented in the next chapter.
Designing for susceptibility

Having discussed influence strategies as a way to deal with bias, highlighted the benefits of focusing on individualized experiences (see Chapter 3) and found that humans vary in terms of susceptibility to different biases (see Chapter 4), this chapter describes the attempt to apply these novel concepts to a user-centered design process and evaluate its effects on user performance and experience.

5.1 Incorporating our findings

This section summarizes and explains how the findings from the previous chapters were factored into the design process of this research phase.

5.1.1 Targeting Sunk cost fallacies

As mentioned before, a sunk cost can be defined as any form of investment in a project or activity that one cannot recover. The sunk cost fallacy occurs because human beings become emotionally attached to their investments [124]. When deciding on whether to continue or abandon a certain project or strategy, normative decision models dictate that past investments should not be considered when the goal is to maximize success and that choosing to consider so is irrational [125]. Violating the normative principle, this fallacy influences one to heavily prioritize reparations from past investments over prospects of future costs and gains.

Intuitive notions on common triggers for sunk cost fallacies make one instantly gravitate towards the concept of monetary investment and loss. With this in mind, an e-commerce interface could provide immediate triggers for the bias in question, but demonstrating palpable differences in decision-making in such an environment seemed to be difficult to express in terms of objective usability metrics.

The concept of a stock exchange interface was also explored but the project lacked the time and background to appropriately devise interfaces with content of such a specialized nature. Additionally, results from the CAL component of the A-DMC showed that participants had less grasp on the nuances of finance and economics in comparison with other topics such as health and interpersonal relationships.

Exploring concepts of cost outside of normal currency, gamification principles such as point systems and rewards were considered. There is evidence that point and rewards systems in game-like environments are also susceptible of triggering sunk costs effects [126]. So it seems it is possible to trigger this bias in any type of interface as long as it contains these gamification components.

The results found in the technological familiarity survey played an important role in choosing the type of interface. Looking at the most common tasks performed on a daily basis, the participant pool seemed to gravitate away from online shopping and was most familiar with computer interactions that involved search queries for media content (looking at pictures and videos) and new topics they wanted to learn more about. Since the objective was to showcase the effect of design on user performance when adapting to individual
differences, and considering the fact that most participants were in fact students, a learning platform was chosen as the ideal environment.

Choosing to design a learning platform not only enabled the illustration of variance in metrics such as improvement and information retention over time but also allowed gamification components such as point systems, rewards and challenges to be applied to increase exposure to the bias being explored.

5.1.2 Targeting personality facets

Choosing to design a learning platform not only enabled the illustration of variance in metrics such as improvement and information retention over time but also allowed gamification components such as point systems, rewards and challenges to be applied to increase exposure to the bias being explored. The next step would be the selection of the personality features at play. The four bias predictors found to be significant in the regression model in Section 4.3.2 belonged to one of the following personality traits: Agreeableness (Modesty and Tender Mindedness), Openness to Experience (Fantasy) and Conscientiousness (Deliberation).

However, given that the model highlighted facets and not general traits, there is an important choice to be made: should one design for the trait to which the facets belong or design for the particular facet? The answer is non-linear. The body of evidence for designing for individual facets is very limited. However, designing for the parent trait does not guarantee an adequate adjustment, since high Modesty does not necessarily equate to high Agreeableness. While all facets seem equally viable, it would be beneficial to select one that would adequately illustrate how differences in personality can be targeted to enhance specific behaviors motivated by one’s cognitive patterns. Additionally, featuring at least four components that individually encapsulate all four significant predictors (Fantasy, Tender-mindedness, Modesty and Deliberation) could limit the objectivity of data interpretation during the validation process, as it would render a proper independent analysis of each facet effect unviable. It would be wise to first study each facet in isolation before compiling their effects in future research.

Considering the Affect-Behavior-Cognition-Desire decomposition proposed by Wilt and Revelle [110], it becomes evident that standardized tests such as NEO-PI-R and the International Personality Item Pool (IPIP) [127] do not assess each personality trait with an even number of items pertaining to the influence of affects, behaviors and cognitions. For example, Neuroticism is mostly evaluated with items pertaining to affects while Agreeableness has an even mix of items regarding affects, cognitions and behaviors. One could use this imbalance to justify a selection of facets most influenced by the behavioral and cognitive domains of personality. According to the authors, the traits that contain the most behavior and cognitive related content and least affective content is Conscientiousness. Therefore, this design effort will focus on adapting to the facet that suggests effects that would be more influential in a learning interface environment: deliberation. Deliberation reflects on one’s capacity to reflect on an issue before making a decision [78]. People that are more deliberative plan ahead and ponder options more carefully while less deliberative people are spontaneous and tend to not reflect on consequences too much.
5.1.3 An ADDIE-inspired design process

While first considering which design process to follow, the original concept was to input notions of adaptability, digital nudging and choice architecture into the well-known Design Thinking methodology [128]. But upon further consideration, the Instructional System Design (ISD) model seemed the most adequate to inform decisions regarding a learning platform environment [129]. This particular method invests in creating interface environments that can turn any user into an expert performer. This philosophy seemed to be in perfect alignment with this project’s design prospects. The next section demonstrates how heavily our design process was inspired by the ISD method. This section outlines how the processes associated with ADDIE were adapted to a user-centered approach. The ISD, alike the Design Thinking method, has five stages, as seen in Fig. 5.1. The following sections will illustrate each stage of this model.

![Figure 5.1: The five stages of ISD (or ADDIE), plus optional plugins.][130]

5.2 Analysis stage

The first step in the ISD process includes the definition of a business result that can be improved through the instruction of subjects towards better performance. Adjusting to the context of this project, one could draw from real life and stipulate that the learning platform being built is for the benefit of the students and the institute to which they belong.

So in this case, Lisbon University can be defined as the business in question. High student grades reflect positively on any academic institution and contribute to increased funding, so the business goal is defined as increasing average test scores.

The next step is to define what students would need to meet that goal. The Performance Analysis Quadrant (PAQ) evaluates performance issues (in this context, grades) as a product of level of adequate knowledge and level of motivation to learn [131]. For this design, an adequate level of base knowledge is assumed. Therefore low grades can either be a product of lack of proper resources/environment, suitable training or motivation.

Having identified the core factors that influence grades, what activities and experiences could be offered to offset them? The next section will outline the criterion used to inform the design decisions that are meant to target the subject’s level of deliberation.
5.3 Design stage

As analyzed in the previous section, low grades can be either caused by the lack of a proper learning environment, proper training or motivation. Returning to the ISD model, this stage sets out to define the entry behaviours of the subjects being trained, the learning objectives and learning steps that enable them to perform. Entry behaviors refer to what users know before training. The following sections address how choice architecture and digital nudging can be combined to enhance this process.

5.3.1 Environment and choice architecture

Students are usually exposed to two learning environments: structured and unstructured [132]. In a structured learning environment, the student learns from an expert performer (a teacher or tutor) in an organized session (the teacher is responsible for the logical structure of the lesson). Outside of classroom, students engage in unstructured autonomous study, where they learn by themselves without a specific lesson structure through their accessible resources (notes they take in class, for example). While there are advantages to both types of learning environments, there is evidence that structured spaces are conducive to improved knowledge acquisition and autonomous learning incentives [133]. By providing a space for structured learning outside of the classroom and access to all available learning resources such as slides, books and practicing materials, one can facilitate autonomous learning. There are several principles with which to structure learning [130]. Since this project attempts to designing an environment which emphasize differences in decision-making competences, the inductive-inquisitory method seems to be the best option. Students are presented with examples and then expected to induce new information. Learning through this method emphasizes individual learning strategies, principles of problem solving and the use of heuristics to navigate through the content that is presented. This is also ideal for students with a wide range of base knowledge and fosters deeper information retention [134]. In order to populate the learning space more easily in the future, the completion-strategy principle is applied. This principle presents students with problems that require partial solutions in a way that allows them to induce larger solutions in more complex tasks [130].

In order for this learning space to remain adaptable, one must consider how the content of the lesson will be laid out and how the deliberation facet plays a part in the student's navigation of the space. For content to be structured, it must suggest some type of learning sequence. Usually that sequence is done by topic, which emphasizes vertical, in-depth content searching. In parallel, horizontal searching can be seen as a more generalist, free-form way of learning. Both types of searches can be optimal depending on the task and environment. Since Deliberation is a facet of Conscientiousness, we can expect that a deliberate individual is more likely to ponder both strategies than a spontaneous one [73]. Therefore, spontaneous individuals might benefit from a choice architecture that emphasizes the most beneficial strategy.

5.3.2 Digital nudging

The learning platform should not only offer access to all relevant course materials but also include a training space the student can access to engage in structured autonomous study and practice the skills they acquire.

The next factor to be considered is lack of motivation. How can one motivate a student to practice more? Gamification initiatives heavily target learning environments and have shown to have a positive effect on learning and motivation [135]. As suggested in section 5.1.1, gamification components such as point systems are ideal triggers for the sunk cost fallacy. Sunk costs themselves can have a strong motivational power to them. They inspire individuals to persevere in the completion of a task by reminding them...
of past investments and how far they have come. Baliga & Ely theorized that the sunk cost fallacy can function as an heuristic in environments where the subject must deal with limited memory [136]. When memory capacity is exceeded, the details on what motivated the investment are lost, so the sunk cost fallacy steps in to remind the subjects of the costs of said investment and compel them to complete the journey. When sunk costs are positively framed, they are referred to as sunk rewards. However, it is important to note that simply adding a point system to encourage training does not guarantee learning quality or information retention. Since all types of students are expected to interact with this interface, it is natural to assume that some will be more conscientious than others. Considering the personality facet at hand, there is the possibility that less deliberative students might just aimlessly answer the questions to accumulate points without retaining any information. So how could one create a learning experience that could adapt to these individual differences? This is where digital nudging comes into play. As discussed in section [3.1.2], nudges are used to influence people's behavior toward the option that would make them better off [36]. Within this definition, a scoreboard could be considered a nudge towards motivating the student to use the learning space of the platform to practice their skills in the first place. As reported in Section [4.3.2], the deliberation facet of a subject's personality is a significant predictor of their level of susceptibility to the bias in question, meaning that less deliberative students are more likely to be more sensitive to sunk costs. And considering the environment requirements listed in the previous section, by adding a bonus for achieving specific learning milestones, one would be nudging the student to invest in an optimal learning strategy.

