UNDERSTANDING CONCEPTUAL PROCESSES THROUGH IDENTITY JUDGMENTS VIA BEHAVIORAL AND NEUROPHYSIOLOGICAL METHODS

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THE INFLUENCE OF PERSONALITY TRAITS, MOTIVATION AND PERSUASION PRINCIPLES ON ACADEMIC PERFORMANCE

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ABSTRACT

UNDERSTANDING CONCEPTUAL PROCESSES THROUGH IDENTITY JUDGMENTS VIA BEHAVIORAL AND NEUROPHYSIOLOGICAL METHODS

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This dissertation aims to understand the cognitive and neural underpinnings of conceptual processes during identity judgments. Identity judgments are challenging philosophical problems that are influenced by several factors including spatiotemporal proximity and similarity. Initially, participants were asked to respond to a set of propositions (Conceptual Tendency Test, (CTT)) that were directly related to the core concept of identity, on a 5-point-Likert-scale (from 1 (totally agree") to 5 ("totally disagree")), in two versions: one with "same", one with "different", e.g., "A piece of paper bent over three times is the same/different". Subsequently, they were presented with the seemingly paradoxical "Ship of Theseus" narrative about the identity of a ship over time, and had to respond to it. The purpose of the CTT was to predict and model the responses of participants to the narrative. In order to test a central tenet of the Grounded Cognition paradigm in Cognitive Science, the narrative was presented in various modalities: textual, bodily-interactive, visual. Results revealed resilient response patterns for the Ship of Theseus narrative despite varying modality; only visual demonstration had an impact. Responses to the narrative could be modeled successfully by a variety of methods (Discriminant Analysis; Decision Tree; Neural Network). In addition to these behavioral methods, neurophysiological assessments were made based on EEG/ERP and optic neuroimaging (fNIRS), during the CTT. The polarity of identity statements (same/different) revealed behavioural and neurophysiological differences in the responses of participants, indicating relevant brain systems taking part in the neural processing of identity judgments. Implications for the Grounded Cognition paradigm are discussed.

Keywords: identity judgments, Ship of Theseus, conceptual processes, same/different, EEG/ERP, fNIRS.

ÖZ

AYNILIK YARGILARI ÜZERİNDEN KAVRAMSAL SÜREÇLERİN DAVRANIŞSAL VE NÖROFİZYOLOJİK METOTLAR ARACILIĞYLA ANLAŞILMASI

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Bu doktora tezi, aynılık yargıları üzerinden kavramsal süreçlerin bilişsel ve nöral temellerini anlamayı amaçlamaktadır. Aynılık yargıları literatürde uzamzamansal mesafeden ve benzerlikten etkilenen zorlu felsefi problemlerdir. Katılımcılardan öncelikle hazırlanan Kavramsal Eğilim Testi (KET) çerçevesinde sunulan 48 önermeye beşli Likert Skalasında (1: kesinlikle katılıyorum; 5: kesinlikle katılmıyorum) yanıt vermeleri istenmiştir. 48 önermeden yarısı aynıdır diğer yarısı farklıdır olarak sunulmuştur. KET sonrasında katılımcılardan literatürde Theseus'un gemisi olarak geçen paradoksal yazınsalı yine aynı skalada değerlendirmeleri istenmiştir. Kavramsal Eğilim Testinin uygulanmasının amacı katılımcıların paradoksa verdikleri yanıtı tahmin edebilecek bir model sağlamaktır. Bilişsel Bilimler alanındaki temel yaklaşımlardan biri olan Topraklanmış Biliş paradigmasını test edebilmek için: metinsel, vücutsal etkileşim ve görsel sunum olmak üzere üç farklı deneysel tasarım geliştirilmiş ve uygulanmıştır. Elde edilen sonuçların sadece görsel sunum yapılan testlerin normal örüntü dışında bir etkiye sahip olduğunu ortaya koymuştur. Verilen yanıtlar farklı modelleme yöntemleriyle (discriminant analizi, karar ağacı ve nöral ağ analizi) başarılı bir şekilde modellenmiştir. Yapılan davranışsal çalışmalara ek olarak KET esnasında nörofizyolojik testler (EEG/ERP ve fNIRS) uygulanmıştır. Elde edilen sonuçlar katılımcıların aynı-farklı kutuplaşması ve katılma eğilimi üzerinde farklı nöral sistemlerin nörofizyolojik seviyede farklı etkilere neden olduğunu ortaya koymuştur. Ek olarak, elde edilen bulgular Topraklanmış Biliş paradigması açısından tartışılmıştır.

Anahtar kelimeler: aynılık yargısı, Theseus'un gemisi, kavramsal süreçler, aynı/farklı, EEG/ERP, fNIRS.

DEDICATION

To my parents

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CTT: Conceptual Tendency Test
DLPFC: Dorsolateral Prefrontal Cortex
DMPFC: Dorsomedial Prefrontal Cortex
DA: Discriminant Analysis
DTA: Decision Tree Analysis
EEG: Electroencephalography
ERP: Event-related Potentials
fMRI: Functional Magnetic Resonance Imaging
fNIRS: Functional Near Infrared Spectroscopy
IFG: Inferior Frontal Gyrus
NNA: Neural Network Analysis
PFC: Prefrontal Cortex
SOT: Ship of Theseus

CHAPTER 1

INTRODUCTION

As cognitive agents, we tend to label the things (objects and people) around us, giving them specific identities. This is my neighbor Serkan, this is the cell phone I use (or my cell phone) and there are numerous similar instances that we distinguish from each other. One fundamental reason for that is the necessity to organize our world of perception. Identity might serve as a cognitive label that we attach to individuals – objects that have spatiotemporal continuity in time and that are quantifiable like a cup but not the coffee inside. On the other hand, there is an on-going philosophical debate about what factors are influential in our identity judgments. We might accept a reassembled car as the identical or the same object (or not) after a full disassembly into its particular pieces. What are the relevant factors while performing this kind of identity judgments? For instance, does spatiotemporal proximity in the case of the reassembled car have an influence on our identity judgments?

We probably perform more than several hundreds of identity judgments within a single day and most of these judgments are performed without conscious deliberation –more as a part of automatic processing. These decisions are generally based on evaluation (deliberative or automatic) of the options, or alternatives. Recent research findings in the framework of grounded cognition have shown that most of the decision-making and reasoning processes can be influenced by the nature of the task, or the context or situation as well as by the modalities of the given task. It is still debated to what extent people's mental processes are affected by sensorimotor modalities. Thus, depending on the findings in the academic literature (Barsalou, 1999, 2003, 2005), it could be argued that cognitive processes such as decision-making and reasoning might not be isolated from lower-level processes such as perception and sensation. In other words, the so-called modality-independent nature of the cognitive processes has been attacked by the new theories within cognitive sciences that emphasize the prominent role of modalities in cognitive processes.

1.1 Aims and Scope

The Grounded Cognition framework comprises new theories that emphasize the role of bodily states, situations/situated actions, and simulations. Unlike the formalist approaches that emphasize abstraction for cognitive processes, these novel theories take subjective experience into account. In a decision-making context, people tend to rely on their own subjective understanding of these concepts and make use of them in a given situation. One of the most interesting points related to this kind of decision-making processes is about dilemmas or paradoxes in which people face two mutually exclusive options in a given situation. The Ship of Theseus is a good candidate for illustrating this phenomenon of vacillating between two mutually exclusive options. This dissertation focuses on understanding the nature of these decision-making processes within a general cognitive framework. From a wider perspective, the main framework involves the role and status of concepts and conceptual processing. The theoretical framework adopted here is the grounded cognition framework that handles conceptual processing in terms of sortals.

The initial part of this dissertation aims to understand how people reason during the resolution of a given identity problem, namely the Ship of Theseus. In a nutshell, a ship owned by Theseus has been renewed part-by-part (Ship A, called "continuant"). At the end, all of the parts of the old ship have been renewed and the removed parts were taken together to build another ship (Ship B, called "replica"). Thus, there are two ships. The challenging problem is the following: Which ship is the ship of Theseus, the renewed one, ship A, or the one that has been built up with the old parts, ship B? The problem has been described by several philosophers (Frege, 1969; Kripke, 1980; Lewis, 1983) and related to the definition of "sameness" or "identity" which is referred to as "object persistence" in the psychology literature (Scholl, 2007). Depending on their conceptualization, it is plausible to claim that people's decisions are determined by several precursor beliefs about the critical concept at stake. In the present thesis, participants have initially been asked to approve or disapprove a set of propositions, compiled in a questionnaire (which is presented in Appendix A), which are directly related to the core concept involved in the paradox. In order to obtain their degree of approval or disapproval, participants have been asked to give responses on a Likert-type scale from 1 to 5 (where 1 corresponds to total agreement, 5 to total disagreement and 3 to a neutral response). The main aim of administering this "Conceptual Tendency Test (CTT)" is to provide a mathematical model that can predict the final decision of the participants on the paradoxical Ship of Theseus narration. One of the main targets has also been to provide a description of the sorting dimensions that are relevant for the conceptual judgments, such as animacy [+animate/- animate], mereology (part/whole), or others. These dimensions would be identified on the basis of the predictive statistical models.

1.2 Research Questions and Hypotheses

In the scope of the grounded cognition framework, three main research questions are proposed within this dissertation: (1) Can the outcome of the reasoning processes on the paradoxical Ship of Theseus narration be predicted by solely relying on the conceptual processing with a focus on the target concept "identity"? This concept is studied with a conceptual tendency test (CTT) that involves different identity domains and furthermore asks the same question, once in an affirmative way (in terms of being the "same" (*aynıdır*) and once in a negative way (in terms of being "different" (*farklıdır*)). (2) Can the outcomes of the reasoning process on the paradoxical Ship of Theseus narration be affected by the task setting, as manipulated in various behavioral studies employing a variety of on-line and off-line behavioral methodologies? In these studies, the effects of textual, perceptual (in the form of a visual demonstration) and sensorimotor presentation (in the form of a wooden model ship) are studied. Subjective ratings as well as eye-tracking data are collected. (3) What are the neurophysiological underpinnings of conceptual reasoning about identity judgments related to the Ship of Theseus? The application of EEG/ERP and fNIRS methods is suggested for understanding the on-line processing from a level different than the mere behavioral level. The first research question has been reformulated as a set of propositions and hypotheses in order to provide a solid research framework. There might be a powerful and deterministic connection between one's conceptual structure (of a given concept) and one's conceptual processing. However, regarding the second research question, this connection might be not that strong and open for situational impacts. In this respect, one might argue that the concept of identity could be evaluated on several different dimensions like assessing sameness on the temporal dimension ("identity over time"), or the animacy dimension. The conceptual evaluations as measured by the CTT could be taken as conceptual profiles of the participants and taken as the basis for possible predictions of their answering of the paradoxical Ship of Theseus narration. The conceptual processing of a person might provide relatively solid insight about the conceptual tendencies of this person and her reasoning processes related to that concept at stake. In this study, our main focus is on the concept of identity/sameness, thus we have a conceptual framework for understanding the processing dynamics of this concept on different dimensions. The initial part of the dissertation is devoted to demonstrating such a relation via performing a survey that is followed by the paradoxical Ship of Theseus narration (henceforth, SOT).

It has initially been hypothesized that it will be possible to construct a mathematical model for predicting participants' responses to the SOT narration solely based on their responses to the CTT. The model is expected to have theoretical contributions concerning the conceptual implications of the paradoxical reasoning process. For instance, Ship A respondents seem to have an understanding that objects do exist and remain identical as long as their function is preserved; Ship B respondents, however, seem to focus on the preservation of the ship's essence, i.e., its physical basis. Secondly, it has initially been hypothesized that the reasoning processes and the final decisions for the SOT narration can be manipulated via the above-mentioned factors. To be more specific, the experimental conditions presenting the disassembly/reassembly processes as a visual demonstration or by the aid of a wooden model ship are considered to have an impact on the reasoning process because of their modality-specific influence in terms of visual perception and bodily experience, respectively. The results of the various modalities of presentation (textual, visual demo and wooden model ship) demonstrate that similar responses to the identity judgment regarding SOT are obtained despite some changes due to the mode of presentation. Thirdly, it has also been hypothesized that the neurophysiological recordings via EEG/ERP and fNIRS methods can contribute to our understanding of identity judgments and on-line processing during conceptual reasoning processes and identity judgments. The obtained results via EEG/ERP method clearly show that a processing difference occurs at the neural level while responding to "same" (*aynıdır*) versus "different" (*farklıdır*) conditions, as pointed out above. Moreover, the findings from the fNIRS experiment illustrate that strong disagreement cases when compared to strong agreement cases seem to cause a higher level of experienced conflict. An even higher level of conflict is observed for the indeterminate positions, as evidenced by the activation level across the left dorsomedial regions of the prefrontal cortex.

1.3 Contributions

To sum up, this dissertation mainly focuses on human conceptual processing claiming that concepts and conceptual processing have a decisive role during reasoning including the identity judgments. This dissertation contributes to the scientific literature particularly with respect to conceptual processing specifically during identity judgments. First of all, the conceptual tendency tests (CTT) might be used for predicting and understanding the theoretical implications of higher-order reasoning processes as in the Ship of Theseus narration. The empirical findings provide a basis for further quantitative models that support previous qualitative findings (Rips et al., 2006). Secondly, this dissertation aims to demonstrate by means of behavioral experimentation the factors involved in conceptual and reasoning processes as proposed within the grounded theories of cognition by Barsalou (2010) and several other researchers. Modality-specific interventions may have crucial impact on the reasoning processes that could be observed via the comparison to the baseline condition, i.e., the standard textual version of the SOT narration. Furthermore, this research project also aims at studying the neural underpinnings of the reasoning processes and the ERP and fNIRS markers that might be used as indicator of the conceptual tendencies and conflicting situations that the participants experience during the tasks.

This cognitive science thesis is an interdisciplinary project requiring relevant contributions from various fields including philosophy, linguistics, psychology and neuroimaging. The nature of conceptual processes that are the main themes of this dissertation has long been a matter of debate in ancient and contemporary philosophy. Moreover, contributions from linguistics are crucial during the analysis of processing differences of same (*aynıdır*) and different (*farklıdır*) propositions that can be demonstrated via response times as well as EEG/ERP methods. The contribution from psychology is central, especially in terms of designing and implementing the relevant experiments. Beyond behavioral experimentation, neuroimaging contributes at a crucial point, when it comes to highlighting the neural correlates of conceptual processes during the identity judgments. The most significant point about using EEG/ERP and fNIRS methods is detecting participants' elicited brain responses towards the presented propositions as well as observing condition-wise differences (in terms of same versus different propositions and in terms of the five response options on the rating scale). Thus, since this dissertation is benefiting from several scientific fields and their related methodologies, it fulfills the requirements of an interdisciplinary cognitive science project.

1.4 Organization of the Thesis

The thesis includes ten chapters that cover the corresponding subjects in an organized manner. A brief description of each chapter is as follows:

Chapter 1 has introduced the motivation for the present doctoral thesis, which includes the explanation of the research questions, the hypotheses, a brief preview of the outcomes and the main contributions of this dissertation. Chapter 2, which is a literature overview of studies from relevant theoretical framework of grounded cognition, includes theories and main concepts from philosophy, psychology, linguistics and cognitive science. Chapter 3 includes the summary of pilot studies conducted prior to the main experiments as well as relevant information about how the methodology was developed. Chapter 4 presents the empirical findings from the baseline experiment, i.e., the spatiotemporal proximity (STP) experiments in which the participants were either in high or low STP conditions. Chapter 5 includes the description of the embodiment condition conducted with a wooden model ship. Chapter 6 contains the visual demonstration experiments via eye-tracking method. Chapter 7 provides relevant findings about the application of EEG/ERP method in the search of N400 brain signals during the *aynıdır* and *farklıdır* conditions. Chapter 8 includes the experimentation via optic brain imaging method (fNIRS) in order to study the conflicting situation that the participants may experience. Chapter 9 covers the condition-wise comparison for illustrating the difference in responses patterns for the Ship of Theseus question. Moreover, this chapter includes the description and comparison of the computational models generated based on the responses to CTT in order to predict the responses to the Ship of Theseus. Chapter 10 contains the general discussion of the empirical findings of the experiments performed in relation to the theoretical framework, research questions and initial hypotheses. Chapter 11 provides the conclusions related to the proposed framework, the limitations of the current study as well as suggestions for future work.

CHAPTER 2

THEORETICAL FRAMEWORK

An interdisciplinary approach has been highly relevant for this study in order to provide a sufficient framework for studies especially related to concepts and conceptual processing. This chapter starts with a general outlook for the concepts with covering the ontology of concepts, theories of concepts, and conceptual vagueness. In the second part, grounded theories of cognition and grounded concepts are summarized in relation to their processing. In addition, these theories are elaborated by providing empirical evidence from the scientific literature. In the third part, the identity concept has been explained with regard to the philosophical discussions of the Ship of Theseus narration. "Identity judgment" is the central term for this dissertation that emphasizes peoples' decision on a state in the world or an object to be the same or not. Moreover, there are psychological principles in the literature pertaining to identity judgments such as transitivity, similarity, spatiotemporal continuity, and sortals. The forth part includes a survey on the empirical findings that are relevant for identity judgments mostly from the studies of Hall (1998), Rips et al. (2006) and Rips (2011).

2.1 Concepts and Conceptual Processing

Concepts are generally considered to be bundles or packages of information as well as being constituents of thought by taking part in cognitive processes like categorization, inference, reasoning, decision-making and learning (Murphy, 2002). Besides this generally definition of concepts, which is uncontroversial, the nature of concepts as well as their ontology and structure are highly controversial and recently debated issues. Going back to Ancient Greek records, a simple exemplary question would be "What is knowledge?" It is even difficult to find a general consensus on a simple definition for knowledge. However, it might also be argued that it is possible to provide a correct analysis of knowledge through conceptual analysis that would end with informative, necessary and sufficient conditions for knowledge (Merricks, 1998). These informative, necessary and sufficient conditions might be claimed as the criteria of knowledge but it is also debatable if a similar analysis could be provided for all of the concepts, including identity, the crucial concept here.

On the other hand, the term "conceptual processing", is basically used for the application of the identity concept in this dissertation. In semantic terms, by application (or concept application) a semantic relation is meant through which "a concept encodes the conditions that are singly necessary and jointly sufficient for something to be in its extension" (Laurence & Margolis, 2015: pg. 9). As a psychological process, concept application is generally used for judgments if an object falls under a concept or not. For instance, an animal with a given picture could be judged as a bird or not. In the relevant literature, the judgments of concept application have been done with regard to the token-identity or type-identity. For the concept applications related to identity, the main question is not whether, for example, a bird is still a bird after a series of transformations but the question is whether a bird is still the same bird after these transformations. These judgments have been shown to diverge to a certain extent relying on the empirical evidence (Blok et al., 2008). Moreover, these judgments might be highly influenced by our conceptions of people and objects while tracing individuals in the real world (Rips et al., 2006). Thus, providing a framework about the ontology and theory of concepts might help to resolve the theoretical issues related to the conceptual analyses to a certain extent.