5.4 Development stage

In order to bring this learning environment to life and test the assumptions from section [5.3], an interactive prototype was created using Proto.io prototyping software. Considering the findings in Section [4.2.2], the interface was built with components from Material Design to visually emulate the users' most common browsing experiences.

The learning platform was branded as "Centro de Estudos Online da Universidade de Lisboa" or CEO-UL, and simulated an online learning center that could hypothetically serve as a repository for pedagogic content across all courses at the University of Lisbon and a social platform where students could communicate with their teachers and log on hour of autonomous by using the learning space to study or train for test. This is, however, a simple framing mechanism. The only interactive portion of the interface encapsulated the learning space. The prototype featured the learning space already open on a particular lesson.

5.4.1 UI components

The design delivered a familiar interface environment - a website layout with vertical menu, user account, breadcrumbs to simulate navigation and a lessons page. As depicted in Fig. [5.2], the base UI components in the learning space were the following:

A. Lesson modules, which divide the lesson content into separate tabs;

B. Questions and multiple options, which populate the modules;

C. "Next" buttons, which record each answer and proceed to the next question within the module.

The lesson modules emulate the notion of lesson structure and allow the student to choose either content exploration strategies (vertical, horizontal or a mix of both). The multiple option questions embody the completion-strategy principle, where each question simulates a smaller version of the more
complex task being learned. The next buttons present an instance of choice architecture as they navigate vertically through the lesson.

Figure 5.2: User journey in the personality-adapted interface. UI Components catalogued from A to C are common to both interfaces while UI components from E to G are exclusive to the “Per Module” mode (PMM).

Specific components (see figures 5.2b and 5.2d) were created to produce an adaptive digital nudge to support individual differences in the Deliberation facet:

D. **User scoreboard**, which displays how many learning points the user has collected.

E. **Module progress bar**, which informs the user of how close they are of completing a given module;

F. **Module Completion bonus**, which is a simple visual reminder displayed at the end of each completed module;

These components collectively produce a nudge that ensures more spontaneous individuals maintain an optimal learning strategy throughout the interaction. The scoreboard is not simply used as a fun gamification principle, it creates the notion of value and prompts the loss aversion heuristic [21]. The module completion bonus rewards the student for completing a module by giving them free points. The progress bar brings additional information about lesson structure, allowing more deliberative people to plan their content search accordingly and less deliberative people to feel anchored to the sequence being promoted. Through these three mechanisms, the student is nudged towards vertical content search. The questions the student answers, the closer they get to the bonus the harder it becomes to change strategy due to loss aversion.
5.4.2 Split design: two evaluation modes

An additional element (see Fig. 5.2a) was added in the initial screen so the students were led to one of two different interaction modes: the Per Question Method (PQM) and the Per Module Method (PMM). These different paths were presented as different evaluation methods for their lesson, which in return attributed points differently. Both modes express the ability to explore the modules freely. When the user selects PQM, the lesson only exhibits basic UI components and the scoreboard since it was defined as a basic requirement for student motivation. This mode embodies current design philosophies. It does not support adaptability and it avoids triggering biased thinking patterns. It is used as the control interface. This particular mode attributes +2 learning points for every item answered correctly. When the user selects PMM, the interface displays all available UI components. This mode encapsulates notions of adaptability and positively designing for intuition. It is out bias-adapted interface. This mode attributes +1 learning points for every item the user answers correctly. Additionally, the user receives a +10 bonus for completing each module. The maximum score in both designs is +80 learning points, which guarantees there is no particular advantage to picking one evaluation mode over the other. Once the user enters this mode, they are shown a scoreboard at the top right corner of the interface and a module progress bar that visually illustrates how far they are from completing a given module. Users are also visually reminded of their bonus in the "Module Completed" screen (see Fig. 5.2d).
6  Evaluation methodology

This chapter documents the process of evaluating the effectiveness of the design options proposed in Chapter 5. This includes the definition of hypotheses, evaluation instruments, metrics and protocols for the final user studies. The results of this evaluation will be thoroughly reported in the next chapter.

6.1 Validation Questions

With the prospect of analyzing the effects the strategies applied to interface design, this section presents the primary questions that should be answered by the end of the evaluation process:

- **Question 2.1 (Q2.1):** Does the adaptive design produce any impact on user performance and perception of usability?

- **Question 2.2 (Q2.2):** Which design strategy yields the best user performance: avoiding susceptibilities (standard design) or empowering susceptibilities (personality-adapted design)?

6.2 Hypotheses

Since the personality-adapted interface (PMM) was created to consider individual differences and enhance user performance, it is expected to produce higher rates across objective performance metrics when compared to the control interface (PQM). The same applies to subject metrics regarding perception of usability, as we predict that more adaptable and intuitive experiences lead to better experiences. This lead to definition of the following hypotheses:

- **Hypothesis 1.1 (H1.1):** Susceptible users will display higher rates in one or more performance metrics when using the PMM design, compared to the PQM design.

- **Hypothesis 1.2 (H1.2):** Non-susceptible users will maintain or display higher in one or more performance metrics when using the PMM design, compared to the PQM design.

- **Hypothesis 2 (H2):** The PMM design will result in higher usability scores than the PQM design on the [System Usability Scale (SUS)] scale.

6.3 User Studies

For this study, participants from the data collection phase were invited back along with the potential recruitment of new subjects. Due to the possibility of a more heterogeneous participant pool, it was important that the topic of the lesson on the prototypes was accessible to different degrees and levels of education. Thus, the CEO-UL platform prototype was populated with a lesson on the topic of vocabulary
acquisition, with a collection of over 120 words rarely used conversationally. The following sections document in detail how the exercises were formulated and which instruments were created to evaluate how well vocabulary was retained after each lesson.

6.3.1 Instruments

Along with the instruments used in the collection phase (see Section 4.1.3), which are necessary for the registration of new participants, three additional instruments were created to evaluate changes in performance, information acquisition and retention:

- **Vocabulary diagnostic test**
  This test collects a baseline for the extent of the subject's advanced vocabulary comprehension. It includes 30 items scored in a multiple choice format, featuring complex verbs, nouns and adjectives from A to Z.

- **PQM comparative test**
  A test with a fixed selection of 15 items taken from the diagnostic test, allowing for grade comparison and study of vocabulary acquisition under the prototype's "Per Question" evaluation method.

- **PMM comparative test**
  A test with a fixed selection of 15 items taken from the diagnostic test, allowing for grade comparison and study of vocabulary acquisition under the prototype’s “Per Module” evaluation method.

The SUS was also used in this phase. It presents the user with a scale that allows for a subjective usability assessment through a total of 10 items in a Likert scale response format [137]. This scale was included at the end of each comparative tests so that the user could evaluate each design.

6.3.2 Usability metrics

In alignment with the ISO/IEC 25010 directive for quality control of the International Standard Organization (ISO), this study will consider the following qualities to define objective metrics:

- **Effectiveness**, defined as “accuracy and completeness with which users achieve specified goals”;
- **Efficiency**, defined as “resources expended in relation to the accuracy and completeness with which users achieve goals”.

The operationalization of effectiveness will be as follows:

- **Answer effectiveness**, defined as the ratio between the number of correct answers and the number of items answered in total;
- **Grade improvement**, defined as the difference between the number of correct answers in a comparative test and the original number of correct answers in the corresponding items in the diagnostic test, divided by the total number of items in the comparative test;

The operationalization of efficiency will be as follows:

- **Lesson completion rate**, defined as the ratio between the number of answers and the total number of items in the lesson.
- **Module completion rate**, defined as the ratio between the number of completed modules and total number of modules;

Subjective metrics will be obtained through the SUS score to analyze the user’s perception of usability in comparison with objective metrics of usability.
6.3.3 Apparatus

Each user session was setup using the following hardware:

- **ASUS ROG laptop**, where the prototypes were presented to the user;
- **Wired Mouse**, to facilitate interaction with the interface;
- **Windows Game bar recorder**, used to screen capture the interactions with each prototype;
- **Digital timer**, to time the interactions.

6.3.4 Participants

Aside from the same age restriction used in section 4.1.5, subjects were now required to speak European Portuguese as a native language. Subjects from the first data collection phase were invited back to participate in these user studies. We also recruited new participants through the same strategy (social media exposure). A total of 31 participants participated in the validation phase of this project. One contribution was discarded due a misunderstanding about the time constraint on the tasks, which caused interactions with the two conditions to be very uneven. From this new total of 30 participants, 4 were newly recruited and 26 were repeating subjects (16 males and 14 females). The age range fell between 18 and 36 as in the first phase ($M = 23, 18; SD = 4, 16$). The collected personality data was inserted into the prediction model to classify subjects according to their level of bias (see Section 4.3.2). Recalling the classification criterion in Section 4.2.3, participants’ predicted SC scores ranged from 3.70 to 5.54 ($M = 4, 39; SD = 0, 36$), resulting in 15 participants being classified as Resistant (where 4 were identified as truly resistant) and 15 classified as Susceptible (where 1 was classified as truly susceptible). However, a positive skew ($S < 1$) was detected (see Table 6.1), whereas the actual scores remained symmetric. Investigating further, only 50% of the subjects were correctly classified through the model.

To ensure accurate representation of the sample, participants were classified based on their actual scores on the SC component ($M = 4, 23; SD = 0, 46$). With this new classification, 14 participants were considered Resistant (with 5 were truly resistant) and 16 were Susceptible (where 5 were also truly susceptible).

Table 6.1: Descriptive statistics for predicted SC scores (using a prediction model) and actual SC scores (using the A-DMC).

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual SC score</td>
<td>30</td>
<td>3.30</td>
<td>5.30</td>
<td>4.2267</td>
<td>0.46158</td>
<td>0.166</td>
<td>0.033</td>
</tr>
<tr>
<td>Predicted SC score</td>
<td>30</td>
<td>3.70</td>
<td>5.54</td>
<td>4.3596</td>
<td>0.36436</td>
<td>1.203</td>
<td>2.748</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Within this classification, Deliberation scores on the NEO-PI-R were surprisingly similar in terms of mean. Subjects within the Resistant group were, on average, in the 70th percentile ($M = 19, 54; SD = 3, 777$) but so were Susceptible subjects ($M = 19, 50; SD = 6, 470$). However, the mean is not an adequate representation of both samples. The high standard deviation in the Susceptible group demonstrates how individual scores may be scattered anywhere between the 20th and the 98th percentiles.
6.3.5 Procedure

On arrival, subjects were asked to sign a consent form allowing the screen capture of their interactions with the interface and the use of their answers on the tests for academic purposes. Each subject then registered as a new or repeating participant and was given a user guide (see Appendix A.2) that helped direct them during the session. Said guide included an introduction to the platform and the tasks they were required to complete.

The user guide also contained a scenario that would be playing out during the session to bring some context to the use of the platform. It included the following excerpt:

**PART I:** You have a course this year that requires you to submit a scientific paper at the end of the semester. The professor believes a solid vocabulary is very important when writing an article worthy of being published. Thus, they have asked the students to do a diagnostic test to assess their current vocabulary.

**Task:** Complete the diagnostic test. This task will not be timed.

**PART II:** The professor was not so pleased with the average grades so he published a lesson onto the CEO-UL and encouraged the students to practice their vocabulary. According to this course’s evaluation method, students are rewarded for using CEO-UL. For every 20 points they get practicing through the platform, they will get a +0.5v bonus towards their final grade, up to a maximum bonus of +2v. Time to practice!

**Main objective:** Gain vocabulary to improve your first test score.

**Task A:** Practice using the “Per Question” method. Once you’ve selected a evaluation method, you have 5 minutes to practice.

**Task B:** Practice using the “Per Module” method. Once you’ve selected a evaluation method, you have 5 minutes to practice.

During the diagnostic test, a timer was set to go off after five minutes to familiarize the user with the sound and help mitigate the planning fallacy, which is the tendency to underestimate the time it takes to complete a task. It is also related to our perceptual attention to the passage of time. They were allowed to continue after the timer went off and see their grade once they had completed the test.

After enabling the Windows Game bar recorder, Tasks A and B on the user guide were randomly assigned to ensure no design was being favoured. After each interaction, they were able to see how many points they had collected and were then asked to complete the comparative test associated with the task at hand. Finally, they repeated this process for the other design. Users were allowed to see their test grades after each comparative test.
6.3.6 Expected behaviors

Regarding the control interface, Resistant participants are expected to display lower lesson completion rates in comparison to Susceptible participants due to the higher predicted levels of deliberation. By taking more time to deliberate and absorb information, lesson pacing will be slower and more items might be left unexplored. Susceptible participants are therefore expected to have higher lesson completion rates due to impulsiveness and intuitive thinking, which results in barely skimming the answers for information.

The contrary is expected from the module completion rate. Deliberators are expected to opt for a planned, vertical approaches to content exploration while non-deliberators might jump from module to module to try to explore as many letters as possible. Deliberators are expected to be more effective at answering questions correctly in comparison to more spontaneous participants. Baseline grades are expected to be considerably equal.

Additionally, there is some speculation to be made on differences in said metrics when using the bias-adapted design. Susceptible individuals are expected to complete more modules with the adaptive design due to the sunk rewards component implemented on the bonus system. Lesson completion rates might experience some fluctuation as the combination of empowering intuitive thinking patterns and providing nudges towards higher deliberative standards might either foster more efficiency (higher completion rate, constant answer effectiveness) or more effectiveness (lower completion rate, higher answer effectiveness) depending on the student. There is a slight chance that answer effectiveness might also increase for individuals in the susceptible group. Resistant participants are expected to maintain their level of performance as they are supposed to already be naturally motivated to perform the tasks without applied digital nudging.

To conclude, it is expected that grade improvements rates (between baseline and comparative tests) will be highest for participants in the Susceptible group. Such expectations will be studied in the next chapter.
7 | Results

This chapter reports the results from the validation process presented in the previous chapter. Descriptive analysis was performed on both objective and subjective metrics in order to extract useful trends from the test and questionnaire responses, such as variations in grade improvement rates and perception of usability elements. Results from the follow-up statistical tests are presented for each type of user metric and discussed regarding their potential to prove the hypotheses set in Section 6.2.

7.1 Objective metrics: performance data

This section covers the results from statistical tests performed on the performance metrics regarding effectiveness and efficiency.

7.1.1 Descriptive statistics

Recalling the objective metrics defined in Section 6.3.2, descriptive analysis was conducted on Answer Effectiveness, Grade Improvement, Lesson Completion Rate and Module Completion Rate. Table 7.1 presents means and standard deviations for each metric when the bias susceptibility factor is omitted. All four metrics reported higher average performance rates when learning vocabulary from an adaptive interface in comparison to the control interface. To investigate the distribution of data regarding differences in sunk cost susceptibilities, box plots for each metric were presented in Figures 7.1 through 7.4 and analyzed individually.

Table 7.1: Descriptive statistics of the main performance metrics targeting effectiveness and efficiency, regardless of susceptibility factor.
Considering Lesson Completion (or how many questions in the lessons the student was able to complete), it was expected that the rates from students classified as Resistant would not be influenced by the adaptive design. It was also theorized that Susceptible students would complete more questions on average due to their tendency to display lower scores in the Deliberation facet (see Section 6.3.6). However, the data suggested that the Resistant group was able to complete a larger number of questions more consistently when learning with the adapted interface (\(M = 0.73; SD = 0.14\)) than with the control interface (\(M = 0.72; SD = 0.15\)).

As expected, the Susceptible students demonstrated a tendency to complete more questions in both designs when compared with the other group. While they were able to answer more questions with the adaptive design (\(M = 0.85; SD = 0.13\)), it is important to note that high lesson completion rates were not meant to present a direct measure for learning quality. Resistant individuals were predicted to have a more deliberative nature. Thus, within the time constraint, more deliberation could easily equate to a slower pacing and lower lesson completion rates. The objective of the adaptive design was to nudge impulsive students toward more deliberated answers. A hint of this effect is suggested in Fig. 7.1B as the minimum observed completion rate drops to 60%.

Considering Module Completion (or how many modules the student was able to complete), the rates were discrete values since students could complete 4 modules (100%), 3 modules (75%), 2 modules (50%), 1 module (25%) or none. These rates depended on time management and content search strategy - lower module completion rates indicate horizontal content search while higher rates indicate vertical search. The data suggests that the Resistant group tended to complete +50% of modules both in the control interface (\(M = 0.57; SD = 0.23\)) and the adapted interface (\(M = 0.59; SD = 0.19\)). It is important to note that the outlier is a perfect representation of a student who opted for horizontal search strategy, where they emphasized being exposed to a wider variety of words across the alphabet instead of completing each module in depth. Since the outlier is not present in the adapted interface results, it suggests that the digital nudge embedded into the adapted design had the desired effect: directing the student to opt for a vertical search strategy.

According to what was expected, the Susceptible group was more reactive to the behavioral queues...
in the adapted design. On average, they completed more modules in the adapted interface ($M = 0.77; SD = 0.18$) than in the control interface ($M = 0.64; SD = 0.32$). Answer effectiveness measured how accurately the student was able to answer the practice questions (see Fig. 7.3). As theorized in Section 6.3.6, it was expected that Resistant students would respond more effectively than Susceptible students in the control interface due to the effect of the time constraint and the expected higher level of deliberation for each question. Resistant participants’ effectiveness seems to rise when comparing the control design ($M = 0.70; SD = 0.12$) to the adapted design ($M = 0.74; SD = 0.10$).

In a similar trend, so did the Susceptible groups, despite the increased variance in effectiveness when

Figure 7.2: Box Plots for Module Completion Rates: a side by side comparison for Sunk Cost Resistant and Susceptible groups

Figure 7.3: Box Plots for Answer Effectiveness: a side by side comparison for Sunk Cost Resistant and Susceptible groups
interacting with the adapted design. Note that the two outliers in the control interface do not appear in the adapted interface. This could indicate that the adapted interface was successful in promoting more deliberation in each question.

Due to the structure of the lessons, the most critical indicator of student performance was the grade improvement metric. It not only assessed the improvement rate between the diagnostic test and the comparative test but also served as an indicator of how much new information was retained and successfully applied from the lesson. The adapted design had a observable effect on both groups (see Fig. 7.4). Students started out with an average baseline of 11 correct answers out of 30 items ($M = 10.93; SD = 5.04$). Resistant students had a mixed response to the adaptive design. Improvement rates were lower but more consistent in the control interface ($M = 0.24; SD = 0.068$) compared to the adapted interface ($M = 0.29; SD = 0.153$). While some benefited from the adaptive design and experienced a grade improvement of +50% of their baseline grade, it is clear by the lower bounds that some experienced the opposite effect. This could be due to the potentially distracting nature of the point system. If the student is led to believe the points are more important than the test scores, it could negatively affect this metric.

Susceptible students, however, not only displayed higher improvement rating, but also seemed to experience less variance with the adaptive design. While the minimum rate increased (showing at least some factor of vocabulary retention from the lesson), it is also important to note that the maximum rate also decreased.