2.1.1 Ontology of Concepts

There are different approaches for the ontology of concepts. There are three dominant perspectives trying to explain the ontology of concepts: (1) mental representations, (2) abilities, (3) correspondence (Fregean "sense") (Murphy, 2002). The mental representations view is that concepts are psychological entities that take direct part in representational theory of mind (Murphy, 2002). Mental representations might correspond to symbols that could be described as relations between agents and their mental representations. The second philosophical perspective, concepts as abilities, could be described as mental particulars or as abilities peculiar to agents. Concepts are not word-like entities but rather conceptualizing is a talent that would provide a distinction between, e.g., a cat and a non-cat (which appears to be a very trivial operation for a human under most circumstances). This perspective has been criticized, since it seems to be insufficient for explaining the productivity of thought as well as not distinctive enough for clarifying the nature of mental operations. However, for explaining cases like categorization and similarity judgments, concepts-as-abilities perspective provides a strong account. The third philosophical perspective, Fregean "sense", considers concepts as abstract objects that are main constituents of propositions. From a referential point of view, concepts are assumed to 'mediate between thought and language under a unique mode of representation' (Laurence & Margolis, 2015).

Contrary to the traditional approaches to concepts, Barsalou et al. (2003) claim that understanding the nature of concepts via philosophical investigations or scientific research is not achievable. For them, the main focus should be on conceptual processing. The general perspective for concepts throughout the grounded cognition framework and literature resembles an ability-kind of understanding of conceptual processing. On the other hand, studies on concepts could be evaluated as a combination of different domains like cognitive, social, cultural, and grounded cognition. For example, the application of cross-cultural psychology methods to philosophical intuitions for folk concepts has demonstrated that people have systematically different intuitions surrounding folk concepts due to their cultural differences (Nichols, 2004; Nisbett, 2003). This dissertation is aimed at investigating the role of grounded cognition without eliminating the other dimensions but rather, focusing on grounded concepts and identity judgments.

2.1.2 Theories of Concepts

Many different theories of concepts have been developed regarding the philosophical investigations as well as empirical evidence covering the behavioral and neuroscientific data. This section summarizes the main theories in the relevant academic literature in relation to the identity concept. Rather than trying to compare and contrast these theories their advantages and disadvantages are discussed only briefly. The main aim is to provide a conceptually rich theoretical framework for understanding the identity concept and for interpreting the empirical evidence obtained during the experiments.

The Classical Theory of concepts claims that lexical concepts are assumed to be structured mental-representations (Murphy, 2002). When any concept is applied, a set of necessary and sufficient conditions is encoded accordingly and during this encoding process sensory as well as perceptual features are processed (Locke, 1690/1975). For instance, a chair has been assumed to decompose into a set of concepts like object, physical, portable, non-living, artifact, seat etc. and this set of concepts has been referred to as semantic markers. However, there have been strong criticisms especially for lexical concepts as empirical evidence is lacking that supports the definitional structure view of the classical theories (Kintsch, 1974). Moreover, there have been plenty of arguments against this analytic view that argues that concepts have definitions. Yet, it is also one of the significant issues that the classical theories predict a determinative conceptual processing by which the categorization processes cause determinate implications; however, the empirical evidence holds that there is a considerable degree of indeterminacy. This indeterminacy results in fuzzy or vague incidences (also called “conceptual fuzziness”) as directly observed for the cases including similarity or identity judgments, since there are no rules or consensus for a given case like “a broken pencil is the same” (Medin, 1989).

The empirical evidence for the typicality effects and related psychological data that could not be explained and accounted well enough by the Classical Theories paved the way for the emergence of new theories including Prototype Theory by Eleonor Rosch in the 1970ies (Rosch, 1978). Prototype Theory claims that concepts, as being structured mental representations, are processed for encoding object features. Lexical concepts are generally explained to be complex mental representations of information that is encoded by statistical analyses of their properties as compared to similar ones resembling ones in the same or close basic-level categories (Wittgenstein, 1953/1968). Since typicality effects are observed for the well-defined concepts, prototype structure does not seem to be the main reason for the typicality effects. Moreover, it is a fact that prototype structures of concepts are insufficient for accounting for the atypical instances as well as causing false inferences for non-instances (Laurence & Margolis, 2015). Additionally, many concepts, especially abstract concepts like identity, belief and desire are argued to lack any prototypes because of being vague and intricate (Osherson & Smith, 1981). Lastly, compositionality has been argued to be a potential issue to be resolved for the prototype theory. To be more specific, the interactions between complex concepts and their constituents are considered to form via functions – however, Prototype Theory does not sufficiently account for these functions (Fodor & Lepore, 1996). Theory theory, on the other hand, mainly claims that cognition is performed through processes similar to scientific reasoning and concepts are kind of representations with structures. Determined by mental theories, these structures hold information about the relations and connections to other concepts (Carey, 1985, 1991). The critics argue that it is possible to have a concept despite the fact that the mental theory is totally erroneous (Kripke, 1980). Moreover, the theory theory has been criticized because of being unstable such that the changes in mental theory should not vary the content of a concept (Rips, 1995). The other main criticism about the theory theory approach is that the mechanisms related to new scientific discoveries argued to apply for general mechanisms are still poorly understood despite the fact that there have been attempts to explain it (Gopnik & Meltzoff, 1997). Although this approach has relevancy to a certain extent as it is considerable successful in explaining certain types of categorization judgments, the main argument is that it is currently insufficient to explain the whole concepts and conceptual relations. However, it might successfully be applied to cases like the identity concept and identity judgments that do not seem to have a rigid structure, since it is possible to apply identity concepts to various objects at different times and at different places.

Neoclassical theories of concepts claim that concepts are ‘structured mental representations that encode partial definitions’ (Laurence & Margolis, 1999, p. 54). There have been significant criticisms for the neoclassical theories such as the partial definitions that have been left without sufficient explanations/accounts for reference determination. There have been criticized for suffering from similar problems as the classical theories. There are 3-D models generated to account for reference, as by Jackendoff (1987) who claimed a sophisticated spatial representation organized around a 3-D model but these spatial representations are argued to be about the meaning of words and insufficient to account for reference determination. There is also the regress problem of semantic fields that is about accounting for the meaning of a word under different semantic circumstances. On the other hand, Conceptual Atomism theory claims that lexical concepts have no structure and they are primitive with the main assumption that the contents of concepts are just their reference, not the other concepts but directly the world itself. However, this approach suggesting that they have no structure claims that concepts are innate. Moreover, it seems not possible to provide a psychological account for several cognitive processes including categorization. Conceptual combination also raises a potential problem for conceptual atomism, since there is no explicit account for compositionality. To sum up, there have been different accounts of concepts in the relevant cognitive science literature. There are also pluralistic/dual accounts that try to combine two or more theories in order to provide a more acceptable account for explaining concepts. There are also eliminativist accounts, as proposed by Smith (1993) and Machery (2009) who argue that there are no concepts and the debates on concepts are redundant. As mentioned above, the main aim of this section is not to find the most suitable theory of concepts but to provide a fruitful theoretical framework for the identity concept and the conceptual processes related to it. For this dissertation, identity, as a vague and abstract concept, is at the main research focus as well as its application on various hypothetical settings. The understanding of concepts as Conceptual Atomism theory suggests would be more suitable to explain the processes related to identity judgments. Beyond the arguments about the innateness of the concepts, it is plausible to accept that concepts like the identity have direct relevance for the world rather than other concepts. Moreover, the vagueness caused by the conception of identity (especially application of identity) might be accounted by the theory of Conceptual Atomism.

2.1.3 Conceptual Vagueness

Vagueness has been as a matter of philosophical and linguistic debates related to the characteristic features of natural language meaning. This controversial issue is directly related to the gradient properties of predicates and the borderline cases just as being not tall nor short but in-between which causes a significant problem for categorization as an uncertain condition related to natural language (Sorensen, 2001). It has been argued that vagueness is a part of our daily and ordinary language usage but this kind of vagueness in language should be avoided especially in formal and specialized texts (otherwise it might be distracting and even misleading) such as regarding concepts like disability in vision (Peirce, 1902). For instance, how much loss of vision is required in order to be accepted as legally blind? And similarly at which stage can an embryo be accepted as a legal human? There are many more examples that are observed in the everyday language like adulthood, race, and gender. Moreover, many scientific concepts have been categorized to be inevitably vague, since several concepts like species cannot be defined precisely but it is obvious that this is a very useful terminology since it refers to the vast majority of cases. Besides its frequent appearance in everyday language, vagueness has been accepted to be philosophically important especially in the discussions of coming up with a definition of right in the moral sense, since it is very difficult to provide such a definition that will clearly delineate the boundary between morally right and wrong. This is especially valid for borderline cases or cases faced during moral dilemmas. The solution might be related to providing more precise definitions especially in relation with the context and general characteristics of the environment. However, it should also be underlined that vagueness should not always be understood as a criticism for the need of an exact definition; it might be referred to as an inevitable part or aspect of natural language such that some of the cases might be intrinsically uncertain (Peirce, 1902). A common example is about accepting (or not) as dogs the offspring of breeding Huskies with wolves. This example shows that one's definition or conception (about doghood) might not be that clear and more interestingly, this definition could change depending on several contextual cues, directions and influence. Here, it could be asserted that identity appears to be such a vague concept, since there are no clear-cut rules or criteria of identity over time. There are different factors that could be realized to influence one's identity judgments such as compositional identity and spatiotemporal continuity (Merricks, 1998). On the other hand, it may be the case that several potentials factors and cases have a direct influence on identity judgments. In other words, the identity concept and related judgments might appear to be highly context-dependent such that the changes in the context might lead the people towards different conceptions of identity. Moreover, it might be the case that different intuitions regarding the folk psychology might pave the way for different interpretations (Nichols, 2004).

2.2 Grounded Cognition Framework

The grounded cognition framework provides an alternative account to the sandwich model as the mainstream theory to explain cognition as processes between perception and action (Hurley, 2001). The grounded cognition framework initially emphasized the roles of perceptual and motor processes that have been neglected by traditional theories of cognition. Proponents of the grounded cognition framework claim that it is necessary to extend the research to domains that have initially been disregarded by classical cognitive mechanisms (Aydede & Robbins, 2009; Barsalou, 2010). There are four additional research domains that have been included in the grounded cognition framework. These domains are (1) perception, action, and introception (Hsu et al., 2012; Simmons et al., 2007), (2) bodily states and physical actions (Barsalou et al., 2003; Niedenthal et al., 2005), (3) physical environment (Gibson, 1966, 1979), and (4) social environment (Donald, 1993; Tomasello, 2009). Beyond these additional domains that restructured the interdisciplinary field of mind/cognitive sciences, the focus of this section in relation to grounded cognition will be narrowed to concepts and conceptual processing regarding the scope of this thesis.

2.2.1 Grounded Concepts

The situated conceptualization account assumes that conceptual knowledge about an object is not represented against an empty background. A soccer ball is not solely a soccer ball but composed of connections to many memories related to soccer ball. In other words, it is argued that concepts are not isolated from the experiential associations but the concept, soccer ball, is claimed to represent and modulate one's all interactions with soccer balls (Barsalou et al., 2010). For this dissertation, concepts are defined as "dynamically distributed systems in the brain that represent a category in the environment or experience that controls the interactions with the category's instances" (Barsalou, 2008, pg. 2). Gertner and Stevens (1983) have underlined the importance of conceptualizations during task completion: "…people's views of the world, of themselves, of their own capabilities, and of the tasks that they are asked to perform, or topics they are asked to learn, depend heavily on the conceptualizations that they bring to the task." (p. 3) Barsalou (1999) has argued that the human conceptual system does not solely act like a recording system (like cameras or any human-made recorders) but acts to represent a bundle of categories that is highly dependent on the situations rather than relying on single cognitive operations. For challenging the view that conceptual processing is achieved amodally, Barsalou (2000, 2002, 2003) performed series of experiments including conceptual tasks in which the perceptual and motor variables have been shown to directly affect the task output (Barsalou et al., 2008). Thus, Barsalou (2003) concludes that it is probable that conceptual processing is not performed in an amodal fashion but instead is grounded in the modalities. In these respects, Barsalou also argues against the traditional distinction between semantic and episodic memory in which semantic memory has been hypothesized as an abstract system of meaning units resulting from a transduction process. Instead, Barsalou (2003) argues for a system in which the semantic system directly relies on the feeding from episodic memory instead of isolating these systems. It is possible to group the empirical evidence for demonstrating the grounding aspect of concepts and conceptual processing into three domains: (1) behavioral evidence, (2) lesion evidence, and (3) neuroscientific evidence.

2.2.2 Empirical Evidence for Grounded Concepts

Behavioral evidence and tasks have been accepted as one of the most robust methods of demonstrating differences in the cognitive psychology literature. One of the most remarkable behavioral experiments in our context has been conducted by Louwerse & Jeuniaux (2010) who focused on the linguistic and embodied nature of conceptual processing. They tried to find out how linguistic factors like typical word order in language and embodiment factors like iconicity relationships between objects were effective in conceptual processing. They aimed to compare and to contrast words and pictures in different and complementary conditions. They designed and implemented 4 complementary experiments in which the participants judged the semantic relationship ("yes" or "no") and iconicity relationship ("true" or "not true"). In other words, subjects had to decide if there is a semantic relationship between the presented words (Experiment 1a) and the presented pictures (Experiment 2a). Moreover, the participants were expected to judge the iconicity of the given words (Experiment 1b) and of the given pictures (Experiment 2b). They have measured the error rates as well as response times of the subjects in order to demonstrate the comparison between the two factors. The results of these experiments have shown that people are very susceptible to linguistic and embodiment factors during their conceptual processing, as evidenced by significant facilitation of processing for pictures over words in the embodiment condition and for words over pictures during the linguistic condition (where the frequency of the presented words appeared as a vital factor). Moreover, there is plenty of evidence obtained from behavioral experiments that demonstrates the presence of different bundles of information for the same concept in different situations (Barsalou, 1987, 1988). In addition to these, there is empirical evidence from neuroimaging studies that indicates that different situations and contexts may lead to the activation of different neural circuits for the same concept (Hoenig et al., 2008; Wilson-Mendenhall et al., 2011). Especially during the processing of social concepts, it has become evident that various domains such as mentalizing, emotion, and interoception participate in conceptual processing (Northoff et al., 2006; van Overwalle, 2009; Simmons et al., 2010; Kober, 2008).

Secondly, researchers have demonstrated that lesions crucial to the processing of certain modalities increase the risk of losing the conceptual categories that rely on that modality (Martin, 2007). To be more specific, it has been shown that lesions in visual areas (in the brain) increase the risk of losing the category of animals (since the animal category is more dependent on and interacts with the visual modality evolutionarily). A similar argument has been developed for the tool category. Here, lesions in motor processing areas have been found to increase the probability to lose the conceptual tool category since they are more related and simultaneously activated. Miceli et al. (2001) have shown that category representation about colors is highly dependent on color processing areas. Moreover, it has also been argued by Levine et al. (1985) that spatial processing is directly related to location knowledge thus this type of knowledge is not amodal either. These category-specific deficits clearly demonstrate the effective contribution of modalities in category representations. Category-specific deficits might lead to cognitive insufficiencies such that patients might become unable to name pictures of animals (like dog, cat, lion etc.) or pictures of tools depending on their specific impairment. Traditional theories of cognition have assumed that category and knowledge representations are processed in amodal fashion, in other words, modality-independent. However, these studies have implicated that modalities may have a significant contribution to category representation and conceptual processing.

Thirdly, Barsalou (2008) argues that plenty of empirical evidence supports the view that simulation plays a key role in conceptual processing. The studies presented by Barsalou (2008) demonstrated that the conceptual processing of an object triggers activation in related brain areas of perception and action for this object. In other words, instead of a modality-independent representation, objects are mentally represented with their real-world properties and relations. Several brain regions have been related to specific mental functions, e.g., fusiform area has been shown to be related with shape and color of objects, middle and superior temporal lobe is activated for object motion, and premotor as well as parietal regions are activated for the agent's actions on this object. Such relations have been expected for most of the theories of cognition. However, it is crucial to note that these activations are also seen during the conceptual processing of that object. In other words, it is more likely that the properties of objects (represented in certain modalities) are also activated during conceptual processing of that object. With a property verification tasks in which the participants are asked to judge if a given object might exhibit the property presented, the simultaneous brain images show that modal representations are activated such as taste, sound, action and shape during judgments (Goldberg et al., 2006a, 2006b). There is also considerable empirical evidence for category-related modality activations within the brain that has been explained in the previous section on lesion studies. Visual areas are activated during processing of the animal category (Martin, 2001, 2007) whereas motor areas are activated for tool-categories (Thompson-Schill, 2003). Moreover, it has been shown that gustatory areas are activated during conceptual tasks about food (Simmons et al., 2005). Moreover, an experimental study performed by van Dantzig et al. (2008) has shown that perceptual and conceptual representations as well as processing seem to rely on the same systems. The results of their study showed that perceptual processing affects conceptual processing as observed in conceptual property-verification tasks. Lastly, distinct areas have been found to relate to motion processing for animals versus artifacts (Martin, 2007), which have been referred to as “category-segregation” by Barsalou (2008).

2.2.3 Abstract versus Concrete Concepts

The processing of abstract concepts has initially been presented as a challenge for the grounded theories of concepts, since it was argued that the contribution from the sensory-motor systems is likely to be highly limited or even absent for the conceptual processing of abstract concepts as opposed to concrete concepts of objects and simple behavior such as running and swimming. From the traditional perspective of cognition, concepts such as “knowledge” and “truth” are assumed to be actually abstract since they do generally not refer to physical objects and thus, they do not embody sensory-motor interactions (Kiefer & Barsalou, 2013). However, empirical evidence suggests that it is plausible that both concrete and abstract concepts are grounded in situated experience (Barsalou, 1999). A neuroimaging study by Wilson-Mendenhall et al. (2011) indicated that the brain areas relevant for mental states and social interaction are activated during the processing of abstract concepts speaking in favor of simulated internal states. Thus, it has been argued that the representation of concepts within given situations is performed in relation to the relevant objects and agents that both influence internal and external states. The difference between abstract and concrete concepts lies in the somewhat differing contribution by internal and external situations for concepts such as “truth” vs. “bird”, for example (Kiefer & Barsalou, 2013). For concrete concepts, it is argued that external situations, the physical features of the bird, play a stronger role in the related conceptual processing whereas abstract concepts such as truth are claimed to be perform through the contribution of simulating internal states, experiences, and complex events (Barsalou & Wiemer-Hastings, 2005). Thus, the requirement for the integration of broader situational information for abstract concepts as opposed to concrete concepts is arguable (Wilson-Mendenhall et al., 2011). To conclude, the grounded cognition framework assumes that all concepts, both concrete and abstract, are situated but the degree of the contribution of internal states and external situations seem to differ during their processing. “Alternatively, it has been argued for “representational pluralism”, namely that perceptual as well as non-perceptual representations may be involved in the processing of concrete and abstract concepts, thus allowing for “embodied” as well as “dis-embodied” cognition, respectively (Dove, 2009, 2011).”

For the specific case of the identity concept involved in the Ship of Theseus, it might be plausible to claim that the processing of both abstract and concrete concepts should be considered, since this paradoxical narration involves an abstract concept – “identity” – and a concrete concept – “ship” – while trying to decide on the given situation. Thus, it might be the case that an agent experiences two different/divergent conceptual processes for the abstract and concrete concepts “identity” and “ship”, respectively. The reasoning and decision-making process for the Ship of Theseus is likely to involve the competition among internal states and external situation in this sense. The controlled changes within the presented contexts regarding the contribution of external situation for the conceptual processing of the Ship of Theseus introduced in this study might provide an empirical framework for understanding the role of those external situations during identity judgments. More specifically, providing modality-dependent representations is considered to play a crucial role in conceptual tasks that might direct individuals towards a unique solution with respect to the identity judgment (Kiefer & Barsalou, 2013). Accordingly, it is of high importance to better understand the concept of identity and the psychological process of identity judgments in order to propose experimental hypotheses to be tested.

2.3 Concept of Identity

Identity has the meaning of being the same, however, there are two types of sameness and these are qualitative and numerical identity (Geach, 1973). First, qualitative identity is the property or feature sharing such as two dogs being qualitatively identical (as in "type" identity). This type of identity is expressed in terms of some similarity distance among two or more objects and refers to general concepts (Rips et al., 2006). For instance, two birds of different species are perceived and categorized as birds. However, numerical identity requires total qualitative identity that inevitably means an object can only have numerical identity to itself with an emphasis on the link between quantification and identity (Quine, 1964). According to Quine (1963), identity is a highly context- and language-dependent concept regarding the indistinguishable predicates of a language. For a language that contains predicates about "income" and "people", the latter can only be distinguished in terms of their income (but nothing else). In this illustrative case having the same income turns out to express identity. In this sense, it is of interest to test whether any minor change on an object distorts its numerical identity (as in "token" identity). There are opposing philosophical accounts that accept (or reject) that a change in compositional identity distorts the identity itself. On the other side, a functionalist perspective argues for the spatiotemporal continuity as a necessary and sufficient condition for criteria of identity. This divergence among the views towards identity challenges the possibility that there are certain, clear-cut criteria for identity as in the fission case in which a participle is divided into two. One possibility is that there is no set of criteria of identity as argued by Merricks (1998). An alternative account might be proposed to claim that despite the fact that there is no consensus on the criteria of identity, people tend to rely on a basic set of criteria in their identity conception as well as identity judgments. This lack of criteria of identity might be linked to the conceptual vagueness of the identity concept on one side. The presented cases for identity might be unclear, probabilistic and sometimes ambiguous but still there might be psychological principles that influence these judgments (Scholl, 2007). On the other side, this possibly vague nature of identity concept and related judgment processes might be influenced relatively easily by the mode of presentation. This potential effect might be linked to the grounded theories of cognition that assume that external factors might be internalized during the reasoning processes, thus, depending on the interaction of the agent with the presented factors, it could be argued that the reasoning process, more specifically the identity judgment, might change its direction. Understanding the psychological mechanisms and principles for persistence of objects has been one of the main research domains for identity judgments. These empirical works may shed light on our metaphysical intuitions about object persistence. It is important to understand the principles that determine the notion of identity of objects.

2.3.1 Principles of Identity Judgments

There are three relational principles that have been influential on the notion of individual identity: (1) reflexivity, (2) symmetry, and (3) transitivity (Mendelson, 1964). These are the very basic relational principles in order to provide a useful framework for research. Despite the fact that people might violate these principles in their daily lives, it is possible to argue for a general tendency for identity judgments. These principles are formulated as follows:

Principle 1a, $x_i=x_j$, (reflexivity)
Principle 1b. $x_i=x_j$ then $x_j=x_i$ (symmetry)
Principle 1c. $x_i=x_j$ and $x_j=x_k$ then $x_i=x_k$ (transitivity) (Rips, 2006)

These basic relational principles represent the central tenets for the identity relations. An object should be identical to itself (Principle 1a). If an object x_i is identical to x_j then, symmetrically, x_j should be identical to x_i (Principle 1b). If x_i is identical to x_j and x_j is identical to x_k then, transitively, x_i is identical to x_k (Principle 1c). Some relations have been claimed to include some of these properties like the relation of liking that is not reflexive, not symmetric, and not transitive (Crane & Farkas, 2004). In this respect, identity contains all of these properties, as it is reflexive, symmetric, and transitive (Crane & Farkas, 2004). The kinds of relation having these three properties are also referred to as equivalence relation. They may also be expressed beyond the identity relations such as having the same biological mother (Crane & Farkas, 2004).

2.3.1.1 Principle for Numerical Identity

The principle for numerical identity, also related to Leibniz's Law, holds that two objects are identical if and only if any property of one of them is true for the other one. This has been a widely accepted form of characterization of numerical identity. This principle can formally be expressed as follows:

Principle 2. if $x_i=x_j$, then Fx_i if and only if Fx_j (Leibniz's Law)

The converse of Leibniz's Law, the principle of the indiscernibility of identicals, provides a space for property change of objects over time but philosophical arguments have been developed against this principle. The main question can be formulated as how an object's identity may persist while it undergoes changes in its intrinsic properties (Chisholm, 2004). Chisholm (2004) argues that material objects cannot survive against change in their properties (p. 530). Here, Chisholm follows the arguments of Butler (1736) in order to provide a distinction between 'loose & popular' and 'strict & philosophical' senses of identity. For Chisholm (2004), an object does not exist anymore, as it loses even a single property. Despite the fact that this account may be evaluated to be consistent in itself (also known as mereological essentialism), people seem to have varying intuitions about identity judgments related to the property change over time. Since our initial aim has been to understand and describe these intuitions, we prefer to leave these prescriptions aside for the moment. There are also other principles mentioned in the cognitive psychology literature to be influential on identity judgments.

2.3.1.2 Similarity

Our knowledge of common and distinctive properties of objects enables us to determine the level of similarity between different objects. There might be a threshold for the level of similarity that might determine sameness/identity judgments, depending on the context. Although the similarity principle provides a useful account for comparing two presented instances relying on their properties, there are three main problems with this proposal (Hall, 1998; Scholl, 2007). First, a cat hiding under a sofa could be mistaken as another cat that has very similar properties with the initial cat. Secondly, similarity overemphasizes the properties of the objects rather than the similarity of the objects themselves. Thus, in some occasions, the question might be converted from "sameness of objects" to "sameness of properties". The latter is considered to be easier than the former but there is no guarantee that there is only one individual if the two observed instances have identical properties, e.g., regarding the case of monozygotic twins (Rips et al., 2006, p. 3). The third one is related to natural or unnatural change of objects in time. An individual or an object might change dramatically within 20 years both physically and mentally. Thus, despite the fact that similarity provides a useful tool for making identity judgments of objects correctly, there are several crucial problems that arise in relation to this principle.

2.3.1.3 Spatiotemporal Continuity

This principle claims that people tend to judge two individuals or objects to be the same (or identical), if these entities overlap in their spatiotemporal path. If there is an unbroken path (in other words, no spatiotemporal gap) for these two individuals, they are judged as identical as in the example of the person $\text{Florence}_{1970} = \text{Florence}_{2006}$ (Rips et al., 2006). This theory has been described to have roots in perceptual tracking in very early during infancy, as demonstrated with the empirical studies of Carey and Xu (2001). The study of Carey and Xu (2001) has shown that infants below one year of age tend to attribute identity on the grounds of spatiotemporal continuity, even in the case of two non-identical objects.[1] Cognitive psychologists have generally accepted spatiotemporal continuity as a highly significant factor in judgments of object identity. Spatiotemporal continuity has been explained to be more substantial as compared to the similarity hypothesis but there are counter-arguments against this view as well. A thought experiment by Armstrong (1980), Nozick (1981) and Shoemaker (1979) proposes two machines one of which is capable of vaporizing an object and the other one is capable of materializing the vaporized object back into its initial position. Despite the fact that there is an inevitable gap for this object in its spatiotemporal dimension, it is debatable if it could be accepted as the same object or not especially for cases in which the duration is very short. Rips et al. (2006) presented a computer case in which a computer has been explained to be totally disassembled and then reassembled at its initial position. Participants judged the computer still to be the same. This computer example demonstrates that it is possible to argue for sameness in spite of the apparent gaps in space or time (Hirsch, 1982). Therefore, an extension of the spatiotemporal gap might be a crucial factor for identity judgments that should further be studied.

2.3.1.4 Sortals

Similar to regarding concepts as abilities, sortals could be described as ways, methods, or rules for individuating and identifying category members using numerical modifiers (Locke, 1975). Thus, the rule is expressed as follows: “an expression is a sortal if and only if it takes numerical modifiers” (Grandy, 2014). Although there is disagreement about the exact definition of sortals, they seem to provide a concrete way of describing an item quantity such as an ice cube. Ice cube is accepted as a sortal, since it is possible to specify the quantity of ice cubes such as in the expression “two ice cubes please”. However, a similar situation is not true for water and thus water is not accepted as a sortal. Theories like schema theories by Rumelhart and Ortony (1977) and theory theories by Carey (1985) assume that concepts contain rules that are discussed under the heading of sortals by Strawson (1959) and other philosophers. For Wiggins (2001), sortals supply the necessary information not only for a distinction among different types of objects but also for tracking the identity of objects over time. Carey (1995) underlined the logical role sortals play in our daily lives: whereas it is not feasible to count what is there in a room as we enter it, we can understand the array of several objects in terms of sortals – categories and identities of objects (Xu, 1997, 2002,

[1] The experimental setup is quite simple: if a yellow duck moves behind an occluder and by the time one expects it to come out from the other side of the occluder, it is a red square, infants below 1 year of age tend to judge it as a single individual. Only older infants, above 1 year of age, take object properties into consideration as well and judge them to be two separate objects. Their judgment seems to take conceptual information into account as well (“a yellow duck cannot be identical with a red square, even if they have moved on the same spatio-temporal path”)).

2003, 2005, 2007). The theory of sortals seems to be useful for specifying the properties of an individual category member that may change over time (Rips et al., 2006). Rips et al. (2006) argue that two objects could be judged as identical if the changes occurring over time are compatible with that object's initial sortal (which has been proposed as the third principle mentioned above). Since sortal concepts are supposed to refer to the associated mental representation, it would be of interest to observe how people tend to make a distinction between two objects of the same kind one of which is composed of different units as compared to its very initial form. These considerations are highly relevant for the present identity question about Ship of Theseus.

2.3.1.5 Framing Effects on Identity Judgments

"Framing effect" is a psychological term contributed by Tversky & Kahneman (1974) to explain how decision-making and judgmental processes can be influenced by the presentation of a question or a text. Many pieces of empirical evidence have indicated that people are highly susceptible framing effects such that they tend to behave totally different to very similar options when presented in different formats. One of the best-known examples presented below illustrates this effect (Kahneman & Tversky, 1981, p.211):

"Imagine that you face the following pair of concurrent decisions. First examine both decisions then indicate the options you prefer.

Decision Case 1. Choose between:
A. a sure gain of *$240*
B. 25% chance to gain *$1000,* and *75%* chance to gain nothing

Decision Case 2. Choose between:
C. a sure loss of *$750*
D. *75%* chance to lose *$1000,* and *25%* chance to lose nothing"

For the Decision Case 1, the expected outcome for the first option (A) is lower than the expected outcome of option B (since the mathematical calculation gives $250 as the output). However, the greater majority of the participants (84%) prefers option A rather than option B. In contrast, in Case 2, the majority of participants (87%) preferred option D over option C despite the fact that their expected outcomes were the same, but the cases were about loss rather than gain. This classical example is considered as involving a kind of cognitive bias in the relevant literature. It is important to provide an adequate explanation why framing effects are influential in decision-making and judgmental processes. Several different theories including prospect, cognitive and motivational theories have been proposed to explain various incidences of framing effects successfully (Kuhberger, 1998).

In the context of the present thesis, it is also crucial to emphasize the possible roles of framing effects during identity judgments. It might be the case that people have a tendency to accept that P_1 but they might not tend to accept that P_2 that is a very similar proposition to P_1 if this proposition is framed slightly differently. If their truth-values do not change with respect to this slight change in descriptions or framing provided, one might argue that individuals should process these propositions similarly and arrive at the same conclusions. However, there are plenty of empirical findings that show this is not the case during reasoning and decision-making. Similar cases of processing two formulas with the same truth-values differently have been referred as extensionality violation in the literature (Bourgeois-Gironde & Giraud, 2009). Extensionality assumes that the decision-making process should not be affected by how a question is described until the relevant factors are presented within this question. If the decision-maker focuses on irrelevant information provided within the text, then it is argued that there is an extensionality violation (Bourgeois-Gironde & Giraud, 2009).

As for the experiments within this dissertation, there are two kinds of possible framing effects. First, the propositions in the Conceptual Tendency Test (CTT) are presented as "same" and "different" judgments in order to observe possible processing differences among these opposing concepts. Despite the fact that a symmetric response pattern is expected for *aynıdır* and *farklıdır* judgments, since only their polarity (one being positive, the other being negative) is different, the processing might differ. This is an empirical issue, which we were aware of. For that reason we presented the CTT in both versions. Secondly, the Ship of Theseus narration was framed differently with respect to the spatiotemporal proximity of the disassembly and reassembly processes of the ship in order to observe whether the changes in STP have an influence on the final decisions of the participants. For the modal conditions, the narration has been presented as in the baseline condition. Thus, potential influences of the framing have been controlled across different experimental conditions on the textual level of the narration itself. However, the different modalities themselves can be considered as frames. They were manipulated deliberately in the sense of "independent variables" in order to test the assumptions of the grounded cognition paradigm. In this respect, the "modality" effect predicted by grounded cognition can be understood as a "framing" effect, *par excellence*.

2.3.2 Ship of Theseus

Michael Clark (2002) has introduced the Ship of Theseus that has been described as a paradox related to identity and material composition. Clark (2002)'s initial argument is about the hypothetical condition in which the removed parts are thrown away (instead of building another ship with these removed parts, as in the original narrative). Clark argues that it is clear the single ship had a change in its material composition but it would continue to exist as the Ship of Theseus. For Clark (2002), changing only a part of the ship does not have to mean a necessary change in the identity/sameness or object persistence, considering the fact that almost no entity remains stable for more than a few milliseconds, in particular non-living things which undergo constant change at the molecular level. Thus the main question appears to be related to material composition: does an object persist as the same due to its compositional identicalness? The question appears to be paradoxical when Ship B that has been built by using the removed parts comes into play. As mentioned above, most people see no problem with accepting Ship A as the identical ship if there is no information presented about Ship B. However, when both of the ships are presented, people tend to think differently depending on their conceptualizations of sameness/identity and their attitude towards object persistence. Although this identity judgment does not seem to have only a single solution, it is possible that this process might be highly context-dependent and intuition-guided which might be determined by the conceptual processing at lower levels. As Kurtz (2006) has pointed out: "The real problem of persistence remains one of balancing trade-offs. To explain how objects persist… we must revise and /or forfeit some of our basic intuitions." (p. 24).

2.3.2.1 Ship of Theseus as a Puzzle, a Paradox, or a Dilemma

One of the debatable questions about the Ship of Theseus is its categorization as a paradox or a puzzle, since it is referred differently to in the literature. In order to provide a more comprehensive framework for this question, it is important to begin with introductory definitions for these two terms. Paradoxes have been described to involve more than one common sense solution; they generally involve two mutually exclusive options (Olin, 2003). Since it has been generally defined that paradoxes are not restricted to only one common sense solution, they have been termed as *Insolubilia* (in other words, "unresolvables") and *antinomy* - which is a commonly used expression synonymous with the term "paradox" (Geach, 1955). Most paradoxes involve contradictions as in the given proposition: "This sentence is false". The Ship of Theseus has been categorized as a paradox due to conceptual vagueness. Vagueness, in this case, arises due to the vague nature of the identity concept. Sorensen (2003) has stated the critical role of paradoxes in the classical debate between rationalists and empiricists. Sorensen (2003) argued against the full analytical approach (that handles paradoxes in isolation) that ignores the "bigger picture" of human reasoning. Sorensen and some other scholars have been interested in conceptual understanding of paradoxes (also questioning common sense) rather than questioning how the human mind processes and reasons during the resolution of paradoxes while resolving them. However, alternatively there are researchers like Scholl (2007) who have focused on understanding the psychological mechanisms behind human reasoning on object persistence.

On the other hand, puzzles have been explained to be a type of game or problem that are generally designed to test ingenuity or knowledge[2]. There is generally a single feasible correct solution or answer to each puzzle. There have been different types of puzzles that could thematically be categorized such as number and logic puzzles. Despite the fact that they generally have entertaining purposes, there are also significant types of puzzles like logistical or mathematical. In the "Material Constitution" article of the Stanford Encyclopedia of Philosophy (Wasserman, 2015), the Ship of Theseus as well as the Debstor, the Statue and the Clay, the problem of Dion and Theon were introduced as puzzles. Since a puzzle, by definition, demands a single and unique solution, it could be argued that the common sense solution for the Ship of Theseus – were it a puzzle – should be unique. However, the resolutions provided by philosophers as well as the intuitive judgments by laymen highly differ. The third option is to define Ship of Theseus as a dilemma. In Greek, dilemma means double proposition. A dilemma is described as a problem with having two possible outcomes that both are preferable to a certain extent to suggest as a solution. The way it is generally offered might be like proposing A or B, as a forced-choice task. For the Ship of Theseus, these contradictory options could be presented as the Ship A or the Ship B. Each categorization has some validity but the aim of this thesis is not to find the correct one. The Ship of Theseus will be referred to as a paradox in a loose sense within this dissertation. More specifically, it will be called "paradoxical Ship of Theseus narration".

2.4 Empirical Work related to Identity Judgments

In this section, the academic literature about the empirical findings on identity judgments has been summarized and the most crucial issues related to the present thesis are discussed explicitly. There is limited empirical work done in the relevant literature, notably by cognitive psychologists. There are mainly three empirical studies by Hall (1998), Rips et al. (2006) and Rips (2011). Their experimental studies provided the basis and initial point of departure for the current dissertation.