![Box Plots for Vocabulary tests Grade Improvement Rates](image)

Figure 7.4: Box Plots for Vocabulary tests Grade Improvement Rates: a side by side comparison for Sunk Cost Resistant and Susceptible groups
7.1.2 Data analysis

As mentioned in section 4.2.3, participants that were identified as Potentially Susceptible or Potentially Resistant were attributed to their respective parent group (Resistant or Susceptible). As the distributions in the box plots above suggested the data did not follow normal distributions, Shapiro-Wilk tests were performed to assess normality across all metrics. While the test was not significant for Lesson Completion in regards to either Resistant ($D(14) = 0.956, p > 0.05$) or Susceptible group ($D(16) = 0.956, p > 0.05$), the tests were significant for at least one of the groups across all other objective metrics (see highlighted values on Table 7.2), meaning they deviated from normality.

Table 7.2: Shapiro-Wilk normality tests for all four performance metrics across both groups.

<table>
<thead>
<tr>
<th>SC group</th>
<th>Kolmogorov-Smirnov$^a$</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>df</td>
</tr>
<tr>
<td>PQM Lesson Completion</td>
<td>Resistant</td>
<td>0.153</td>
</tr>
<tr>
<td></td>
<td>Susceptible</td>
<td>0.157</td>
</tr>
<tr>
<td>PQM Module Completion</td>
<td>Resistant</td>
<td>0.306</td>
</tr>
<tr>
<td></td>
<td>Susceptible</td>
<td>0.203</td>
</tr>
<tr>
<td>PQM Answer effectiveness</td>
<td>Resistant</td>
<td>0.132</td>
</tr>
<tr>
<td></td>
<td>Susceptible</td>
<td>0.300</td>
</tr>
<tr>
<td>PQM score improvement</td>
<td>Resistant</td>
<td>0.265</td>
</tr>
<tr>
<td></td>
<td>Susceptible</td>
<td>0.199</td>
</tr>
<tr>
<td>PMM Lesson Completion</td>
<td>Resistant</td>
<td>0.228</td>
</tr>
<tr>
<td></td>
<td>Susceptible</td>
<td>0.179</td>
</tr>
<tr>
<td>PMM Module Completion</td>
<td>Resistant</td>
<td>0.327</td>
</tr>
<tr>
<td></td>
<td>Susceptible</td>
<td>0.220</td>
</tr>
<tr>
<td>PMM Answer Effectiveness</td>
<td>Resistant</td>
<td>0.165</td>
</tr>
<tr>
<td></td>
<td>Susceptible</td>
<td>0.170</td>
</tr>
<tr>
<td>PMM Score improvement</td>
<td>Resistant</td>
<td>0.213</td>
</tr>
<tr>
<td></td>
<td>Susceptible</td>
<td>0.179</td>
</tr>
</tbody>
</table>

$^a$. This is a lower bound of the true significance.

a. Lilliefors Significance Correction
Given the non-parametric nature of the data, in order to prove hypothesis H1.1 proposed in section 6.2, a Wilcoxon Signed Ranks test was conducted to assess differences in the performance metrics after interacting with both designs, regardless of SC group (see Table 7.3). Despite all ranks suggesting that participants add higher performance rates after interacting with the adaptive design, there were no significant differences reported by the test ($p > 0.05$). Upon conducting further tests to each level of sunk cost resistance, the ranks also pointed favorably towards the adaptive design in both groups but the Wilcoxon test showed no significant differences between groups.

Table 7.3: Wilcoxon Signed Ranks test results on overall sample.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PMM Lesson Completion - PQM Lesson Completion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Ranks</td>
<td>11</td>
<td>15.36</td>
<td>169.00</td>
</tr>
<tr>
<td>Positive Ranks</td>
<td>16</td>
<td>13.06</td>
<td>209.00</td>
</tr>
<tr>
<td>Ties</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PMM Module Completion - PQM Module Completion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Ranks</td>
<td>8</td>
<td>9.13</td>
<td>73.00</td>
</tr>
<tr>
<td>Positive Ranks</td>
<td>12</td>
<td>11.42</td>
<td>137.00</td>
</tr>
<tr>
<td>Ties</td>
<td>10</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PMM Answer Effectiveness - PQM Answer effectiveness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Ranks</td>
<td>15</td>
<td>13.87</td>
<td>208.00</td>
</tr>
<tr>
<td>Positive Ranks</td>
<td>15</td>
<td>17.13</td>
<td>257.00</td>
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<tr>
<td>Ties</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>PMM Score improvement - PQM score improvement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Ranks</td>
<td>12</td>
<td>10.92</td>
<td>131.00</td>
</tr>
<tr>
<td>Positive Ranks</td>
<td>14</td>
<td>15.71</td>
<td>220.00</td>
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</tr>
<tr>
<td>Total</td>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. PMM Lesson Completion < PQM Lesson Completion  
b. PMM Lesson Completion > PQM Lesson Completion  
c. PMM Lesson Completion = PQM Lesson Completion
7.2 Subjective metrics: usability

This section covers the results from statistical tests performed on subjective metrics regarding user perception of usability.

7.2.1 Descriptive statistics

Unlike the trend seen on the objective performance metrics, perception of usability was more polarized in the adaptive design. As illustrated by Fig. 7.5, the minimum observed SUS score decreased in both groups after interacting with the adaptive design. In both designs, the Resistant consistently gave higher average usability scores than the Susceptible group. However, the minimalist control interface had an higher average score from both Resistant subjects ($M = 90.36; SD = 1.794$) and Susceptible subjects ($M = 90; SD = 1.661$) in comparison to the scores given to the adapted design.

Figure 7.5: Box Plots for Systematic Usability Score: a side by side comparison for Sunk Cost Resistant and Susceptible groups
7.2.2 Data analysis

In order to evaluate differences between scores, the Shapiro-Wilk test was performed to guarantee the data was close to a normal distribution. None of the tests were found to be significant \((p > 0.5)\), which motivated a preliminary matched-pairs t-test to assess differences in scores for the entire sample. The test did not find significant differences in perceived usability \((t(29) = 1.464, p > 0.05)\). In order to assess the effect of the within-subjects factor (susceptibility to sunk costs) on the independent variable (perceived usability), a two-way mixed ANOVA was conducted. Since the independent variable only has two levels of the repeated measure in question (control design and adapted design), proof of sphericity does not apply. A Levene’s test is performed to assess the homogeneity of variance assumption. As illustrated by Table 7.4, the tests are non-significant \((p > 0.05)\), so homogeneity is secured. Analyzing the between-subject effects, one can conclude that the design does not produce a significant effect on perception of usability \((F(1) = 2.079, p > 0.05)\) and that level of susceptibility did not have a significant effect on usability perception given a specific design \((F(1) = 0.009, p > 0.05)\). Despite the fact that the interaction order was randomized, the test was controlled for covariance with this factor and it was shown to have no influence in the results \((p > 0.05)\).

Table 7.4: Levene’s test of homogeneity across the subjective metrics.

<table>
<thead>
<tr>
<th></th>
<th>Levene Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
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<tbody>
<tr>
<td>PQM SUS score</td>
<td>Based on Mean</td>
<td>0.000</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Based on Median</td>
<td>0.170</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Based on Median and with adjusted df</td>
<td>0.170</td>
<td>1</td>
<td>25,414</td>
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<tr>
<td></td>
<td>Based on trimmed mean</td>
<td>0.003</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>PMM SUS score</td>
<td>Based on Mean</td>
<td>0.767</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Based on Median</td>
<td>0.344</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Based on Median and with adjusted df</td>
<td>0.344</td>
<td>1</td>
<td>26,594</td>
</tr>
<tr>
<td></td>
<td>Based on trimmed mean</td>
<td>0.760</td>
<td>1</td>
<td>28</td>
</tr>
</tbody>
</table>

Tests the null hypothesis that the error variance of the dependent variable is equal a. Design: Intercept + SC_group
7.3 Discussion

In this chapter, results from the design validation method were presented. Observing the box plots allowed, to a certain degree, to speculate the effects of each design on each group. Data trends suggested that the embedded digital nudges had an effect on student behavior. While the Efficiency related metrics were designed to simply showcase differences in behavior, Effectiveness related metrics sought to illustrate the effect of those behaviors in the learning process. On more than one occasion, Susceptible students detected as potential outliers showed to respond quite positively to the digital nudges towards higher deliberation and vertical learning strategies. This implies that digital nudging and harnessing biased behaviors has a visible effect on learning quality.

Considering the validation questions proposed in Section 6.1, the existence of an observable effect allows one to answer Q2.1: the adaptive design did have an impact of performance and usability metrics. Moreover, trends indicated that the adaptive design fostered higher performance rates across all objective metrics, which hints to the conclusion that empowering susceptibilities is the optimal design strategy for better user performance. Trends aside, the size and significance of these effects remain paramount to the validation process. Since no significant differences in performance were detected between designs ($p > 0.05$), both hypotheses H1.1 and H1.2 presented in chapter 6 must be refuted. This could simply be the result of the loss of several research sessions due to misprinted instruments in an earlier phase of participant registration, which contributed to a relatively small data sample in the evaluation portion of this project ($N = 30$) and ultimately seemed to obscure any statistically significant findings and sizable effects that could prove the hypotheses.

It is also suspected that adding the time constraint to the task, despite being valid and to some degree necessary to enable accurate comparisons of data, had a pervasive effect across all metrics. Participants often mentioned feeling the pressure of having 5 minutes to complete the lesson, despite the fact that lesson completion was not the target task but a by-product of one’s interactions.

In fact, since hypothesis H1.1 depended fully on the effects of the grade improvement metric, Lesson Completion was a narrative metric by which one could assess speed and compare to other metrics such as answer effectiveness in order to derive deliberation profiles. As mentioned in Section 7.1.1, increased Lesson Completion by itself is not a good measure of what the student learned.