2.4.1 Study by Hall (1998)

Although the Ship of Theseus has already been subject to many philosophical debates that are mainly related to the identity/sameness concept and material constitution, there is limited experimental work done related to this subject. One empirical study performed by Hall (1998) demonstrates that adults have the tendency to choose the continuant Ship A instead of the replica, Ship B, despite the radical transformation that the continuant went through. In that study, Hall (1998) did not present the original Ship of Theseus narration but demonstrated a paradoxical or puzzling situation in which an object whose parts became successively substituted by new parts (the continuant) and a second object made from the original parts (the replica). As Hall (1998) demonstrated, the tendency for selecting the continuant object could significantly be increased if the object that has been described is an animal rather than an artifact and if the transformation of that animal lacked a human cause, e.g., a kind of biological growth process could be assumed. These parameters were also

[2] Cambridge-online dictionary: http://dictionary.cambridge.org/dictionary/english/puzzle

found to be sensitive to the age of the subjects. A significant difference was found when the responses of 7-year-old children were compared to the responses of 5-year-old children such that older children tended to prefer the continuant Ship A more than younger children. Thus, one of the general conclusions was that adults and children over 7 years of age have a general tendency to choose the continuant (Ship A) rather than the replica (Ship B) regardless of the object being an artifact like a ship or an animal like a starfish. To sum up, the empirical evidence presented by Hall (1998) suggests that categorical knowledge about specific kinds of objects and canonical transformations might be an essential factor during identity judgments.

2.4.2 Study by Rips et al. (2006)

Another experimental study by Rips et al. (2006) was performed in order to understand how people perform identity judgments given two alternative objects. The theoretical framework was built upon the "causal continuer model" that has already been proposed by Nozick (1981). According to this model, being causally proximate enough is one of the main criteria for object persistence. Based on the model by Nozick (1981), Rips et al. (2006) have attempted to develop a quantitative model that is able to make accurate predictions about identity judgments. Their empirical findings support the causal continuer model in the sense that people have a higher tendency to accept objects grown from earlier ones rather than external factors such as human intervention. When the relevant information about causal connectedness is absent, people tend to rely on other factors such as similarity, spatiotemporal continuity and yet others while making their judgments. Their empirical findings also demonstrated that there is a significant dissociation between identity judgments and judgments of basic-level categories as shown by Hall (1998). In their experiment, the participants were presented a case with an individual undergoing transformations by which different amounts of her original parts were preserved but the rest was changed. For the identity responses, the participants tended to accept that it was the same individual after transformation only if all of the original parts (100%) were preserved. For the other conditions including cases of preserving 75%, 50%, 25% and 0% of the original parts, the participants tended to reject that it was the same individual. Moreover, most of the participants agreed that such transformations do not influence the basic-level category of the individuals if the residual parts were obtained from a member of the same (versus different) category. Lastly, their causal continuer model was able to predict the dissociations in identity and similarity judgments related to cases of splitting or shrinking in which spatiotemporal information was absent. Their main conclusion has been related to the predictive success of the causal continuer approach supported by their adduced empirical evidence.

2.4.3 Study by Rips (2011)

Rips (2011) performed another empirical study in which he examined the case of split identity exemplified by icebergs. In this study, participants were read stories about an iceberg that has been broken into two smaller icebergs: the eastern one and the western one. Here is the original scenario presented during the experiment (Rips, 2011, p. 356):

Scientists are studying the properties of a particular iceberg, Sample 94, off the coast of Greenland. Sample 94 has a cubical shape, 3 x 3 x 3 m. After recording their data, the scientists leave for a time. Returning to the site, they find two smaller icebergs—Icebergs A and B—in the vicinity where Sample 94 had been. Iceberg A measures 1 x 1 x 1 m, and Iceberg B 2 x 2 x 2 m.

In the first experiment, the participants were asked to decide which one should be evaluated as the original iceberg. Many participants declared that both of them are the originals despite their different spatial locations. This finding could be termed as "confirmation bias", since these participants tended to find the option among the others that would comprise both single options, A and B. They might therefore prefer to select this option. Or they might have experienced confusion about the real meaning of the term "both". In other words, they did not consider that both are simultaneously the originals. Rips (2011) therefore designed a second experiment in order to check whether this has been due to some misconceived interpretation of the participants. To be clearer, the main question was formulated supposing the participants had understood the question to be about the properties of the icebergs rather than about the icebergs themselves (see the related discussion between qualitative and numerical identity in section 2.3 above). In this respect, the icebergs have been attributed proper names (like Philp or Gax) that would possibly transform their concepts from being object concepts to singular concepts. Yet, the results obtained from the second experiment were very similar to the ones obtained during the first experiment. Thus, Rips (2011) concluded that the participants do not tend to comprehend the question just related to the properties of icebergs but the icebergs were accepted as mere objects. Rips (2011) developed two more experimental designs in order to observe the participants' understanding for the original concept. His findings clearly show that participants tend to understand the question "which is the original?" as "Which is, in its own right, entitled to be the original?" In other words, the participants seem to find the most inclusive solution instead of the most suitable and optimal one. Rips deduced that although participants generally confirmed that identity is transitive, reflexive, and symmetric (as in algebraic operations like $x=y$ & $y=z \rightarrow x=z$; see again section 2.3.1), the difficulties (and the perplexities in Rips' words) could be due to applying the concept of identity to different occasions. This is consistent with the idea that the identity concept (and so identity judgments) is a vague and tricky concept. More importantly, Rips (2011) speculated that the difficulties depicted above could be due to the limitations of our recognition memory during the application of identity judgment in certain cases. Thus, the problems might not be limited to the representation level of the concepts themselves, since the surrounding (for instance the presence of the competitors) might cause a vital difficulty in reidentification of a cat in an environment full of similar cats. In other words, despite the fact that the identity judgments can be considered to be context-independent judgments, the context and more specifically the contextual features might cause deviations to a certain extent. Rips (2011) argued that the violation of transitivity might be due to the conflict between the context independency of the identity concept and the context dependence of identification (p. 372). One might speculate that the violations in the application of transitivity as well as the inconsistent judgments of a single participant are probably due to her focus of attention during the evaluation process of each judgment. This might be such a dynamic process that could be influenced by certain external factors in addition to internal ones. In the concluding section of the article, Rips (2011) questioned the possibility whether the confusions about identity might be related to the nature of an object rather than the concept of identity itself.

2.5 Current State-of-Art

The identity concept can be described as an abstract concept that has a relatively high level of vagueness. This conceptual vagueness makes it difficult to provide a consensus on the identity concept, since one can argue for both compositional identity and spatiotemporal proximity for a given case like the Ship of Theseus. On one side, it is a controversial issue and interesting to provide a resolution of the Ship of Theseus in terms of its definitive properties as a paradox, a puzzle, or a dilemma. Identity judgments have been one of the most interesting research domains in the last decades in this respect. To date, not only philosophers but also cognitive psychologists have addressed this research question. Thus, there have been a few empirical studies performed for understanding how people make identity judgments depending on the objects and scenarios presented. Despite the limited empirical work in the literature, Scholl (2007) emphasized the potential beneficial role of obtaining empirical evidence by which our metaphysical intuitions can be questioned and analyzed on better grounds. The current empirical literature indicates that identity judgments are dissociated from basic-level category judgments (Hall, 1998; Rips et al., 2006). Moreover, the current empirical evidence suggests that object category (animal versus artifact) appears as a factor in identity judgments. On the other, it is of our main interest to provide an object-oriented analysis with respect to change in time, the nature of the object, and the part/whole relation in the transformation of the object. In contrast to the somewhat limited scope of previous studies which were restricted to philosophy and (cognitive) psychology, in this thesis, a more comprehensive, inter-disciplinary approach will be presented, extending the relevant areas of cognitive science to comprise linguistics as well, and, using a wide range of state-of-the-art methodology, comprising behavioral, eye-tracking, and neuroscience methodology, as well as computational modeling.

CHAPTER 3

CONCEPTUAL TENDENCY TEST

Since one of the main targets of this study has been to assess participants' conceptual tendencies in relation to their identity judgments, a Conceptual Tendency Test (CTT) directed at their conceptual beliefs has been developed. Several pilot studies as well as statistical analyses aimed at checking its validity and reliability were conducted for this purpose. The test was also evaluated as crucial for providing a predictive model for the responses to the identity question regarding the Ship of Theseus narration. This chapter firstly aims to summarize the developmental phase of the conceptual tendency test. Secondly, the obtained results are summarized in order to illustrate the general tendencies for identity judgments. Moreover, the contrast related to the differences between "same" (*aynıdır*) and "different" (*farklıdır*) judgments are presented.

3.1 Conceptual Domains and Propositions

In the relevant literature, different conceptual categories are discussed that are potentially relevant for identity judgments. These conceptual categories are regarded as conceptual domains for the identity concept in this study. The relevant conceptual domains, in terms of their (mostly dichotomous) features, are human/non-human, part/whole, animate/inanimate, natural/artificial and time. 27 propositions were formed with respect to these conceptual domains. These propositions were asked to the participants in a series of preliminary pilot studies to obtain the conceptual tendencies of people. Note that their conceptual tendencies could only be captured via the presentation of propositions and by obtaining their verbal responses in relation to their degrees of belief, although language appears as a potentially interfering factor. This is because, strictly speaking, their linguistically reported rather than their actual perceptual and conceptual processes are measured here. Both may not be the same, indeed. Yet, there is no other developed methodology to acquire their cognitive responses bypassing language. However, the neurophysiological studies comprised within this dissertation shed some light on more basic cognitive responses, in terms of eye-movements and brain activation, at least when the dependent variables are considered.

3.2 Pilot Studies

The following pilot study has aimed at understanding how suitable the use of a conceptual tendency test for predicting the responses to the Ship of Theseus would be. Two conditions were designed in order to observe any effect of the order of presentation of the SOT paradox and the questionnaire. One of the prior concerns has been related to the order of the presentation: Would the presentation of the questionnaire prior to the paradox resolution influence the resolution of the paradox as compared to giving the questionnaire after presenting the paradox? The second question was related to providing a statistical model in order to predict the responses to the paradox. Given positive results, it might be possible to use these propositions for the Conceptual Tendency Test (CTT).

3.2.1 Participants:

There were 57 participants in total who have participated in the pilot studies. All of the participants were students; almost half of them (27 of 57) were undergraduate students and the rest was graduate students. All students were from Özyeğin University and Middle East

Technical University. Gender distribution was also balanced (29 females and 28 males). The ages of the participants ranged from 18 to 35.

3.2.2 Procedure:

The participants were given a paper-based version of the propositions. They were given unlimited time to finish the questionnaire and the identity question regarding the SOT narration. Filling out the questionnaire took approximately 12 minutes on average.

3.2.3 Results

First, it was of high importance to see if the order of presentation (paradox > propositions; propositions > paradox) has any "priming" impact on the response patterns. Therefore, two groups of participants received the propositions and the paradox in alternating order. Results from n=57 participants showed that the influence of order was not significant ($\chi^2(df=4)=1.722$, $p>.658$), suggesting that potential impacts of priming by order can be neglected After having ruled out this potential confound, there have been two aims for performing the statistical tests on the data obtained from the pilot studies. The first research question has been to observe which questions would be more suitable regarding a reliability test. The second question was about providing statistical models to predict the final responses to the SOT relying on the responses to the CTT.

3.2.3.1 Statistical Analyses for the Pilot Studies

A reliability analysis has been performed in order to check how many of the propositions will pass the reliability test and to detect which propositions should be removed from the test in order to factorize the main dimensions of the survey. The reliability analysis performed just before the other statistical tests required the elimination of 3 propositions from the test items in order to increase Cronbach's alpha coefficient above the expected level (α=0.80). These excluded propositions as well as their reliability coefficients are presented in the Appendix B.

Reliability Coefficients

No. of Cases = 57 No. of Items = 24
Alpha = .8334

Figure 3.1 The results of the Reliability Analysis: number of cases, number of items, and Cronbach's Alpha level.

3.2.3.2 Generating Predictive Models

The first mathematical model to apply to the pilot data set was discriminant analysis. The target of the model was to predict the responses to the identity question regarding the Ship of Theseus narration. Weak and strong judgments for Ship A were clustered as well as the Ship B judgments as a separate cluster. The intermediate position ("3") was left out. Thus, the model had to predict whether the current participant decided for Ship A or Ship B as the Ship of Theseus. The predictive model generated consisted of 4 propositions with their coefficients. Participants giving responses to these propositions reached a final Z-score and depending on their final score, their final decision (to the SOT) was predicted with 79.5% of success. This result can be accepted as a relatively successful model, since it provides allows correct prediction in 4 out of 5 times. The second mathematical model to apply was a logistic regression model. The logistic regression test as a predictive model also provided a relatively powerful model (72.3%) for 2 category-based responses (Ship A or Ship B). These two mathematical models indicate that it might be possible to generate a statistically valid model to predict the final responses for the Ship of Theseus solely relying on the responses to the conceptual tendency test. This is shown in chapter 9 for the final version of the CTT. At this point, the next step in the preparatory phase was to finalize the content of the conceptual tendency test and to prepare the behavioral tasks.

3.2.3.3 Finalizing the Conceptual Tendency Test

The content of the conceptual tendency test has been finalized mainly due to the results of reliability analyses. Moreover, the items of the conceptual tendency test have been increased (doubled) with the addition of *farklıdır* propositions as a contrast to *aynıdır* propositions. That is, there now exist two versions of each proposition: one with *aynıdır* and one with *farklıdır*. It has been our interest to observe whether these conceptual judgments are responded to in a similar or different pattern. Thus, in total, the conceptual tendency test was composed of 48 propositions. The propositions are listed in the Appendix A.

3.3 Performing the Main Experiments

Forty-eight propositions were prepared as image files and were presented in random order for 15 seconds on the computer screen by E-Prime 1.0 and 2.0. Participants were asked to rate the propositions from the CTT that are directly related to the core concept involved in the Ship of Theseus. Participants responded on a 5-Point Likert Scale from 1 to 5 (where 1 corresponds to total agreement, 3 to neutral, and 5 to total disagreement). A screen shot for a proposition has been provided in the figure below.

Figure 3.2 One example for the presentation of a proposition.

There were 24 proposition pairs half of which were phrased in terms of "same" ("A" for Turkish "aynı" ("same")), and half in terms of "different" ("F" for Turkish "farklı" ("different")), e.g., A: "A bicycle that has its pedals removed is the same"; F: "A piece of paper bent over 3 times is different". They were given a fixed duration of 15 seconds to give their responses that was followed by a fixation duration of 3 seconds in which they could give their final response.[3]

[3] For the neurophysiological assessment conditions, the propositions were presented with different durations. For the EEG/ERP experiments, the propositions were presented in 5 parts and each part was presented for 1350 milliseconds that are followed by a blank screen for 150 milliseconds. The

After the presentation of all propositions, participants were then presented with the Ship of Theseus narration in one of the experimental conditions, see chapter 4: in the high STP condition, the ship was renewed/reassembled over a short period of time (5 years) and at a neighboring port; in the low STP condition it was reassembled over a long period of time (50 years) and at a distant port. Participants were given unlimited time to respond on a 5-point Likert scale, where ratings of 1 and 2 were considered as strong and weak "Ship A" ratings, ratings of 3 as "undecided" and ratings of 4 and 5 as weak and strong "Ship B" ratings, respectively.

3.3.1 Results from the Conceptual Tendency Test (CTT)

The behavioral results obtained from the conceptual tendency tests are summarized in this section. The main outputs illustrate the distribution patterns of the identity judgments for both *aynıdır* and *farklıdır* conditions. It is important to determine which of the propositions are highly agreed and disagreed upon to find out the potential determinants underlying participants' responses to the identity question regarding Ship of Theseus narration. Moreover, it is quite significant to reflect the general tendencies for the identity judgments. Below, the frequency plots as percentages for agreement cases (1-2), intermediate cases (3), and disagreement cases (4-5) are demonstrated with the propositions in both polarity conditions, respectively. In the following, the distribution of participants' responses (in percentage) will be presented for all 24 pairs of *aynıdır/farklıdır* propositions, for all 5 positions of the Likert scale.

P1A: Participants have a higher tendency for not accepting a single person to be the same after a liver transplantation (1-2: 30.6% versus 4-5: 66.1%). P1F: As expected, participants had a higher tendency to accept they will be different after this liver transplantation (1-2: 76.0% versus 19.9%). This finding shows that people are susceptible for the identity judgments considering a human being undergoing organ transplantation. Organ transplantation thus seems to be a significant case for interrupting identity. Note also that despite the general symmetry in "same" vs "other" judgments, this symmetry is not perfect. For example, whereas in P1A ca. 30% agree and ca. 66% disagree, in P1F ca. 20% disagree to the negative version and 76% agree with the negative version. Thus, there is a gap between 30% and 20% (agreement to positive/disagreement with negative) and between 66% and 76% (disagreement to positive/agreement with negative), respectively. The gap for this proposition pair, P1A/F, amounts to 10%. Note that the intermediate condition does not seem to be affected by the polarity reversal to the same extent.

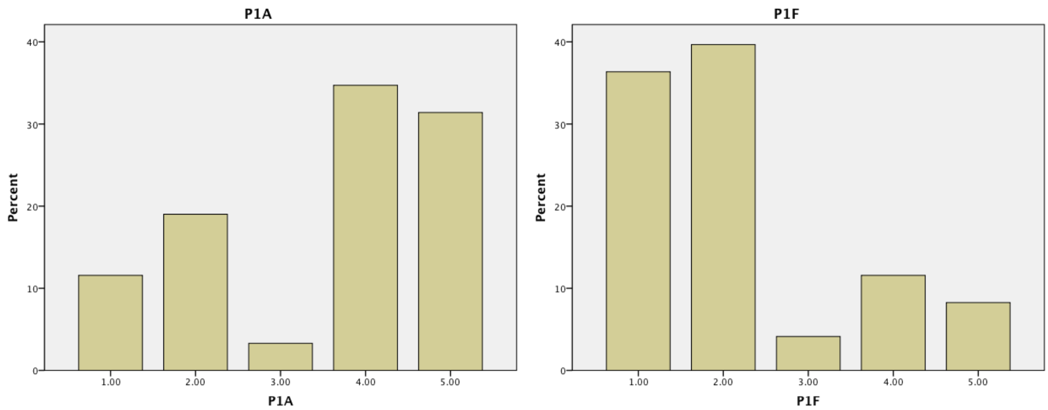


Figure 3.3 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P1A

participants were asked to respond in the 5-Likert scales within 5 seconds. In the fNIRS experiments, the propositions were presented for a fixed duration of 10 seconds via OpenSesame. The presentations of propositions were followed by a response screen of 8 seconds. After the participants responded, the resting screen was presented for 8 seconds in order to provide the baseline measurement.

and P1F respectively.

P2: Participants had a tendency to disagree that monozygotic twins are the same (1-2: 30.6% versus 4-5: 53.6%). As expected, they had a tendency to agree that they are different (1-2: 65.3% versus 4-5: 33.9%). Since these are humans and presented as distinct entities, they are judged to be different despite the fact that they have the identical genetic material and a very high level of physical similarity.

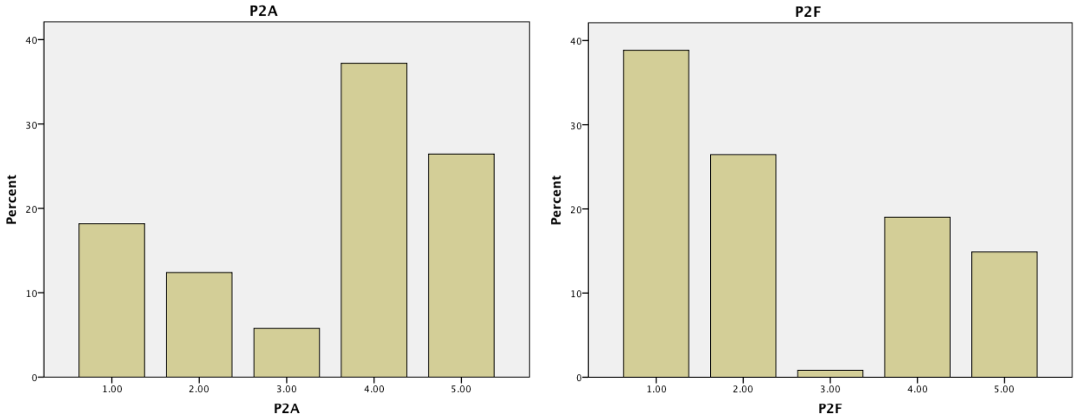


Figure 3.4 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P2A and P2F respectively.

P3: The participants had a tendency to accept two livers with the identical genetic features to be the same (1-2: 62% versus 4-5: 30.6%). They tended to disagree with the different (*farklıdır*) version of this proposition (1-2: 38% versus 4-5: 52.9%). Despite the fact that organs (here, livers) are living things, since they are part of an organism, they could be judged as the same relying on the given evidence that they are genetically identical. However, participants treat organs very similar to the whole organism, cf. their responses to P1A/F.

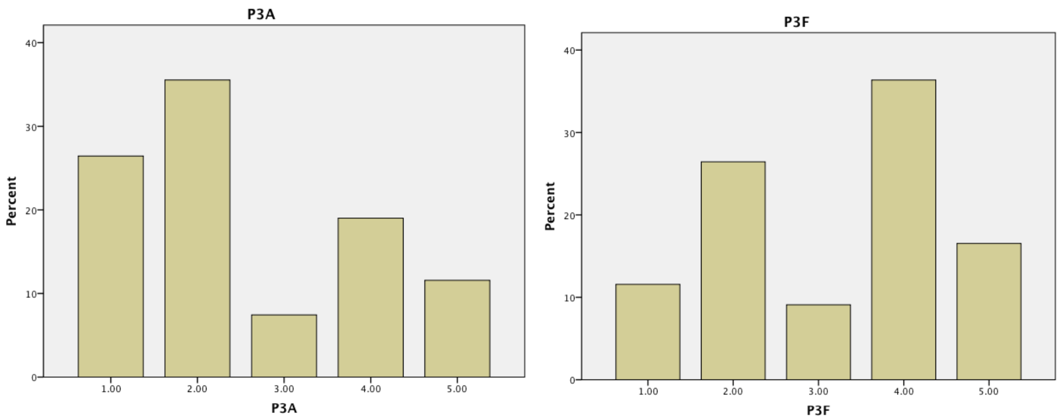


Figure 3.5 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P3A and P3F respectively.

P4: Participants tended to accept that two water molecules under the identical conditions are the same (1-2: 71.9% versus 4-5: 19.8%). As expected, participants tended to disagree that two molecules under identical conditions are different (1-2: 23.1% versus 4-5: 71.9%). Note that participants treat living organisms (whole or parts of) differently as compared to non-living, physical (though organic) matter. While identity does not hold between two (genetically) identical humans (the monozygotic twin case, P2 above), it holds between two physical (organic) entities (P4, here).

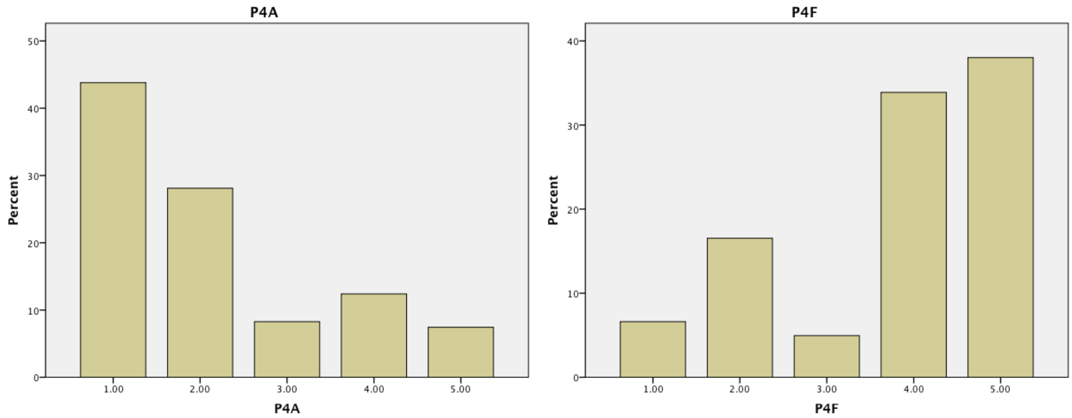


Figure 3.6 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P4A and P4F respectively.

P5: Participants do not agree that a person is the same from birth till death (1-2: 92.5% versus 4-5: 4.1%). As expected from the *aynıdır* response pattern, participants tended to disagree that a person from birth till death is different (1-2: 84.3% versus 4-5: 10.8%).

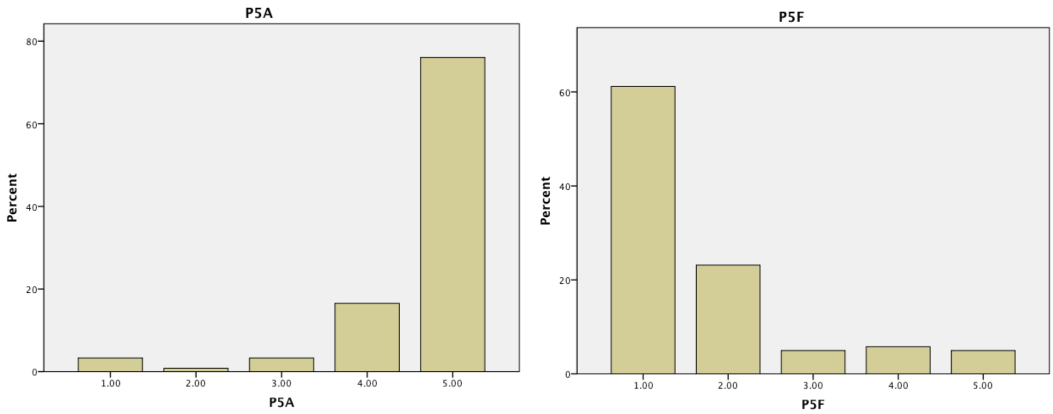


Figure 3.7 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P5A and P5F respectively.

P6: There is a slight balance for the sameness judgments for the two different forms of a piece of paper, undergoing a physical transformation being bent over three times (1-2: 51.3% versus 4-5: 42.1%). Similarly, the responses for *farklıdır* version show that the participants who agreed and disagreed are in balance (1-2: 44.6% versus 4-5: 45.5%).

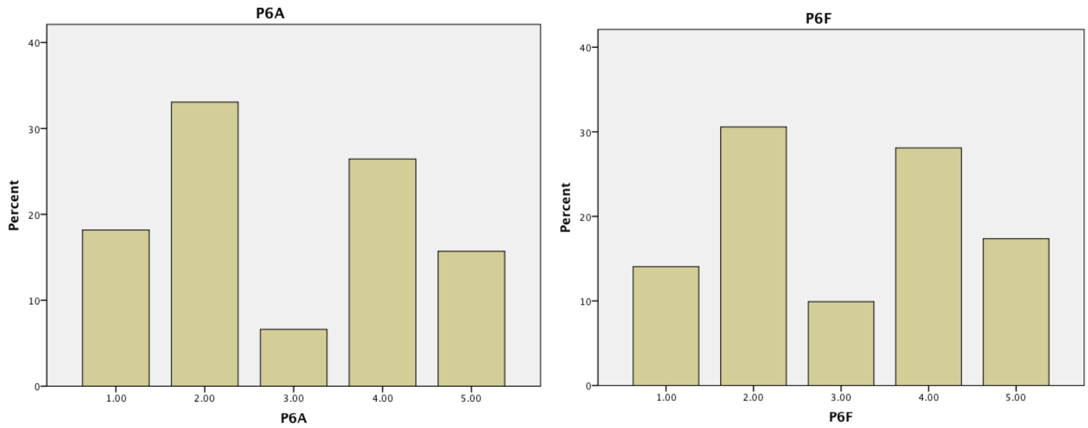


Figure 3.8 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P6A and P6F respectively.

P7: Participants tended to disagree that a bicycle will be the same if its pedals are removed (1-2: 8.2% versus 89.2%). The participants tended to agree that a bicycle with pedals removed is different (1-2: 87.6% versus 4-5: 10.0%). The disassembly of a part from an object was regarded as highly significant change for its identity.

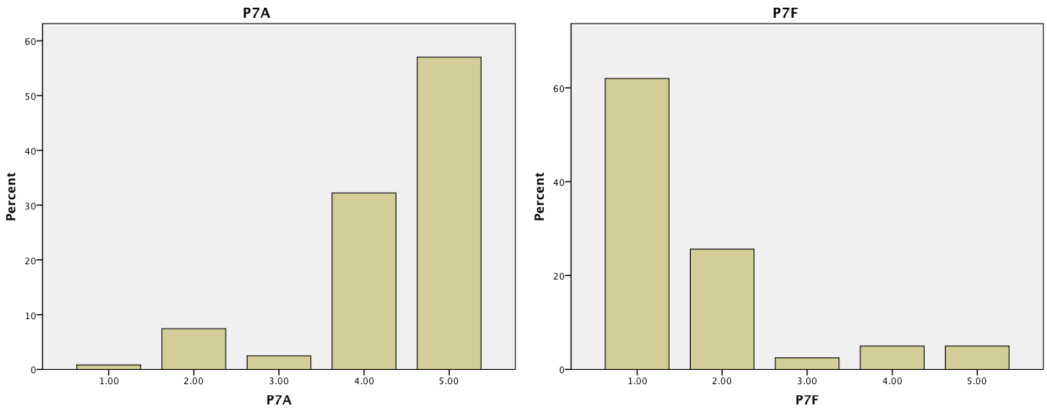


Figure 3.9 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P7A and P7F respectively.

P8: Participants tended to reject a disassembled car to be the same when compared to its initial form (1-2: 16.5% versus 4-5: 79.3%). They had a tendency to accept that a disassembled car becomes different (1-2: 71.9% versus 4-5: 19.9%).

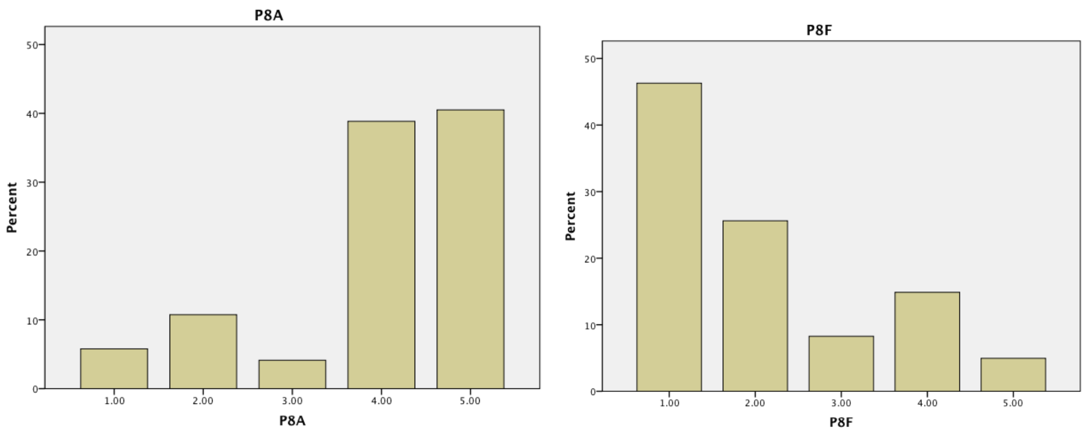


Figure 3.10 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P8A and P8F respectively.

P9: Participants had a tendency for not accepting two birds with identical behavioral and genetic properties to be the same (1-2: 28.1% versus 4-5: 65.3%). As expected, they tend to accept that these are different (1-2: 70.3% versus 4-5: 22.4%). This result again resembles the human case with the monozygotic twins.

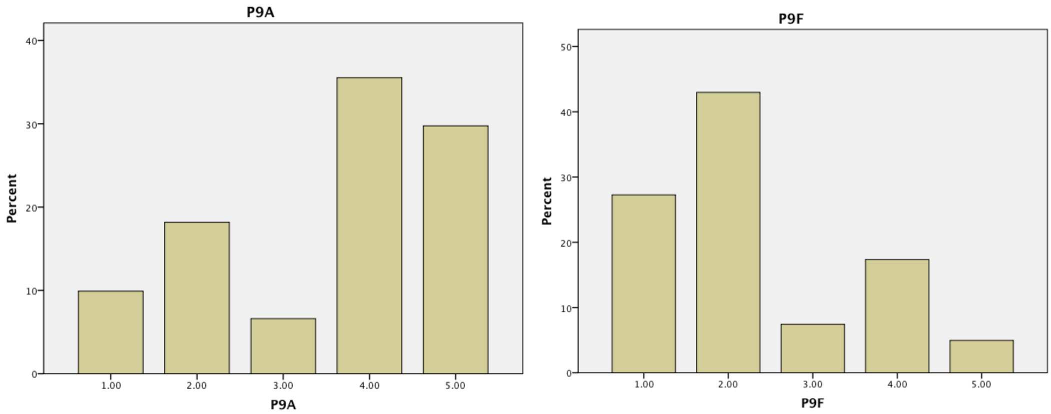


Figure 3.11 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P9A and P9F respectively.

P10: Participants tended to agree that a non-living object was the same even after 1000 years during which its molecules were preserved (1-2: 58.7% versus 4-5: 28.9%). They tended to reject that this non-living object while being preserved becomes different within a time of 1000 years (1-2: 32.2% versus 4-5: 57.1%).

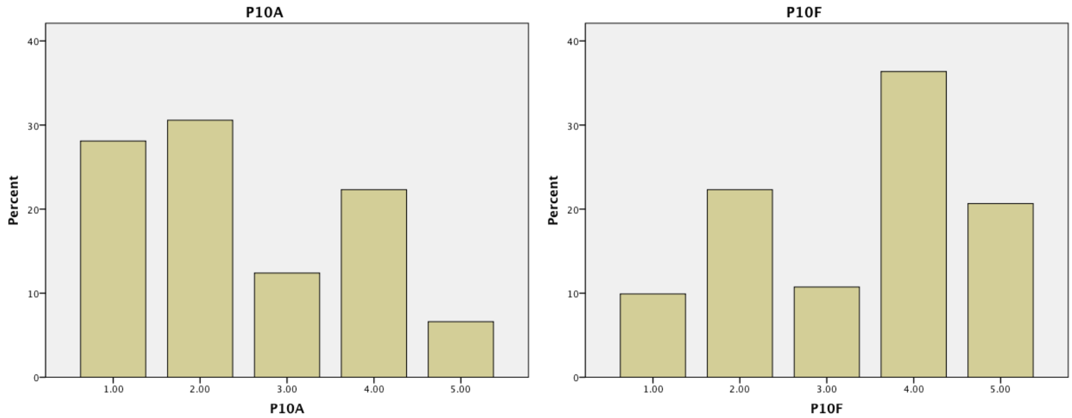


Figure 3.12 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P10A and P10F respectively.

P11: Participants did not accept a glass to be the same that has been broken into its molecules but fully reassembled to its original form (1-2: 38.9% versus 4-5: 57.0%). On the other hand, they slightly tended to accept that this glass is different (1-2: 59.5% versus 4-5: 38.0%).

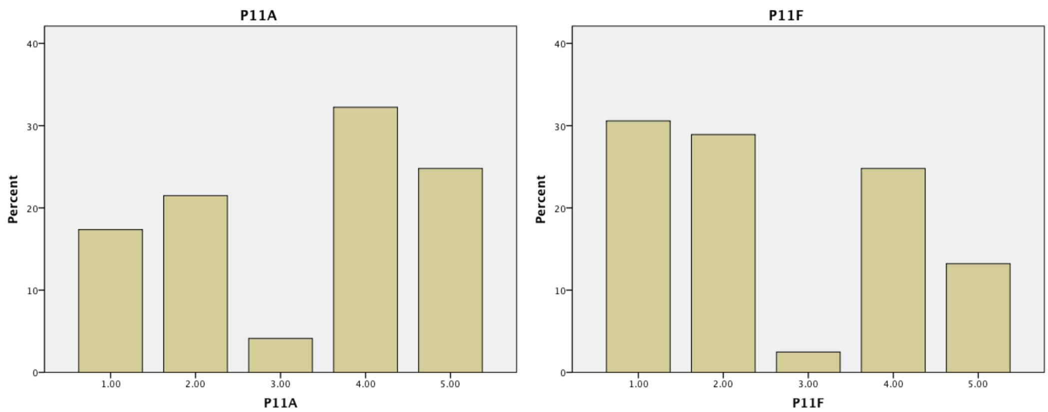


Figure 3.13 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P11A and P11F respectively.

P12: Participants tended to respond in balance for the proposition that different aggregates of water (gaseous, liquid and solid) are the same given their identical chemical formula (1-2: 43.8% versus 4-5: 45.5%). Similarly, their responses were in balance for the *farklıdır* condition (1-2: 45.5% versus 4-5: 43.0%).

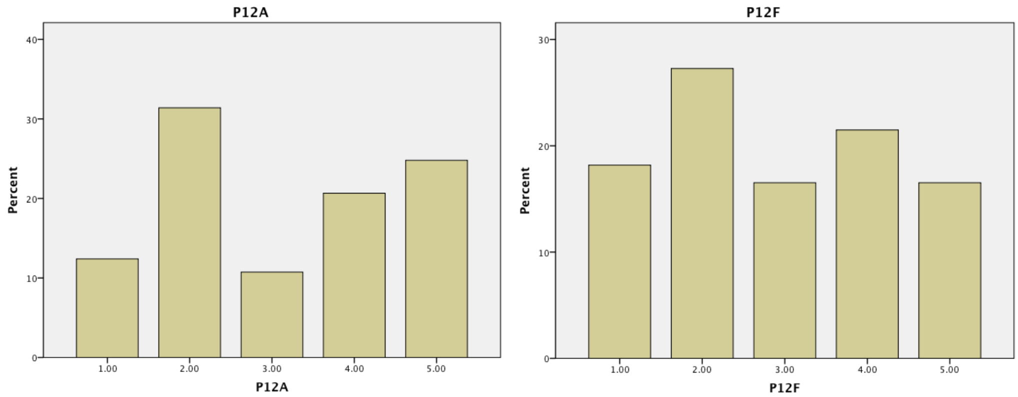


Figure 3.14 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P12A and P12F respectively.