Moreover, the study of more complex metrics from the resulting data could describe a more accurate portrait of exactly how much new information was retained by the students.

Regarding perception of usability, it was noted that students seemed to consider the minimalist control interface more usable than the adapted design. This could indicate that triggering a sunk cost fallacy artificially was in a way subconsciously detected by the students. Alternatively, it could mean that the nudges were not subtle enough. Considering that the design process was mostly a theoretical exercise (where most design decisions were supported by articles and academic insights instead of palpable user research), the solution to obtain better usability perception would entail further user studies, workshops and interviews to establish a more iterative solution.
8 Conclusion and future work

The present dissertation began by discussing the key elements that are missing from better user experience and performance. It focused on two distinct issues: the lack of proper adaptability to diverse thinking patterns and the lack of positive design strategies regarding individual susceptibilities to decision-making biases. Preliminary investigations focused on the characterization of decision-making competences as individual differences. In particular, research focused on ascertaining the role of personality traits in decision-making strategies, reasoning patterns and cognitive pitfalls.

Several correlations were found to link cognitive resistance to framing and sunk costs to specific traits such as Openness to Experience and Conscientiousness. Additionally, facets such as Deliberation, Tender-mindedness, Fantasy and Modesty were found to be significant predictors of susceptibility toward sunk cost fallacies. These early findings promoted a second body of research that focused on investigating design initiatives with positive approaches to cognitive biases. Disciplines such as behavioural economics, decision theory and evolutionary theory of cognition have contributed to this theme with methods such as digital nudging and choice architecture, which constitute constructive strategies towards designing for bias.

After developing a conceptual learning platform prototype that featured components designed to adapt to the students’ individual levels of susceptibility to sunk cost fallacies and deliberation, it was tested in its ability to produce palpable performative effects in terms of knowledge acquisition and grade improvement. Students that were more susceptible to the sunk cost fallacy displayed behavioral shifts in both efficiency and effectiveness. Preliminary results implied that the adaptive interface was successful in producing digital nudges towards more deliberative reasoning (higher answer effectiveness) and using biased behaviors to the advantage of the student (promoting vertical content search through higher module completion). While there were no statistically significant differences in performance to report, the data seemed to suggest that individuals who were more susceptible to the sunk cost fallacy benefitted from the adapted learning environment across all objective performance metrics to some small degree.

Since the initial proposal expected to gather a sample size of at least 100 subjects to adequately study the role of personality in susceptibility to decision-making biases and the effect of personality-adaptive design methods on user performance and experience, the refutation of the hypotheses proposed in this dissertation might simply be the circumstantial product of the small population sample in the validation process ($N = 30$).

Alternatively, the definition of more specific, complex metrics might be sufficient to uncover significant effects. We leave a recommendation to analyze video interactions individually to assess which content search strategy was used by the student instead of basing it off the Module Completion metric. Additionally, analyzing grade improvement through word retention rates could help pinpoint which words were in fact retained after the lesson. Word retention is here defined as the ratio between number of novel words retained during a comparative test and the number of novel words acquired during the lesson. A novel words corresponds to an answer the subject was not familiar with during the diagnostic test (for example, if the user did not know that the correct answer to Question X was “serendipity”, then serendipity is a
novel word to said user).

In regards to perception of usability, since the design decisions were mostly backed by theory rather than empirical studies, refining them through iterative user research would ensure appropriate adaptability when attempting to corroborate H2. Future research, iteration and validation processes with larger population samples and more specific evaluation metrics are, therefore, highly recommended as they are likely to yield the results the trends have highlighted.

While there was no proof of concept for the design portion of this dissertation, significant contributions were given to the scientific community in the form of a large scale review of design strategies for learning platforms using the ISD method, an article on the societal implications of designing for personality in the Journal of Personality and Individual Differences (Elsevier) and a prediction model that can predict susceptibility to sunk cost fallacies based purely on personality traits with an accuracy of 57.3%, which will no doubt be of use in future design efforts that focus on personality adaptability in HCI research.

In light of these conclusions, there are two primordial investments to be made in the future. Additional exploratory user studies are needed empirically inform design choices outside of theoretical proofs of concept. This could be achieved by incorporating digital nudging and enhanced choice architecture to the Design Thinking process.

Secondly, there are over 100 different types of bias that not only affect decision-making but also working memory and social perception. It remains imperative to promote holistic data collection in order to not only refine the sunk cost susceptibility prediction model but also build additional models. This could be done through the incorporation of machine learning to develop intelligent interfaces that provide dynamic predictions and subsequent adaptability.
Bibliography


### A.1 Consent Forms

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</tr>
</thead>
<tbody>
<tr>
<td>Eu, ____________________________________________, declaro que tomei conhecimento de que nos testes em que irei participar serão gravados:</td>
</tr>
<tr>
<td>□ os meus dados fisiológicos;</td>
</tr>
<tr>
<td>□ as respostas aos questionários demográficos; e</td>
</tr>
<tr>
<td>□ as respostas aos questionários IPC, NEO-PI-R e A-DMC.</td>
</tr>
<tr>
<td>Declaro também que autorizo o uso desses dados para fins educativos, sem mais nenhum fim alternativo fora do uso escolar. Tem interesse em receber os resultados dos seus dados pelo contacto que nos deu?</td>
</tr>
<tr>
<td>□ sim;</td>
</tr>
<tr>
<td>□ não.</td>
</tr>
<tr>
<td>____________________________</td>
</tr>
<tr>
<td>(data)</td>
</tr>
<tr>
<td>____________________________</td>
</tr>
<tr>
<td>(assinatura)</td>
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</table>

<table>
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<td>Eu, ____________________________________________, declaro que tomei conhecimento de que no estudo em que irei participar serão gravadas:</td>
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</tr>
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<td>• as respostas aos questionários NEO-PI-R e A-DMC;</td>
</tr>
<tr>
<td>• as respostas aos testes de vocabulário avançado;</td>
</tr>
<tr>
<td>• as respostas aos questionários de usabilidade SUS; e</td>
</tr>
<tr>
<td>• as interações com o protótipo em formato de captura de ecrã.</td>
</tr>
<tr>
<td>Declaro também que autorizo o uso desses dados para fins educativos, sem mais nenhum fim alternativo fora do uso escolar.</td>
</tr>
<tr>
<td>____________________________</td>
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<td>(data)</td>
</tr>
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</tr>
<tr>
<td>(assinatura)</td>
</tr>
</tbody>
</table>
Centro de Estudos Online da Universidade de Lisboa

Introdução:
A plataforma CEO-UL pretende conectar docentes e estudantes de toda a comunidade universitária e ser uma ferramenta para melhorar o desempenho académico. Aqui podes consultar o perfil de vários professores e ter acesso às suas publicações na plataforma e a um horário de dúvidas online. Podes também partilhar materiais de estudo e discutir diversos tópicos nos fóruns. Os professores podem publicar desafios e exercícios práticos para incentivar os alunos a estudar para os exames e para recompensar as suas horas de trabalho autónomas com pontos que revertem para um bónus na nota final.

Uma das features únicas da CEO-UL é que foi desenhada para se adaptar ao estilo cognitivo de cada aluno e oferece uma experiência de aprendizagem que visa optimizar o seu desempenho. Hoje irás experimentar o componente “Praticar” da plataforma e interagir com os diferentes modos de avaliação que esta oferece para averiguar qual é o modo que optimiza a tua performance.

Cenário:
Tens uma cadeira este ano que requer que entregues um artigo no final do semestre. O professor tem uma veia literária e fez um mini-teste para aferir o nível de vocabulário dos alunos. Como não ficou muito satisfeito com os resultados, decidiu adicionar um desafio à plataforma CEO-UL para incentivar os alunos a estudar.

Segundo método de avaliação da cadeira, os pontos acumulados ao praticar na plataforma são convertidos em valores bónus no final do semestre, até um máximo de 2 valores. Cada 20 pontos equivalem a 0.5 valores. Há rumores que o professor tenciona voltar a fazer outro mini-teste em breve. Vamos melhorar a tua nota?

**Objectivo:** Praticar vocabulário avançado e melhorar a nota do primeiro mini-teste.
- **Tarefa A:** Praticar com o modo de avaliação “Por Pergunta” durante 5 minutos.
- **Tarefa B:** Praticar com o modo de avaliação “Por Módulo” durante 5 minutos.
Registo de Novo Participante

Bem-vindo! Ser-lhe-ão apresentados diversos questionários nesta sessão. Pedimos que leia cuidadosamente cada pergunta e que responda a todas as questões. Não existem respostas certas ou erradas.

*Required

Dados Demográficos

Este questionário contém perguntas sobre os seus dados demográficos. Leia cuidadosamente cada uma delas. Não existem respostas certas ou erradas. Responda a todas as questões.

1. Qual o seu género? *
   
   Mark only one oval.
   
   - Feminino
   - Masculino
   - Outro

2. Qual a sua idade? *

3. Qual o seu nível de escolaridade? *
   
   Mark only one oval.
   
   - Ensino Secundário
   - Ensino Profissional
   - Licenciatura
   - Mestrado
   - Doutoramento
   - Outro

4. Qual o contacto que podemos usar para chegar até si? *

5. Se estuda no Técnico, qual o seu curso?
   
   Mark only one oval.
   
   - LEIC
   - MEIC
   - Outro
6. Se estuda no Técnico, em que ano de estudo se encontra?  
Mark only one oval.  
☐ 1º ano  
☐ 2º ano  
☐ 3º ano  
☐ 4º ano  
☐ 5º ano  
☐ 6º ano  
☐ Outro

Familiarização com Tecnologia  
Este questionário contém perguntas sobre a sua familiarização com tecnologia. Leia cuidadosamente cada uma delas. Não existem respostas certas ou erradas. Responda a todas as questões.

7. Qual o browser que usa mais frequentemente? *  
Mark only one oval.  
☐ Edge  
☐ Google Chrome  
☐ Mozilla Firefox  
☐ Opera  
☐ Safari  
☐ Outro

8. Em média, quantas horas usa esse browser por dia? *  
Mark only one oval.  
☐ Menos de 2 horas  
☐ Entre 2 a 4 horas, inclusive  
☐ Entre 4 a 6 horas, inclusive  
☐ Entre 6 a 8 horas, inclusive  
☐ Mais de 8 horas

9. Qual o sistema operativo de computador que usa mais frequentemente? *  
Mark only one oval.  
☐ Linux  
☐ macOS  
☐ Windows  
☐ Outro

10. Em média, quantas horas usa esse sistema operativo de computador por dia? *  
Mark only one oval.  
☐ Menos de 2 horas  
☐ Entre 2 a 4 horas, inclusive  
☐ Entre 4 a 6 horas, inclusive  
☐ Entre 6 a 8 horas, inclusive  
☐ Mais de 8 horas
11. Qual o sistema operativo de smartphone que usa mais frequentemente? *
Mark only one oval.

- Android
- iOS
- Outro

12. Em média, quantas horas usa esse sistema operativo de telemóvel por dia? *
Mark only one oval.

- Menos de 2 horas
- Entre 2 a 4 horas, inclusive
- Entre 4 a 6 horas, inclusive
- Entre 6 a 8 horas, inclusive
- Mais de 8 horas

13. Qual a rede social que usa mais frequentemente? *
Mark only one oval.

- Facebook
- Instagram
- LinkedIn
- Reddit
- Tumblr
- Twitter
- Outra

14. Em média, quantas horas usa essa rede social por dia? *
Mark only one oval.

- Menos de 2 horas
- Entre 2 a 4 horas, inclusive
- Entre 4 a 6 horas, inclusive
- Entre 6 a 8 horas, inclusive
- Mais de 8 horas

15. Com que frequência faz as seguintes ações usando um computador? *
Mark only one oval per row.

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<tr>
<th>Ação</th>
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<th>Semanalmente</th>
<th>Mensalmente</th>
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Teste de Daltonismo
Ficha de Diagnóstico - Vocabulário Português

O Centro de Estudo Online da Universidade de Lisboa (CEO-UL) é um protótipo de uma plataforma onde estudantes universitários podem aceder para partilhar materiais de estudo, comunicar com professores e treinar para os testes. A particularidade da plataforma CEO-UL é que esta se adapta ao seu perfil cognitivo, oferecendo formatos diferentes de avaliação desenhados para maximizar a sua capacidade de retenção de informação.

Esta plataforma pretende vir a disponibilizar todo o tipo de tópicos, disciplinas e materiais de estudo, já que irá abrigar toda a comunidade universitária da UL. O tópico que seleccionámos para testar hoje conosco é sobre vocabulário avançado na Língua Portuguesa. Antes de iniciarmos os testes, iremos aferir os seus conhecimentos sobre o assunto em questão.

Muitas destas palavras são raramente usadas fora de meios literários, pelo que é compreensível que não lhe sejam familiares. Faça o seu melhor e escolha de forma responsável a opção "Não sei, estaria a adivinhar" quando achar apropriado.

*Required

1. Nº de participante *

2. Complete a frase com o adjectivo que melhor se adequa ao contexto: “O Abílio começou ontem a trabalhar aqui e já acha que sabe tudo, ele é mesmo ___________.” *
   Mark only one oval.
   - Recatado
   - Facundo
   - Filauçioso
   - Redolente
   - Não sei, estaria a adivinhar

3. Complete a frase com o adjectivo que melhor se adequa ao contexto: “Esta maçã está mais que estragada, está completamente ________________.” *
   Mark only one oval.
   - Ascética
   - Putrefata
   - Anódina
   - Pueril
   - Não sei, estaria a adivinhar

4. Complete a frase com o verbo que melhor se adequa ao contexto: “Irei começar a aula por ___________ a presença dos alunos.” *
   Mark only one oval.
   - Homologar
   - Historicizar
   - Denegar
   - Digladiar
   - Não sei, estaria a adivinhar
5. Complete a frase com o substantivo que melhor se adequa ao contexto: "Agora que Rafaela chegou a CEO da empresa, sente que está a viver o _____________ da sua carreira." *

Mark only one oval.
- Grêmio
- Patibulo
- Mosto
- Zénite
- Não sei, estaria a adivinhar

6. Complete a frase com o adjetivo que melhor se adequa ao contexto: "Credo, que vizinho mais _____________, acho que nunca o vi sorrir!" *

Mark only one oval.
- Diletante
- Sorumbático
- Cediço
- Lépido
- Não sei, estaria a adivinhar

7. Complete a frase com o substantivo que melhor se adequa ao contexto: "Adoro a _____________ de prata que os teus pais nos derão como prenda de casamento." *

Mark only one oval.
- Baixela
- Fiorde
- Enclave
- Flâmula
- Não sei, estaria a adivinhar

8. Complete a frase com o substantivo que melhor se adequa ao contexto: "A avó cobriu a cara da neta de _____________ carinhosos." *

Mark only one oval.
- Lazaretos
- Esbirros
- Ósculos
- Périplos
- Não sei, estaria a adivinhar

9. Complete a frase com o verbo que melhor se adequa ao contexto: "Às vezes fico pensativo e como a _____________ sobre a vida." *

Mark only one oval.
- Adernar
- Cogitar
- Cominar
- Instar
- Não sei, estaria a adivinhar
10. Complete a frase com o substantivo que melhor se adequa ao contexto: "Paz no mundo não passa de uma ____________."  
Mark only one oval.  
- Quimera 
- Acrimónia 
- Trâmite 
- Mandala 
- Não sei, estaria a adivinhar

11. Complete a frase com o adjectivo que melhor se adequa ao contexto: "A StarLink visa ao desenvolvimento de uma constelação de satélites com o objectivo de tornar a Internet verdadeiramente ____________."  
Mark only one oval.  
- Assecla 
- Tétrica 
- Ubíqua 
- Inopinada 
- Não sei, estaria a adivinhar

12. Complete a frase com o substantivo que melhor se adequa ao contexto: "Durante a última campanha, o candidato lançou uma violenta ____________ contra o seu opositor e os seus ideais."  
Mark only one oval.  
- Equanimidade 
- Diatribe 
- Mesura 
- Tarimba 
- Não sei, estaria a adivinhar

13. Complete a frase com o verbo que melhor se adequa ao contexto: "O cavalo passou o dia inteiro a ____________."  
Mark only one oval.  
- Destrinçar 
- Nitrir 
- Ferretoar 
- Grassar 
- Não sei, estaria a adivinhar

14. Complete a frase com o adjectivo que melhor se adequa ao contexto: "Armada em comediante, ela fez-me rir com o seu tom de voz mais ____________."  
Mark only one oval.  
- Macilento 
- Incipiente 
- Glabro 
- Jocoso 
- Não sei, estaria a adivinhar
15. Complete a frase com o verbo que melhor se adequa ao contexto: "Ontem tive que aguentar o amigo dele a __________ sobre crossfit a noite toda." *
   Mark only one oval.
   - Xaropear
   - Perfilar
   - Embuçar
   - Abochornar
   - Não sei, estaria a adivinhar

16. Complete a frase com o adjetivo que melhor se adequa ao contexto: "Cuidado com esse vinho que ele é __________ e ainda tens de conduzir." *
   Mark only one oval.
   - Capitoso
   - Bufarinho
   - Plácido
   - Douto
   - Não sei, estaria a adivinhar

17. Complete a frase com o substantivo que melhor se adequa ao contexto: "Antes do prato principal manda-se vir o __________." *
   Mark only one oval.
   - Açude
   - Broquel
   - Acepipe
   - Berloque
   - Não sei, estaria a adivinhar

18. Complete a frase com o adjetivo que melhor se adequa ao contexto: "Não me apetece nada ir ao ginásio hoje, este calor já me deixa __________ que baste." *
   Mark only one oval.
   - Lânguido
   - Afoito
   - Longânimo
   - Alforriado
   - Não sei, estaria a adivinhar

19. Complete a frase com o verbo que melhor se adequa ao contexto: "Ele já morreu há 10 anos e ainda não deixei de __________ as minhas mágoas." *
   Mark only one oval.
   - Pichar
   - Bulir
   - Manducar
   - Carpir
   - Não sei, estaria a adivinhar
20. Complete a frase com o adjectivo que melhor se adequa ao contexto: “Apesar das súplicas, o juiz foi _____________ na aplicação da sentença.”

Mark only one oval.

- Cianótico
- Inexorável
- Condido
- Felírico
- Não sei, estaria a adivinhar

21. Complete a frase com o adjectivo que melhor se adequa ao contexto: “Para gerir este projecto, contratámos a engenheira Marília Silva que é plenamente ____________ nesta área.”

Mark only one oval.

- Ebórea
- Coquete
- Versada
- Manietada
- Não sei, estaria a adivinhar

22. Complete a frase com o verbo que melhor se adequa ao contexto: “Está na altura de ____________ a árvore de natal.”

Mark only one oval.

- Engalanar
- Embotar
- Albardar
- Titubear
- Não sei, estaria a adivinhar

23. Complete a frase com o substantivo que melhor se adequa ao contexto: “Voltei à terra onde nasci e aquilo virou um autêntico ____________, não tem lá ninguém.”

Mark only one oval.

- Périplo
- Peralvilho
- Pingalim
- Páramo
- Não sei, estaria a adivinhar

24. Complete a frase com o adjectivo que melhor se adequa ao contexto: “Na Primavera o meu jardim fica mais ____________.”

Mark only one oval.