P13: Participants tended to disagree that a person undergoing a memory chip implantation is the same (1-2: 29.8% versus 4-5: 60.2%). As expected, they tended to accept that this person is different (1-2: 68.6% versus 4-5: 24.0%). This is a case that shows that external interference with a physical being is regarded as an identity-changing factor.

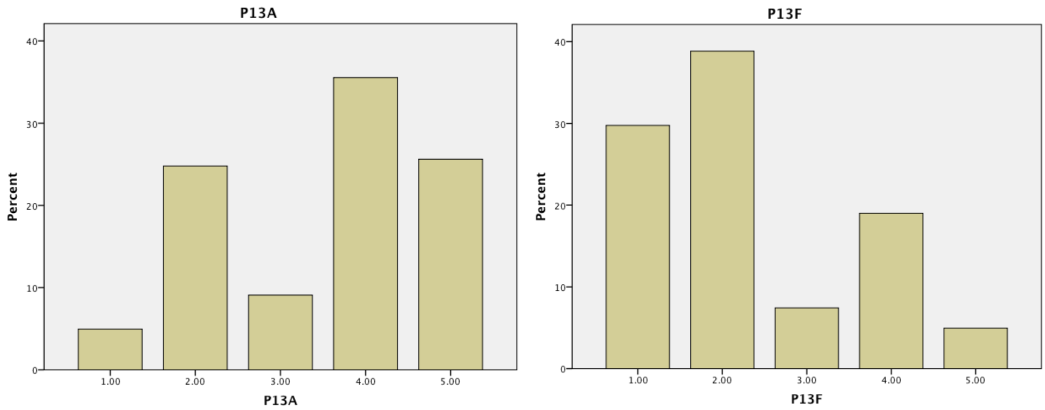


Figure 3.15 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P13A and P13F respectively.

P14: Participants tended to accept that two robots with identical AI software and behaving identically under identical external conditions are the same (1-2: 66.1% versus 4-5: 19.8%). Occasionally, they tended to reject that these two robots are different (1-2: 23.2% versus 4-5: 64.5%).

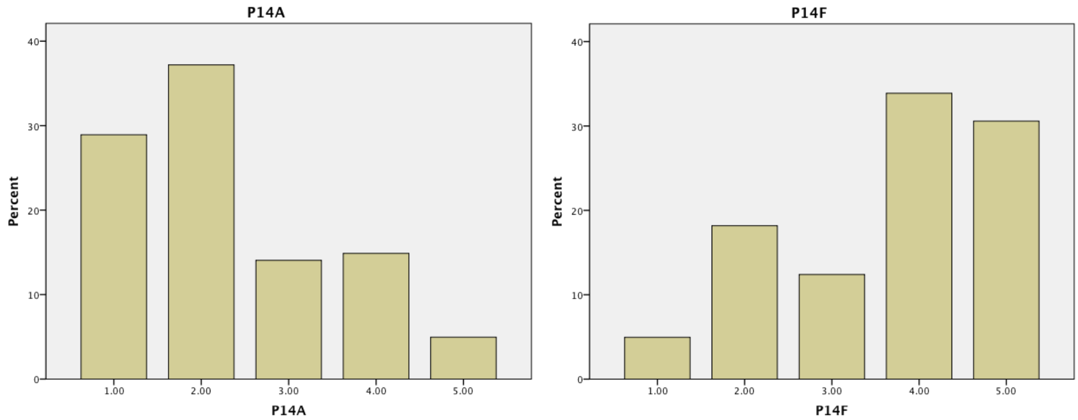


Figure 3.16 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P14A and P14F respectively.

P15: Participants did not tend to accept a cat and a bio-robot (cyborg) to be the same even though they are described to have identical physical properties and behaviors (1-2: 5.0% versus 4-5: 88.4%). As expected, the participants tended to respond that these entities are different. Thus, two different entities, a living organism (a cat) and a non-living counterpart, a bio-robot cat, are judged to be not the same, but different (1-2: 92.6% versus 4-5: 5.0%). Participants were particularly clear in their judgments of this proposition.

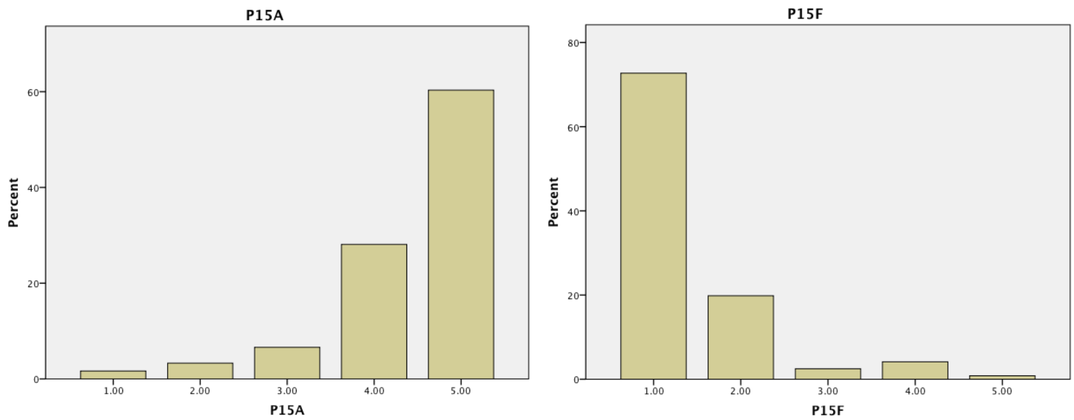


Figure 3.17 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P15A and P15F respectively.

P16: Participants tended to disagree that a bird that is completely disassembled into its molecules and reassembled to its original form is the same (1-2: 29.8% versus 4-5: 56.2%). They tended to agree that the bird is different after disassembly and reassembly processes (1-2: 53.7% versus 4-5: 32.3%). For this case, the participants seemed to accept the idea that a disassembly followed by a full reassembly is an identity-changing factor.

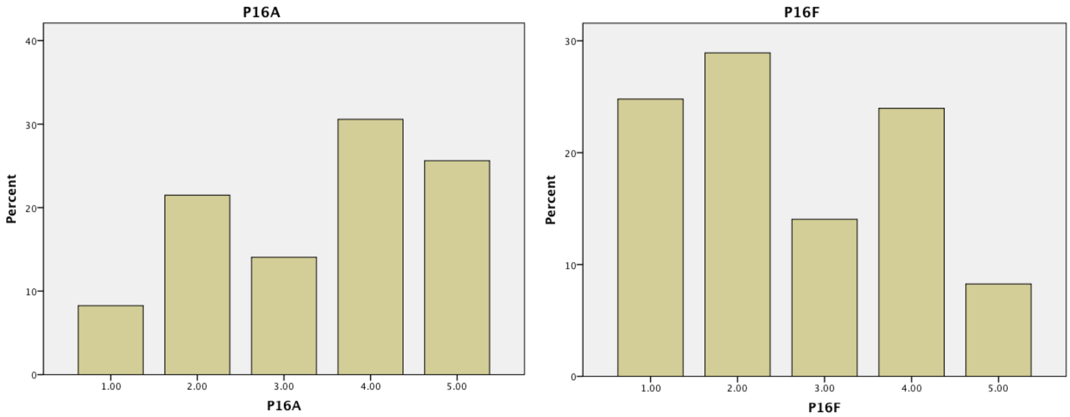


Figure 3.18 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P16A and P16F respectively.

P17: Participants tended to agree that a robot is the same after being disassembled and reassembled (1-2: 68.6% versus 4-5: 24.0%). However, they are observed to respond slightly in balance for their different judgments (*farklıdır* condition) (1-2: 50.4% versus 4-5: 42.3%). This case shows the processing difference between *aynıdır* and *farklıdır* conditions in a particularly striking way. Note that this proposition is modeled after the previous one, showing the difference between animate and inanimate entities. While participants judge a bird not be the same after disassembly/reassembly, they tend to judge a robot to remain the same.

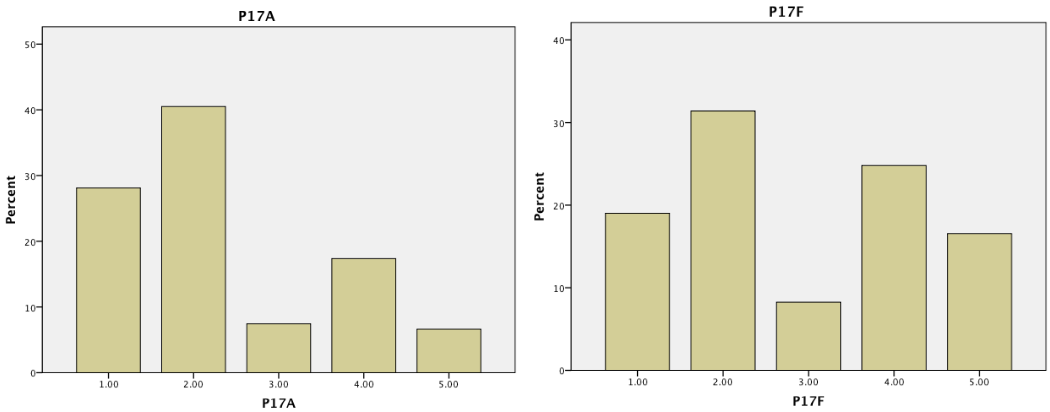


Figure 3.19 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P17A and P17F respectively.

P18: Participants had a tendency to disagree that a racer with a prosthesis leg is the same (1-2: 18.2% versus 4-5: 76.2%). On the other hand, they tended to agree that the racer is different (1-2: 71.9% versus 4-5: 18.2%). This example is a highly relevant real life case which actually is lively discussed in the media as well as in expert committees, e.g., can a racer with such a prosthesis leg be admitted to the Olympics. Participants' judgments seem to be quite clear-cut and symmetric here.

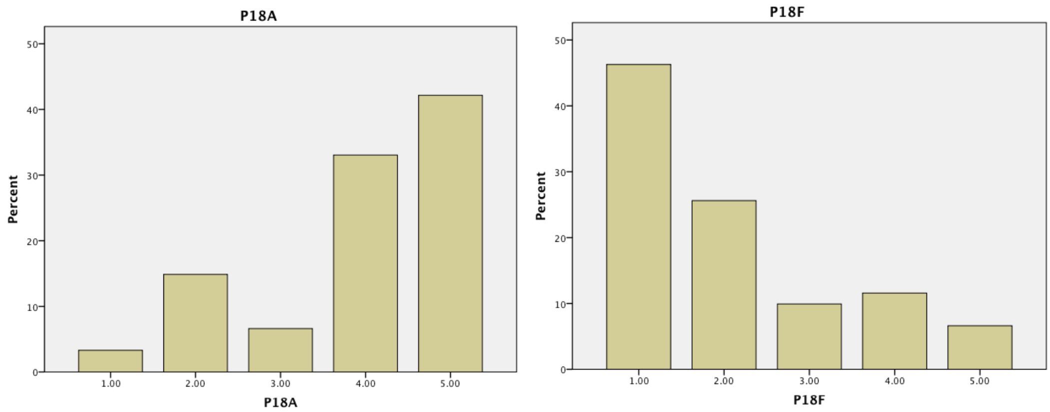


Figure 3.20 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P18A and P18F respectively.

P19: Participants tended to disagree that a person with a third bionic arm transplanted is the same (1-2: 9.9% versus 4-5: 84.3%). They tended to agree that a person is different after a third bionic arm has been transplanted (1-2: 82.6 versus 4-5: 9.9). This result also reflects that participants are susceptible to external manipulations of humans, in this case even more than in P18.

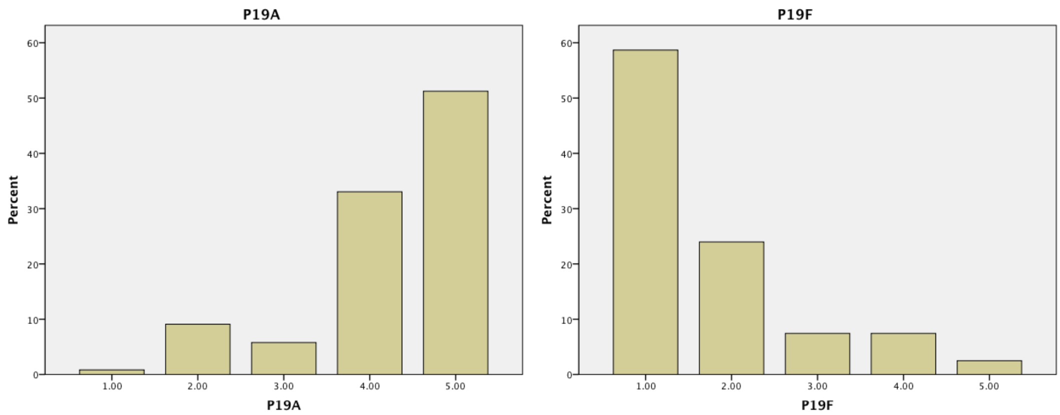


Figure 3.21 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P19A and P19F respectively.

P20: Participants tended to disagree that a person is the same after heart transplantation (1-2: 31.4% versus 4-5: 63.6%). They tended to accept that the person is different after the transplantation (1-2: 72.7% versus 4-5: 20.6). Compared to the case with the liver transplantation (P1), it seems that people tended to behave similarly.

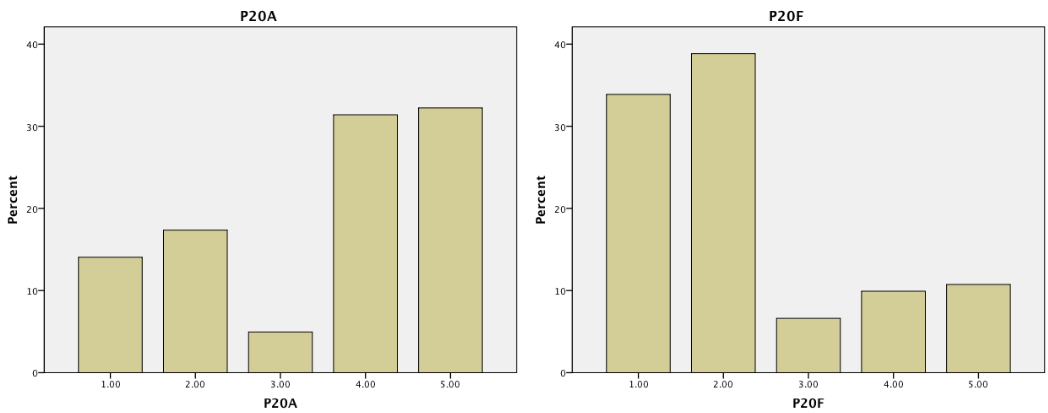


Figure 3.22 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P20A and P20F respectively.

P21: Participants tended to agree that a robot with a memory chip transplantation is the same after the operation (1-2: 56.2% versus 4-5: 36.3%). Interestingly enough, the different judgments for this proposition seem to be almost equally balanced (1-2: 48.8% versus 4-5: 46.3%). The participants seem to be highly influenced by the category of the subject that is a robot in this case, when compared to the human case having a memory chip transplantation (P13).

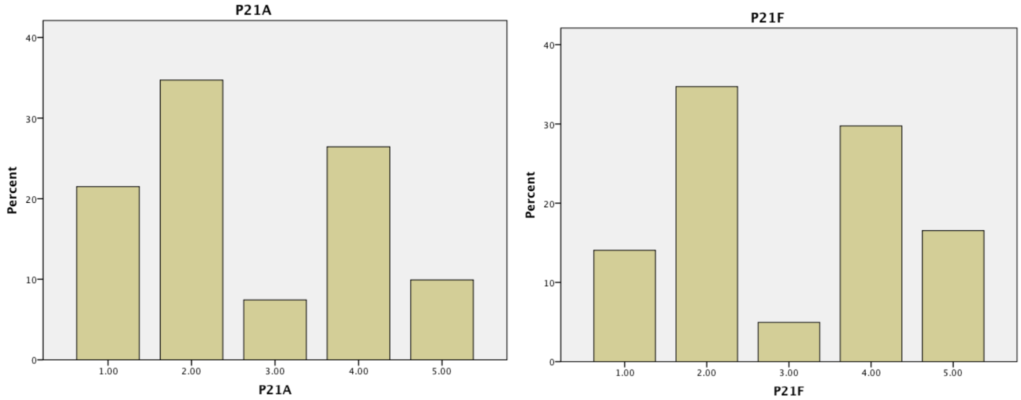


Figure 3.23 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P22A and P22F respectively.

P22: Participants also had a tendency to reject hat a car with its motor removed is the same when compared to its initial state (1-2: 22.3% versus 4-5: 72.7%). On the other hand, they tended to accept that the car is different after its motor was removed (1-2: 81.8% versus 4-5: 15.7%). Despite a car is inanimate, possibly because of the fact that the motor is the very essential part of a car, its removal might be judged as an identity-changing criterion.

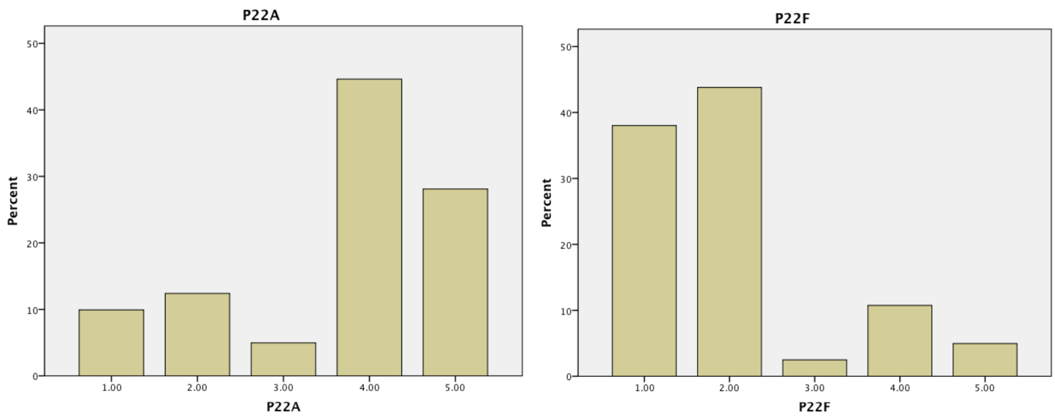


Figure 3.24 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P22A and P22F respectively.

P23: Participants tended to reject that a person undergoing face transplantation is the same after surgery (1-2: 25.6% versus 4-5: 75.2%). Similarly, they tended to accept that a person is different after face transplantation (1-2: 76.9% versus 4-5: 13.3%). They responded to this proposition similarly as to the organ transplantation case (P1, P20). Thus, any physical change of the human body might be regarded as a highly significant factor that disrupts its identity.