- Vetusto
- Repimpado
- Virente
- Acéfalo
- Não sei, estaria a adivinhar
25. Complete a frase com o substantivo que melhor se adequa ao contexto: "Ainda me falta receber a renda do meu mais recente _____________."  
Mark only one oval.
- Estertor
- Locatário
- Milhafre
- Pasquim
- Não sei, estaria a adivinhar

26. Complete a frase com o verbo que melhor se adequa ao contexto: "Não gosto de falar em público, sempre que tento começo a _______________."  
Mark only one oval.
- Prevaricar
- Recrudescer
- Zurzar
- Tartamudear
- Não sei, estaria a adivinhar

27. Complete a frase com o adjectivo que melhor se adequa ao contexto: "Numa festa requintada como esta, o que não falta são homens _____________."  
Mark only one oval.
- Garbosos
- Crispados
- Enfarruscados
- Rubicundos
- Não sei, estaria a adivinhar

28. Complete a frase com o adjectivo que melhor se adequa ao contexto: "Pode tomar este medicamento durante a gravidez, é __________ para o bebé."  
Mark only one oval.
- Displicente
- Agiota
- Onírico
- Inócuo
- Não sei, estaria a adivinhar

29. Complete a frase com o adjectivo que melhor se adequa ao contexto: "Comprei um bouquet de rosas hoje de manhã mas não é muito __________, pensei que emanassem um cheiro mais intenso."  
Mark only one oval.
- Olente
- Beneplácito
- Pernicioso
- Coruscante
- Não sei, estaria a adivinhar
30. Complete a frase com o verbo que melhor se adequa ao contexto: "A empresa terá de ______ todos os trabalhadores afectados pelo acidente na fábrica."

Mark only one oval.

- Esfuziar
- Suplantar
- Vexar
- Ressarcir
- Não sei, estaria a adivinhar

31. Complete a frase com o verbo que melhor se adequa ao contexto: "Com a filha adormecida nos braços, o pai embalava-a com um sorriso ___________."

Mark only one oval.

- Mavioso
- Mordaz
- Violáceo
- Acetoso
- Não sei, estaria a adivinhar
The European Portuguese version of the SUS was developed by Martins et al. [224]; Sousa [232] found a Cronbach’s alpha of 0.627. The following ten items are measured in a five-point Likert scale:

1. Acho que gostaria de utilizar este produto com frequência.
2. Considerei o produto mais complexo do que necessário.
3. achei o produto fácil de utilizar.
4. Acho que necessitaria de ajuda de um técnico para conseguir utilizar este produto.
5. Considerei que as várias funcionalidades deste produto estavam bem integradas.
6. achei que este produto tinha muitas inconsistências.
7. Suponho que a maioria das pessoas aprenderia a utilizar rapidamente este produto.
8. Considerei o produto muito complicado de utilizar.
9. Sentiu-me muito confiante a utilizar este produto.
10. Tive que aprender muito antes de conseguir lidar com este produto.
A.6 Adult Decision Making Competence questionnaire in Portuguese

Please note that this is an illustrative sample of the four components that were selected for Portuguese translation. The complete document is 30 pages long. Access to the full instrument can be obtained by directly contacting the author of this dissertation.

**INSTRUÇÕES**

Cada um dos problemas seguintes apresenta uma escolha entre duas opções. Cada problema é apresentado com uma escala que vai de 1 (representando uma opção) a 6 (representando a outra opção). Para cada item, por favor assinale com uma cruz o número da escala que melhor reflita a sua preferência relativa entre as duas opções.

**Problema 1:**
Imagine que estudos recentes mostraram que um dado pesticida está a ameaçar a vida de 1.200 animais em riscos de extinção. Foram sugeridas duas opções de resposta:
Se for usada a opção A, 600 animais serão garantidamente salvos.
Se for usada a opção B, há uma chance de 75% de que 800 animais sejam salvos, e uma chance de 25% de que nenhum animal seja salvo.
Que opção recomendaria usar?

<table>
<thead>
<tr>
<th>Opção</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Opção</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>

**Problema 2:**
Devido a mudanças nas leis de impostos, você pode vir a receber de volta até 1.200€ em imposto de rendimento. A sua contabilista esteve a explorar formas alternativas de tirar proveito desta situação. Ela desenvolveu dois planos:
Se o plano A for adotado, você receberá de volta 400€ dos possíveis 1.200€.
Se o plano B for adotado, você tem uma chance de 33% de receber de volta o total de 1.200€, e uma chance de 67% de não receber qualquer dinheiro de volta.
Que plano usaria?

<table>
<thead>
<tr>
<th>Plano</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Plano</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>
INSTRUÇÕES

Cada um dos seguintes problemas pede que classifique a sua opinião sobre um produto ou uma situação. Cada problema é apresentado com uma escala de 1 (representando a pior classificação) a 6 (representando a melhor classificação). Para cada problema, assinale com uma cruz o número da escala que melhor reflita a sua opinião.

Problema 1:
Imagine que um tipo de preservativo tem uma taxa de sucesso de 95%. Isso é, se fizer sexo com alguém que tenha vírus da SIDA, há uma chance de 95% de que este tipo de preservativo o/a previna de ser exposto/a ao vírus.
Deverá o governo permitir que este tipo de preservativo seja publicitado como `um método eficaz para diminuir o risco de SIDA`?

<table>
<thead>
<tr>
<th>Claro que não</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Claro que sim</th>
</tr>
</thead>
</table>

Problema 2:
Imagine a seguinte situação. Você vai receber um amigo especial, convidando-o para jantar. Você está a fazer o seu prato de lasanha favorito, com carne picada. O seu colega de casa vai à mercearia e compra uma embalagem de carne picada para si. O rótulo diz 80% carne de vaca magra.
Qual é a sua avaliação da qualidade desta carne picada?

<table>
<thead>
<tr>
<th>Muito baixa</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Muito alta</th>
</tr>
</thead>
</table>

Problema 3:
Num recente inquérito anônimo preenchido por alunos finalistas, 35% daqueles que completaram o inquérito disseram que nunca fizeram batota (câbulas, copiar, plágio, etc.) durante o seu percurso académico. Considerando os resultados deste inquérito, como classificaria a incidência de batota na sua universidade?

<table>
<thead>
<tr>
<th>Muito baixa</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Muito alta</th>
</tr>
</thead>
</table>
INSTRUÇÕES

Este questionário apresenta questões de verdadeiro/falso sobre vários aspectos da vida quotidiana. Por favor indique, para cada afirmação, se acredita que esta seja verdadeira ou falsa assinalando com uma cruz a opção “verdadeira” ou “falsa”. Você pode considerar que alguns itens não têm uma resposta clara. Para esses itens, por favor tente dar a resposta que consideraria correta no geral, ou na maioria dos casos.

Por favor leia os seguintes exemplos para saber mais sobre este questionário.

EXEMPLOS

Exemplo 1:

O clube de futebol de Portimão é o FC Porto.

Esta afirmação é:
  ○ Verdadeira
  ○ Falsa

Queremos que faça duas coisas:
Primeiro, responda à questão. Neste exemplo, poderá pensar “Não, é o Portimonense. Por isso a afirmação é FALSA.” Então iria assinar “Falsa”.

Segundo, pense acerca do quão seguro/a você está da sua resposta. Dê um número entre 50% e 100%.
Por outras palavras, qual é a chance em percentagem de estar correto/a? Assinale um dos números na escala.

<table>
<thead>
<tr>
<th>Certeza total</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%</td>
</tr>
<tr>
<td>60%</td>
</tr>
<tr>
<td>70%</td>
</tr>
<tr>
<td>80%</td>
</tr>
<tr>
<td>90%</td>
</tr>
<tr>
<td>100%</td>
</tr>
</tbody>
</table>

Se a sua resposta é um palpite, assinale 50%. Isto significa que há uma chance de 50% de você estar correto/a e uma chance de 50% de estar incorreto/a. Se está absolutamente seguro/a, assinale 100%. Se não está seguro/a, então assinale um número a meio, para mostrar o quão seguro/a está.

Neste exemplo, pode pensar “Eu estou 100% seguro/a que é falsa, portanto 100%”.

O clube de futebol de Portimão é o FC Porto.

Esta afirmação é:
  ○ Verdadeira
  ○ Falsa

<table>
<thead>
<tr>
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<tr>
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</tr>
<tr>
<td>90%</td>
</tr>
<tr>
<td>100%</td>
</tr>
</tbody>
</table>

Se a sua resposta é um palpite, assinale 50%. Isto significa que há uma chance de 50% de você estar correto/a e uma chance de 50% de estar incorreto/a. Se está absolutamente seguro/a, assinale 100%. Se não está seguro/a, então assinale um número a meio, para mostrar o quão seguro/a está.

Neste exemplo, pode pensar “Eu estou 100% seguro/a que é falsa, portanto 100%”.

Exemplo 2:
Por favor leia os exemplos abaixo. Estes mostram respostas dadas por outras pessoas. Leia-as com atenção e certifique-se que compreende as suas respostas.

**Exemplo 2:**

**O dia da mãe é no primeiro domingo de maio.**

Esta afirmação é:

- **Verdadeira**
- **Falsa**

<table>
<thead>
<tr>
<th>Sem certeza</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
<th>Certeza total</th>
</tr>
</thead>
</table>

- “Sim penso que o dia da mãe é em maio... Diria que é verdadeira.”
- “Estou bastante segura, mas se calhar pode ser só no segundo domingo, por isso diria que estou 80% segura de que é verdadeira.”

**Exemplo 3:**

**Amã é a capital da Jordânia.**

Esta afirmação é:

- **Verdadeira**
- **Falsa**

<table>
<thead>
<tr>
<th>Sem certeza</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
<th>Certeza total</th>
</tr>
</thead>
</table>

- “Não faço ideia, mas se tivesse de adivinhar... Diria que é verdadeira.”
- “Não tenho certeza nenhuma, por isso diria 50%.”

**Exemplo 4:**

**O Passos Coelho tem barba.**

Esta afirmação é:

- **Verdadeira**
- **Falsa**

<table>
<thead>
<tr>
<th>Sem certeza</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
<th>Certeza total</th>
</tr>
</thead>
</table>

- “Não tem nada uma barba, nunca teve, esta afirmação é falsa.”
- “Estou quase seguro, mas ele pode ter deixado crescer a barba, entretanto. Diria talvez 70% seguro que ele não tem barba.”

Se tiver alguma dúvida, por favor esclareça agora.
Para cada uma das seguintes afirmações, indique a sua resposta assinalando com uma cruz se esta é verdadeira ou falsa. Depois assinale o número da escala que indique o quão seguro/a está na sua resposta. A escala vai de 50% (significando que é apenas um palpite) a 100% (significando que você está completamente seguro/a).

1. **Muitos fumadores usam a nicotina nos cigarros para tratar a depressão.**
   Esta afirmação é:
   - Verdadeira
   - Falsa
   
<table>
<thead>
<tr>
<th>Certeza</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sem certeza</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

2. **O stress torna mais fácil formar maus hábitos.**
   Esta afirmação é:
   - Verdadeira
   - Falsa
   
<table>
<thead>
<tr>
<th>Certeza</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sem certeza</td>
<td></td>
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</tr>
</tbody>
</table>

3. **Você pode tirar os vincos das suas roupas colocando-as no secador com uma toalha húmida.**
   Esta afirmação é:
   - Verdadeira
   - Falsa
   
<table>
<thead>
<tr>
<th>Certeza</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
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<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sem certeza</td>
<td></td>
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</tr>
</tbody>
</table>

4. **Depois de uma discussão com o/a seu/sua parceiro/a, não se deve focar em quem teve culpa.**
   Esta afirmação é:
   - Verdadeira
   - Falsa
   
<table>
<thead>
<tr>
<th>Certeza</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
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<tbody>
<tr>
<td>Sem certeza</td>
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</tr>
</tbody>
</table>
INSTRUÇÕES

Cada uma destas perguntas pede o seu melhor palpite sobre a chance de algo vir a acontecer no futuro. Elas usam a escala de ‘probabilidade’ que consegue ver representada abaixo.

Para responder a cada pergunta, por favor assinale na escala, num dos traços, da seguinte forma:

Se achar que algo não tem qualquer hipótese de acontecer, assinale-o como tenho 0% probabilidade. Se achar que algo irá de certeza acontecer, assinale-o como tendo 100% probabilidade. Para nos certificarmos que se sente confortável com a escala, por favor responda às seguintes perguntas para praticar.

1. Qual é a probabilidade de você comer pizza durante o próximo ano?

2. Qual a probabilidade de você apanhar uma gripe durante o próximo ano?

Este é o fim das perguntas para praticar. Se tiver alguma questão, esclareça-se agora.
As próximas perguntas falam sobre eventos que podem vir a acontecer algures durante o próximo ano.

1. Qual é a probabilidade de você ter um acidente de carro enquanto conduz durante o próximo ano?

2. Qual é a probabilidade de você ter de tratar de uma cárie durante o próximo ano?

3. Qual é a probabilidade de você morrer (de qualquer causa – crime, doença, acidente, etc.) durante o próximo ano?

4. Qual é a probabilidade de alguém lhe roubar algo durante o próximo ano?
As próximas perguntas falam sobre eventos que podem vir a acontecer algures durante os próximos 5 anos.

1. Qual é a probabilidade de você ter um acidente de carro enquanto conduz durante os próximos 5 anos?

2. Qual é a probabilidade de você ter de tratar de uma carie durante os próximos 5 anos?

3. Qual é a probabilidade de você morrer (de qualquer causa – crime, doença, acidente, etc.) durante os próximos 5 anos?

4. Qual é a probabilidade de alguém lhe roubar algo durante os próximos 5 anos?
INSTRUÇÕES

Cada um dos problemas seguintes apresenta uma escolha entre duas opções. Cada problema é apresentado com uma escala que vai de 1 (representando uma opção) a 6 (representando a outra opção). Para cada item, por favor assinale com uma cruz o número da escala que melhor reflita a sua preferência relativa entre as duas opções.

Problema 1:
Vocês vai comprar um anel de ouro a prestações para alguém especial. Custa 200€ e você já pagou 100€, pelo que deve outros 100€. Um dia, você vê no jornal que uma ourivesaria nova está a vender o mesmo anel por apenas 90€ como parte de uma promoção especial, e você pode pagá-lo a prestações. A loja nova é do outro lado da rua da loja antiga. Se você decidir ir buscar o anel à nova loja, não poderá receber o seu dinheiro de volta da outra loja, mas irá poupar 10€ ao todo.

Estaria mais inclinado/a para continuar a pagar à loja antiga ou a comprar na loja nova?

<table>
<thead>
<tr>
<th>Loja antiga</th>
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<th></th>
<th>Loja nova</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>2</td>
<td>3</td>
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<td>6</td>
</tr>
</tbody>
</table>

Problema 2:
Você gosta de jogar ténis, mas você adora mesmo jogar bowling. Você acaba de se tornar membro de um clube de ténis e de um clube de bowling, ambos ao mesmo tempo. A jia de sócio do seu clube de ténis custa 200€ por ano e a jia do seu clube de bowling é 50€ por ano. Durante a primeira semana em ambas as associações, você desenvolve uma lesão no cotovele. É doloroso jogar tanto ténis como bowling. O seu médico diz-lhe que a dor irá continuar durante cerca de um ano.

Estaria mais inclinado/a para jogar ténis ou bowling nos próximos seis meses?

<table>
<thead>
<tr>
<th>Jogar ténis</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Jogar bowling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<td>6</td>
</tr>
</tbody>
</table>

Problema 3:
Você tem estado ansioso/a pela festa do Dia das Bruxas deste ano. Você tem a capa certa, a peruca certa e o chapéu certo. Durante toda a semana, você tem tentado aperfeiçoar o fato recortando uma grande quantidade de pequenas estrelas para colar à capa e ao chapéu, e ainda tem de as colar. No Dia das Bruxas, decide que o fato fica melhorar sem estas estrelas todas nas quais você trabalhou tanto.

Estaria mais inclinado/a para usar as estrelas ou ir sem elas?

<table>
<thead>
<tr>
<th>Usar as estrelas</th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th>Ir sem estrelas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>6</td>
</tr>
</tbody>
</table>
INSTRUÇÕES

Cada um dos problemas seguintes apresenta uma escolha entre duas opções. Cada problema é apresentado com uma escala que vai de 1 (representando uma opção) a 6 (representando a outra opção). Para cada item, por favor assinale com uma cruz o número da escala que melhor reflita a sua preferência relativa entre as duas opções.

Problema 1:
Imagine que um hospital está a tratar 32 soldados feridos, e se espera que todos percam uma perna. Existem dois médicos que podem ajudar os soldados, mas apenas um pode ser contratado.
Se o médico A for contratado, 12 soldados irão perder uma perna.
Se o médico B for contratado, há uma chance de 63% de que ninguém perca uma perna, e uma chance de 37% de que todos percam uma perna.

Quais dos médicos recomendaria?

<table>
<thead>
<tr>
<th>Médico</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Médico</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>

Problema 2:
Imagine que Portugal se está a preparar para um surto de uma doença invulgar, que se espera que mate 600 pessoas. Foram propostos dois programas alternativos para combater a doença. Assuma que as estimativas científicas exatas das consequências destes programas são como descritas a seguir:
Se o programa A for adotado, 400 pessoas irão morrer.
Se o programa B for adotado, há uma chance de 33% de que ninguém morra, e uma chance de 67% de que todas as 600 pessoas morram.

Que programa recomenda?

<table>
<thead>
<tr>
<th>Programa</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Programa</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>
INSTRUÇÕES

Cada um dos seguintes problemas pede que classifique a sua opinião sobre um produto ou uma situação. Cada problema é apresentado com uma escala de 1 (representando a pior classificação) a 6 (representando a melhor classificação). Para cada problema, assinale com uma cruz o número da escala que melhor reflita a sua opinião.

Problema 1:
Como gestor do departamento de investigação, uma das suas equipes de projeto abordou-o/a requerendo 100.000€ adicionais em fundos para um projeto que você instituiu há vários meses atrás. O projeto já está atrasado e acima do orçamento, mas a equipa ainda acredita que pode ser completo com sucesso. Tem atualmente 500.000€ no seu orçamento não alocados, mas que devem aguentar-vos durante o resto do ano fiscal. Baixar o saldo bancário em 100.000€ pode comprometer a flexibilidade para responder a outras oportunidades.

Avaliando a situação, você acredita que há uma hipótese considerável de o projeto não ter sucesso, pelo que o financiamento adicional será perdido; contudo, se bem-sucedido, o dinheiro seria bem gasto. Você também reparou que dos projetos empreendidos por esta equipa, 20 dos últimos 50 foram fracassos.

Qual é a probabilidade de você financiar este pedido?

<table>
<thead>
<tr>
<th>Muito improvável</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Muito provável</th>
</tr>
</thead>
</table>

Problema 2:
Imagine que uma mulher estacionou ilegalmente. Depois de falar com ela, você acredita que há uma chance de 80% de que ela sabia que tinha estacionado ilegalmente.

Com isto em mente quanto de multa acredita que esta mulher merece?

<table>
<thead>
<tr>
<th>Valor mínimo</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Valor máximo</th>
</tr>
</thead>
</table>

Problema 3:
Num recente inquérito anônimo preenchido por alunos finalistas, 65% daqueles que completaram o inquérito disseram que nunca fizeram batota (cábalas, copiar, plágio, etc.) durante o seu percurso académico. Considerando os resultados deste inquérito, como classificaria a incidência de batota na sua universidade?

<table>
<thead>
<tr>
<th>Muito baixa</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Muito alta</th>
</tr>
</thead>
</table>