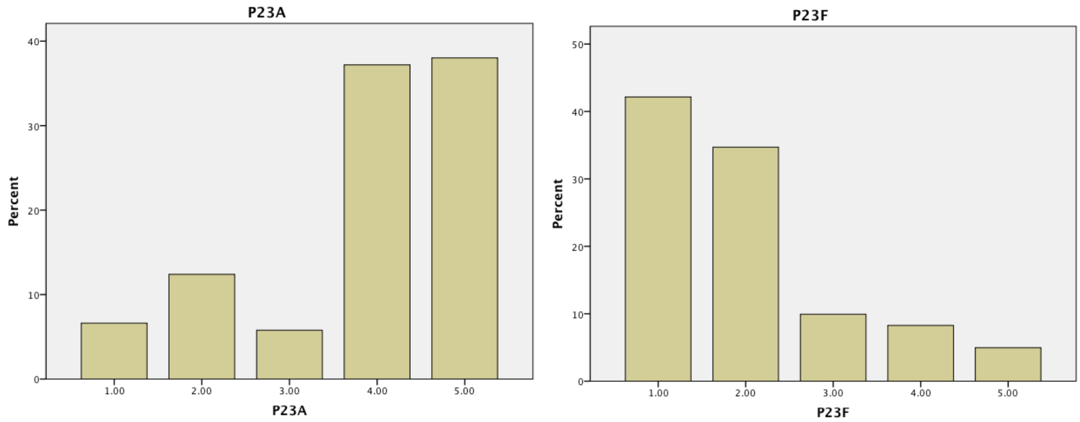


Figure 3.25: The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P23A and P23F respectively.

P24: Participants highly tended to disagree that a yellow banana turning brown is the same (1-2: 5.8% versus 4-5: 93.4%). In a similar fashion, they tended to agree that a yellow banana turning brown is different (1-2: 90.9% versus 4-5: 6.6%). This finding may indicate that it is not the color change per se that makes participants reluctant to judge it the same, but rather that they draw conclusions about its palatability from the color change. Note that this judgement is particularly clear-cut and symmetric.

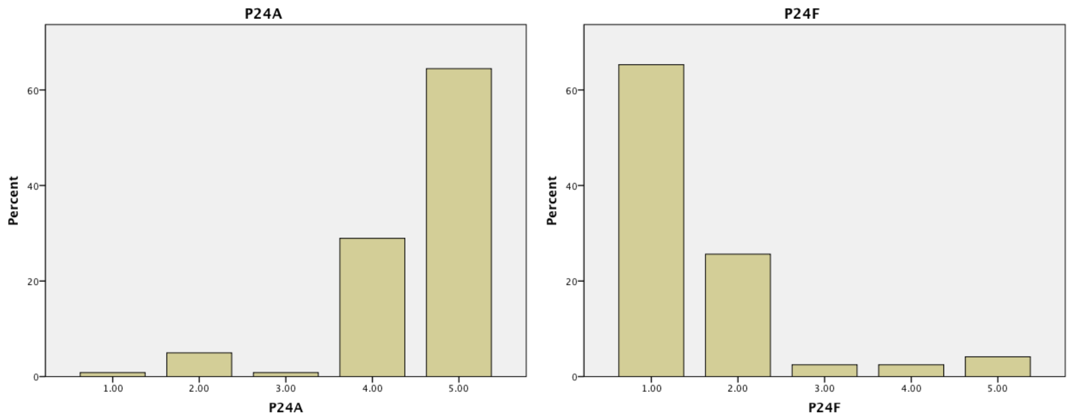


Figure 3.26 The percentage-based frequency plots for *aynıdır* and *farklıdır* responses for P24A and P24F respectively.

3.3.2 *Aynıdır* versus *Farklıdır* Conditions

Given the conceptual tendency test as a whole, participants tended to agree with the *farklıdır* propositions more likely than with the *aynıdır* propositions. 17 of the 24 *farklıdır* propositions were weakly or strongly agreed to whereas only 7 of the 24 *aynıdır* propositions were likely to be agreed with (when compared to the farklıdır counterpart). This result is directly related to the conceptual domains of the presented propositions. For instance, when two entities from different categories are compared, participants tend to judge that these are different despite the fact that they have identical properties as in P15 (a cat and a bio-robot having identical physical and behavioral properties). It is probably safer for them to claim that two distinct entities are different, however, for the case of water molecules, two of them having identical structures are judged to be the same.

Comparing the response time patterns for *aynıdır* and *farklıdır* propositions was another interesting issue. We initially hypothesized that there will be no difference in reaction times, since there is no explicit, formal difference regarding these two conditions. The data from the two different conditions has been tested however, if there was an effect. Interestingly enough, participants tended to respond slower to the *farklıdır* propositions when compared to *aynıdır* propositions. This finding is crucial as it indicates that there might be processing differences due to conceptual differences introduced by the polarity of these two conditions. In this respect, an experimental design with EEG/ERP methodology has been prepared in order to study whether these processing differences can be replicated and possibly be detected with distinctive neural signals, see chapter 7.

3.4 Discussion

One of the main issues has been to detect those propositions that are potentially predictive for participants' responses to the paradoxical Ship of Theseus narration. One essential factor has been to identify propositions that have bimodal response distribution. That means participants responded equally likely to agree and disagree with the proposition. This bimodal pattern could be evaluated as a potential predictor for the resolution of the Ship of Theseus narration. The following propositions were most discriminative in this respect: (a piece of paper bent over 3 times), P16 (a disassembled and reassembled bird), P17 (a disassembled and reassembled robot), P21 (a robot with a memory chip transplantation). These propositions indicate that participants were most likely to differ in their identity judgments for the disassembly-reassembly cases and that their choices of Ship A versus Ship B could be predicted on these grounds. Which conceptual dimensions are most crucial will be discussed in more detail in Chapter 4.

This conceptual tendency test (CTT) has been developed to better understand participants' behavior patterns towards different conceptual cases. The obtained results indicate that they showed considerable – however, not perfect – response symmetry for the two conditions *aynıdır* and *farklıdır*. Participants were instructed not to aim to respond consistently but instead they were encouraged to respond freely to each present item regardless of their previous responses. Thus, it might be argued that people have intuitive tendencies to respond consistently to cases with changing polarity. This consistency, however, is not perfect, suggesting processing differences between the affirmative and negative versions. This issue will be followed up in later chapters.

The observed delay in response times for the *farklıdır* condition as opposed to the *aynıdır* condition might have been caused by the processing difficulty of *farklıdır* judgments as mentioned above. One of the possible explanations could be related to the higher level of observed use of *aynıdır* as opposed to *farklıdır*, i.e., it might be a frequency issue. Another possible explanation might be related to the implicit conceptual meaning of *farklıdır*, i.e., as the negation of *aynıdır*. This finding has further been investigated with different neuroimaging methodologies including EEG/ERP and fNIRS. The experimentation of the neuroimaging studies (EEG/ERP and fNIRS) are presented in Chapter 7 and Chapter 8, respectively.

CHAPTER 4

TEXTUAL CONDITION: THE EFFECT OF SPATIOTEMPORAL PROXIMITY

Reasoning processes have been one of the central targets for cognitive modeling. Modeling of reasoning processes appears as an even harder challenge during the resolution of paradoxes such as the Ship of Theseus. The paradoxical Ship of Theseus narration is cast in a narrative, or, textual format, originally, that is, listeners or readers attend to a story at the end of which they have to reason about which ship is the Ship of Theseus, Ship A, the replica, or Ship B, the reassembled ship. This experimental work aims to observe the possible influences of the variations of the text, in terms of spatiotemporal proximity (STP) on the resolution of the paradox, as explained below. Prior to the paradox, participants were asked to answer the conceptual tendency test (CTT) that is related to the main concept, identity or sameness. The results of the experiments concerning the paradox have shown that the different spatiotemporal conditions do not seem to cause a major change in the final decisions of the participants. This work also attempts to model the empirical data obtained from the CTT in relation to the resolution of the paradox with different modeling techniques: discriminant analysis (DA), decision tree analysis, and neural networks. While each method has its own advantages and disadvantages, this chapter attempts to compare and to contrast these methods trying to select the most suitable model for future work.

4.1 Introduction

Identity judgments have long been at the center of philosophical debates, e.g., is a car still the same after being fixed after a serious accident? Beyond the philosophical debates on the nature of objects and the concept of identity, it has also been a matter of interest how laymen respond to the identity question under different circumstances. Spatiotemporal continuity has been accepted as one of the identity criteria by which the tendency of people to seek for a spatiotemporal path of an individual is meant (Rips et al., 2006). This tendency has probably its roots in perceptual processing during infancy that has been demonstrated by several empirical findings (Carey & Xu, 2001). Rips et al. (2006) presented the case of a computer that was totally disassembled and then reassembled at its initial position. This computer example demonstrates that it is possible to argue for sameness in spite of apparent gaps in space or time (Hirsch, 1982). Therefore, a manipulation of spatiotemporal occurrence might be a crucial factor for the reasoning processes of people. The gap in its spatiotemporal path is one of the characteristics of the paradoxical Ship of Theseus narration where one of the ships, Ship B, is compositionally identical with the original ship but, being reassembled in a distant time, at a remote place, lacks spatiotemporal continuity. Ship A, on the other hand, does not suffer from any such spatiotemporal gap, however, totally exchanges its material parts. It has initially been hypothesized that providing variation in spatiotemporal proximity might have an impact on the final responses of the participants while resolving the paradox. Thus, two realistic scenarios have been formulated that only differed in their spatiotemporal parameters. In the first scenario, the “high STP condition”, the ship is renewed/reassembled over a short period of time (5 years) and at a neighboring port. In the scenario in the “low STP condition” the ship is renewed/reassembled over a long period of time (50 years) and at a distant port. It is expected that the participants in the low STP condition will be more likely to select ship A as the ship of Theseus than the participants in the high STP condition, since the participants in low STP condition would be confronted with a greater spatiotemporal gap

(50 versus 5 years; at a distant versus at the same port) before the onset of the reassembly process. It is also of interest to present and compare the results of different predictive models based on the CTT in terms of their accuracy (predictive success) and to discuss the theoretical basis of the findings.

4.2 Research Questions and Hypotheses

In this current work, the main focus has been on three research questions: (1) Do the above-mentioned differences in spatiotemporal proximity cause a change in the final decisions of the participants? (2) Do the identity judgments in the CTT contain conceptual cores that are influential during the reasoning process on the paradox? (3) Can the final decision of a participant be predicted by the CTT? Our hypotheses on paradox resolution are as follows:

> H_1: Participants take spatiotemporal features into account while making decisions about judgments on identity of an object over time.
>
> H_2: The final decisions of the participants to the paradox can be predicted by their responses to the CTT.

4.3 Experimental Design and Data Collection

50 undergraduate and graduate students (25 female; age-range 19-28 years) were allocated to the two experimental conditions – high versus low spatiotemporal proximity (STP) – randomly. Forty-eight propositions were prepared as image files and were presented in random order for 15 seconds on the computer screen by E-Prime 1.0. Participants were initially asked to rate a set of propositions (the CTT) that are directly related to the core concept involved in the paradox. Participants responded on a scale from 1 to 5 (where 1 corresponds to total agreement, 3 to neutral, and 5 to total disagreement). There were 24 proposition pairs half of which were phrased in terms of "same" ("A" for Turkish "aynı" ("same")), and half in terms of "different" ("F" for Turkish "farklı" ("different")), e.g., A: "A bicycle that has its pedals removed is the same"; F: "A piece of paper bent over 3 times is different". After the presentation of all propositions, participants were then presented with the paradoxical Ship of Theseus narration in one of the STP conditions: in the high STP condition, the ship was renewed/reassembled over a short period of time (5 years) and at a neighboring port; in the low STP condition it was renewed/reassembled over a long period of time (50 years) and at a distant port. Participants were given unlimited time to respond on a 5-point Likert scale, where ratings of 1 and 2 were considered as strong and weak "Ship A" ratings, ratings of 3 as "undecided" and ratings of 4 and 5 as weak and strong "Ship B" ratings, respectively.

4.4 Results & Discussion

The obtained empirical findings are analyzed in section 4.4.1 "Behavioral Results" whereas the mathematical and computational models are explained in section 4.4.2 "Modeling Results". The main aim of this empirical work is to observe if different spatiotemporal proximity conditions have an impact on the paradoxical reasoning and final decisions of the participants.

4.4.1 Behavioral Results

The obtained responses to the Ship of Theseus question revealed a bimodal, V-like distribution (20 cases for ship A, 6 undecided cases, and 24 cases for ship B) for the paradox, as shown in Figure X. The M-shape indicates that few subjects would take a strong stance and respond with the value 1 for A or 5 for B, respectively, but rather take a weak stance (2 or 4). In the middle of the distribution were 6 undecided participants. This result shows that participants avoided strict positions but rather stayed in a flexible zone while reasoning about the paradox. If weak and strong answers are summated, responses for the two conditions (high STP versus low STP) were almost equally distributed and resulted in a V-like pattern, i.e., most participants decided for Ship A or Ship B and only few could not decide. In other words, there was no effect of condition, contrary to our hypothesis. This could be due to the relatively small difference in spatiotemporal proximity between the two conditions presented in the task, considering the general lifetime of a ship. There might have been significant difference if the scenarios were presented as 500 years (low STP condition) versus 1 year (high STP condition) but it has been also crucial to formulate the scenarios on realistic grounds. Furthermore, since the two conditions were tested between subjects, in the absence of any comparison of different spatiotemporal parameter settings, participants may not have had any reason to respond differently.

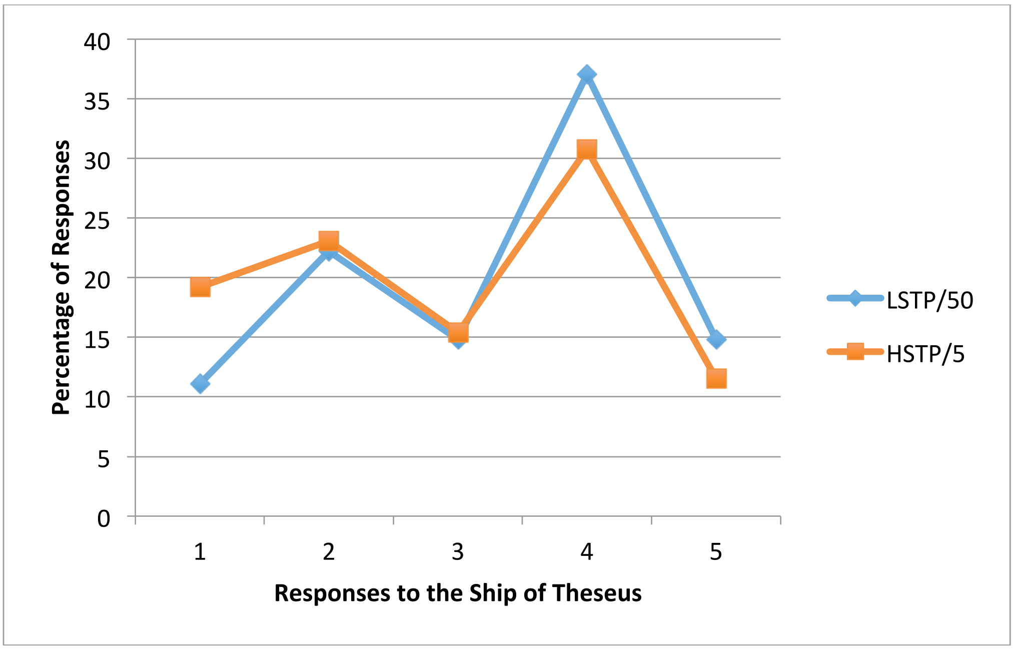


Figure 4.1 Percentage-based distributions of participants' responses to the paradoxical Ship of Theseus narration (Y-axis). Ratings of 1 and 2 were considered as strong and weak "Ship A" ratings, ratings of 3 as "undecided" and ratings of 4 and 5 as weak and strong "Ship B" ratings (X-axis).

The initial statistical analysis on the Conceptual Tendency Test revealed that 4 different propositions (P17F, P21A, P6F, and P2F) reached significance and 6 further propositions (P9F, P10A, P10F, P14F, P17A, P6A) reached a marginal level of significance ($p<.08$). These propositions can be assumed to represent the conceptual cores underlying the reasoning about the ship's identity. Among the significant propositions were P17F, stating that a robot that had been disassembled and reassembled was different now; P2F: that two birds with identical genetic and behavioral features were different; P6F: that a piece of paper bent over 3 times was different; and P21A: that a robot with memory problems after a memory chip transplantation was the same. The reassembly of robot case (P17F) might have been crucial because of its striking similarity to the paradoxical Ship of Theseus narration. It has been initially expected to observe a positive correlation between this proposition and the paradox, for Ship A respondents. P2F might have been important to specify two distinct singular living objects with identical features. This proposition taps the case of "twins": although genetically identical, they count as two distinct individuals, hence are considered different. "Essentialists", i.e. Ship B respondents tend to disagree with this proposition whereas they tend to agree with propositions P6F indicating that for them physical distortions may disrupt the identity of an object. As for P21A, Ship A respondents tend to agree that a robot with a memory chip transplantation is the same revealing that the preservation of the function, here: memory, was more important than any unobservable physical change inside the robot. Two birds with the identical genetic and behavioral features are different (P9F) have been one of the marginally significant propositions. A non-living object preserved for 1000 years is still the same (P10A) or different (P10F) have been other marginally significant propositions.

4.4.2 Modeling Results

SPSS (version 21) has been used for modeling of the empirical data via different methods including Discriminant Analysis (DA), Decision Tree (DT), and Neural Network (NN). The responses for the ship of Theseus have been collected on two levels: Ship A and Ship B responses. In other words, weak and strong judgments for each ship have been collapsed together.

4.4.2.1 Discriminant Analysis (DA)

As a first mathematical model, Discriminant analysis (DA) was used to classify the responses to the paradox relying on the responses to the CTT. In DA groups of participants are discriminated based on linear combinations of variables. The initial discriminant analysis was run with 2 variables for the response to the paradox (Ship A or Ship B). Strong and weak positions for Ship A (1 and 2) and for Ship B (4 and 5) were therefore collapsed and intermediate positions (3) were eliminated in order to meet the statistical assumptions (Box's M-Test). Wilks' lambda was significant for the single function that the DA had computed (V=0.443, $\chi^2(9)$=29.706, p=.002). The canonical correlation[4] that is a function of the eigenvalue was .746 for this function whereas the eigenvalue was 1.257. 88.6% of the originally grouped cases were correctly classified (see Table 4.2). 4 out of 7 (57.1%) misclassified responses stemmed from weak positions (2 or 4) that were obviously harder to classify than strong positions (1 and 5). The structure matrix shown in Table X demonstrates the within-groups correlations between discriminating variables (propositions) and standardized canonical discriminant functions. These propositions in Table X are ordered by the absolute size of correlation within function. It is remarkable that some of the propositions like P6 and P10 have correlation for both directions having similar value for absolute size. These are the items that are responded with symmetry. The structure matrix illustrates that P17F (a reassembled robot is not the same after total disassembly) and P10F (a non-living object preserved for 1000 years is not the same) as well as mildly P6F (a piece of paper bent over 3 times is not the same) are the propositions by which participants are modeled closer to ship B as they disagree to these. These propositions with positive and relatively higher loads show that ship B respondents tend to neglect the argument that the identity changes (being different) due to some mild level of physical distortions (as in P6F) and reassembly processes (as in P17F) as well as the preservation over time (as in P10F). Stated positively, they affirm that objects after such distortions are the same. On the other hand, Ship A respondents tend to disagree that a non-living object preserved for 1000 years is the same (P10A) that is probably due to having no function over the period of preservation. Ship A respondents also tend to disagree that a robot experiencing a memory chip exchange is still the same (P21A). Moreover, Ship A respondents tend to disagree that a piece of paper bent over 3 times is the same. Thus, it seems that undergoing some physical change that will probably distort the main function (i.e. to be written on for a piece of paper) might cause the functionalists to disagree with that proposition (P6A). Finally, Ship A respondents tend to disagree that a reassembled robot after total disassembly is the same (P17A). This response tendency might be due to the loss of function during the periods of disassembly and reassembly.

[4] The association between the set of of independent variables and discriminant score is measured by the canonical correlation coefficient.

Table 4.1 The structure matrix shows the coefficients of the discriminant function.

Structure Matrix

	Function
	1
P17F	.549
P10F	.429
P10A	-.404
P21A	-.373
P6A	-.352
P17A	-.277
P6F	.234
P12A	.125
P9F	-.100
P2F	-.081
P14F	-.044

Table 4.2 Classification Results show that 88.6 % of original grouped cases are correctly classified.

Classification Results		**Ship A or B**	**Predicted Group Membership**		**Total**
			A	**B**	
Original	**Count**	Ship A	18	2	20
		Ship B	3	21	24
	Percentage	Ship A	90.0	10.0	100.0
		Ship B	12.5	87.5	100.0

4.4.2.2 Decision Tree Analysis

As a second model, decision tree analysis was performed with the same data set (see Figure 4.2). The model is based on two core propositions, namely P10F (a non-living object preserved for 1000 years is different), P17F (a robot that is reassembled after its full disassembly is different) and P12A (three forms of water having the identical chemical formulas are the same) (all at significance level p=.001, p=.002 and p=.014, respectively, Bonferroni-adjusted), resulting in 84.1% predictive success (see Table 4.3). Note that these propositions were also significant in the previous DA. This decision tree consists of 5 nodes (3 of which are terminal nodes) and has the depth of 3. It is important to note that two of the propositions, P10F and P17F, are 'different' (F) statements. This finding also indicates that participants responded differently to the 'same' (A) versus 'different' (F) propositions. Interestingly enough, propositions with 'different' status were found to be more critical in predicting identity judgments. The comparison of the same versus different judgments was presented in Chapter 3 and will be presented in Chapter 7 and Chapter 8. Specifically, the

ERP signal difference with respect to the same versus different judgments will be compared and contrasted in Chapter 7 and the reaction time differences of these two judgments will be presented in Chapter 8 and Chapter 9. Figure 4.2 presented below illustrates the inner mechanism of the decision tree model. The Ship A respondents tend to disagree that a non-living object that is preserved for 1000 years would be different (P10F). Stated positively, they tend to believe that such an old object is the same. Moreover, almost all of the Ship A respondents (15 out of 16) disagreed that a disassembled robot is a different robot after total reassembly. The judgment of these participants is consistent with the basic assumption that as long as the robot is still functioning it is the same, however, Ship B respondents differed in their responses. For the third critical proposition (P12A), Ship B respondents generally agree that having the identical chemical formula allows us to accept that these three different forms of water molecules are the same, whereas the ship A respondents are much more divergent in their positions to this proposition (P12A).

Table 4.3 Classification success rates of the Decision Tree Model.

Observed	**Predicted**		
	Ship A	**Ship B**	**Percent Correct**
Ship A	13	7	65.0%
Ship B	0	24	100.0%
Overall Percentage	29.5%	70.5%	84.1%

Growing Method: CHAID Dependent Variable: Ship A or Ship B

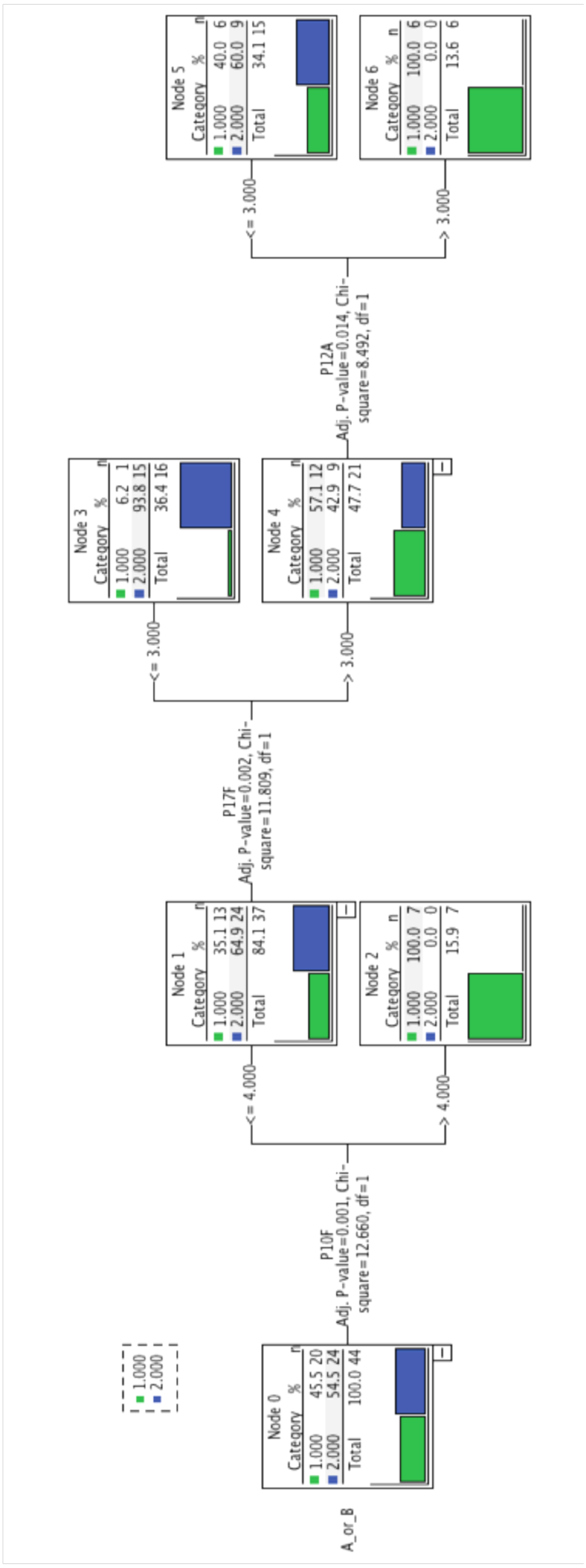


Figure 4.2 Decision tree diagram for predicting Ship A and Ship B responses.

4.4.2.3 Neural Network Analysis

As a third and last model the identity judgments were modeled with the neural network modeling technique (multilayer perceptron) relying on the same critical propositions of the CTT. 68.3% of the cases were used as training items and 31.7% as test items, as shown in Table 4.4. These items have been selected randomly. The model was run with two units in a single hidden layer and the activation function was hyperbolic tangent. Moreover, initial learning rate was set to 0.1 and lower boundary learning rate was set to 0.001. (Initial lambda: 0.0000005; Initial sigma: 0.00005; Interval offset: ±0.5). The obtained Neural Network Model classified test cases with 92.3% predictive success (see Table 4.7). The testing phase has ended with misclassification of only one case out of 13 cases. P17F (reassembled robot), P2F (new born monozygotic twins), and P6A (piece of paper bent over 3 times) have been the propositions with the greatest importance for the model, as Table 4.6 shows. Again, these are the same propositions that figured importantly in the two previous models.

Table 4.4 Case processing summary of the Neural Network Analysis (NNA)

		N	Percent
Sample	**Training**	28	68.3%
	Testing	13	31.7%
Valid		41	100.0%
Excluded		3	
Total		44	

Table 4.5 The model summary of the Neural Network Analysis (NNA)

Training	**Cross Entropy Error**	9.364
	Percent Incorrect Predictions	10.7%
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	0:00:00.01
Testing	**Cross Entropy Error**	3.641
	Percent Incorrect Predictions	7.7%

Dependent Variable: Ship A or Ship B
a. Error computations are based on the testing sample.

Table 4.6 Results of the Independent Variable Importance for the Neural Network Analysis (NNA)

Propositions	Importance	Normalized Importance
P17F	.138	100.0%
P21A	.079	57.1%
P6F	.074	53.7%
P2F	.128	92.8%
P9F	.061	44.6%
P10A	.097	70.5%
P10F	.108	78.7%
P14F	.092	66.5%
P17A	.099	71.9%
P6A	.124	89.7%

Table 4.7 The classification success rates for the Neural Network Analysis (NNA)

Classification

Sample	Observed	Predicted A	Predicted B	Predicted Percent Correct
Training	A	14	1	93.3%
	B	2	11	84.6%
	Overall Percent	57.1%	42.9%	89.3%
Testing	A	5	0	100.0%
	B	1	7	87.5%
	Overall Percent	46.2%	53.8%	92.3%

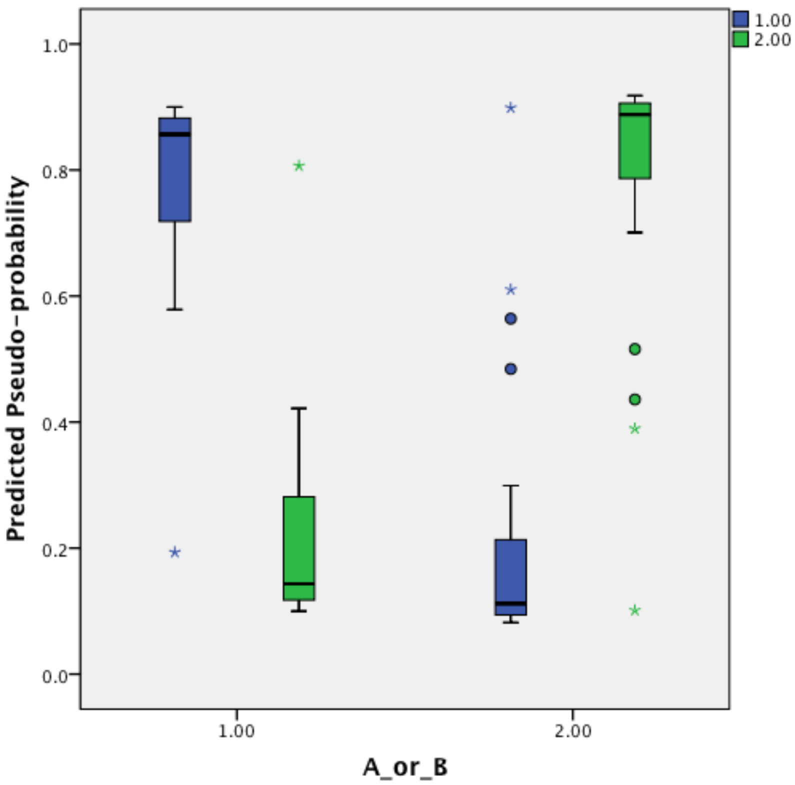


Figure 4.3 The predicted pseudo-probabilities generated by the neural network model performed with the STP data set (for 44 cases; undecided ones removed). 1 and blue stands for Ship A judgments and 2 as well as green stands for Ship B judgments.

4.5 Discussion

The analyses of the behavioral results indicate that the spatiotemporal difference presented at this level do not have any manipulative impact on the participants' decisions. There might be an effect when the spatiotemporal features are contrasted to a higher degree and this contrast is presented to the same participant. However, specifying a stronger contrast may render the narration unrealistic. The canonical response patterns for the paradox will be interpreted on the backdrop of other modes of presentations that will be discussed in the next two chapters. The empirical results of this textual condition yield an M-shape pattern for the 5-Likert scale responses to the paradox. Moreover, when strong and weak judgments are collapsed for Ship A and Ship B responses, there appears a V-shape pattern with high peaks for Ship A and Ship B responses and a trough in-between them for the few undecided responses. The modeling results revealed that the use of mathematical models like DA is beneficial in order to understand and explain the reasoning processes during paradox resolution as in the paradoxical Ship of Theseus narration – despite the fact that a computational model like the neural network model could provide an even better prediction of the same data set. On the other hand, the decision tree model might provide a much more practical account of the data set by being based only on 3 propositions. The present work demonstrates that the final judgments of the participants to the paradox could be predicted with a relatively high predictive success (>84%) solely relying on some critical propositions of a previously designed Conceptual Tendency Test (CTT). Participants tend to rely on a conceptual core about the target concept "sameness" which guides them through their reasoning process. Moreover, 'different' statements seem to play a more critical role in identity judgments when compared to 'same' statements. This finding suggests that these might be two distinct cognitive processes for *aynıdır* and *farklıdır* even though they appear to be highly similar kind of judgments. In conclusion, modeling is a worthwhile methodology in order to better understand higher cognitive processes such as reasoning about paradoxes.

CHAPTER 5

MODAL CONDITION I: BODILY EXPERIENCE WITH A WOODEN MODEL SHIP

Having bodily interaction and experience with the external world has been considered to be a part of the higher order cognitive processes including conceptual processing by grounded theories of cognition (Barsalou, 2008). In this respect, identity judgments can be seen as a form of conceptual processing by which people are faced with the vague concept "identity" during the given identity judgment task. The current study has focused on a known philosophical paradox, the Ship of Theseus that is thought to arise because of conceptual vagueness. In the experiment reported in this chapter, the participants were asked to respond to the Conceptual Tendency Test (CTT) and then to the paradox while demonstrating the disassembly and reassembly processes via two wooden model ships. It was initially hypothesized that the participants would tend to select Ship B over Ship A as the ship of Theseus because of its dominating physical similarity as well as both model ships having no explicit functional feature. However, previewing the results, the obtained empirical findings suggest that bodily interaction with the wooden model ship does not seem to cause a visible change regarding their final decision when compared to the textual condition that has been used as the baseline.

5.1 Introduction

Embodied and grounded theories of cognition have been increasingly influencing the mainstream theories of cognition with an emphasis on the role of the environment, bodily interaction and other modality-dependent features such as perception and emotion, possibly taking roles in higher-order cognitive processes. In other words, the recent theories of cognition claim that human cognitive processes are not executed within an amodal fashion but instead they benefit much from the modalities even in abstract forms of conceptual processing. For challenging the view that conceptual processing is achieved amodally, Barsalou and others performed experiments including conceptual tasks in which perceptual and motor variables have been shown to directly affect the task output (Barsalou et al., 2008).

Thus, Barsalou (2010) concludes that it is probable that conceptual processing is not done in an amodal fashion but instead is grounded in the modalities. In these respects, Barsalou (2003) also argues against the traditional distinction between semantic and episodic memory in which semantic memory has been hypothesized earlier as an abstract system of meaning units resulting from a transduction process. Barsalou (2003) has argued for a system in which the semantic system directly relies on the feeding from episodic memory instead of isolating these systems. The term "grounded cognition" has also been used for describing enactive and extended processes (also referred as extended mind/cognition) that are performed by the organism (cognitive agent) while being in direct interaction with the environment (Clark, 1999, 2008).

This interplay between the organism and the environment has been considered to be an integral part of the mental processes even for processes involving higher-order cognition like reasoning (Stewart et al., 2014). For our current identity judgments, the reasoning processes might be modulated by the agent's interplay with the environment in terms of bodily interaction, namely the physical manipulation with the wooden model ships. Moreover, it might also be the case that the decision-making processes of the participants are highly influenced by the features of other external factors in the environment, e.g., the color of the original and new ships.

The content and set-up of this experimental condition has been developed within the general scope of embodied/grounded theories of cognition specifically in relation to enacted and extended models of mind. It has initially been aimed at causing a behavioral change in Ship A and Ship B judgments, due to the concrete, bodily experience during the resolution of the paradoxical Ship of Theseus narration. For this bodily engagement/interaction, two wooden model ships have been designed and developed by an experienced carpenter. These two model ships have high similarity in their physical appearances. Each of them has been composed of 8 main parts as depicted in Figure 5.1.

5.2 Research Questions and Hypotheses

The research question has been formulated as follows: Is there an effect of bodily interaction with wooden model ships on the paradoxical reasoning processes (i.e. paradoxical Ship of Theseus narration)?

> *H_1:* Having some bodily interaction with the wooden model ship during the resolution of the paradox will have an influence on the participants towards selecting more often Ship B as the ship of Theseus.
>
> *H_2:* This grounded effect will end up with a deviation from the response pattern yielded in the baseline condition.

5.3 Experimental Design and Method

52 undergraduate and graduate students (24 female; age- range 19-28 years) participated in the experiments. Forty-eight propositions were prepared as image files and were randomly presented for 15 seconds on the computer screen by E-Prime 1.0 and E-Prime 2.0. Participants were initially asked to rate the set of propositions referred to as the CTT that are directly related to the core concept involved in the paradox. Participants responded on a scale from 1 to 5 (where 1 corresponds to total agreement, 3 to neutral, and 5 to total disagreement). There were 24 proposition pairs half of which were phrased in terms of "same" ("A" for Turkish "aynı" ("same")), and half in terms of "different" ("F" for Turkish "farklı" ("different")), e.g., A: "A bicycle that has its pedals removed is the same"; F: "A piece of paper bent over 3 times is different". Each proposition was presented for 15 seconds. After the presentation of all of the 48 propositions, participants were then presented with the paradoxical Ship of Theseus narration with the wooden model ship that was used for simulation of the disassembly and reassembly process. One of the ships has been varnished in order to give it a newer outlook compared to the other ship. The old-looking ship has been introduced to the participants as the ship of Theseus in the paradox. The participants have initially been informed that these wooden materials are provided for simulation purposes to help to understand the written text. In other words, it has clearly been stated that these model ships should not be the basis of their identity judgments. The participants have been asked to follow and demonstrate the disassembly and reassembly processes by using these wooden model ships while they were reading the paradox, step by step. They have been provided sufficient help while trying to construct the wooden ships. Participants were given unlimited time to do the simulation while reading the text and then to respond on a 5-point Likert scale, where ratings of 1 and 2 were considered as strong and weak "Ship A" ratings, ratings of 3 as "undecided" and ratings of 4 and 5 as weak and strong "Ship B" ratings.

Figure 5.1 Images illustrate the wooden model ship used during the experiments. Participants were asked to demonstrate the disassembly and reassembly processes over these parts. (a) The wooden parts are shown in this figure (upper left). (b) An instance for one of the wooden model ships has been illustrated that is shown without its sails (upper right). The wooden parts after full disassembly stage have been demonstrated in this figure (bottom).

5.4 Results and Discussion

The participants responded to the paradoxical Ship of Theseus narration resulting in the M-shaped response pattern (see Table 5.1 and Figure 5.2). An M-shape resulted when all 5 positions of the Likert-scale were used; a V-shape resulted when the strong and weak positions of each ship, A and B, were collapsed. It has initially been expected that there would be an effect of the condition that would result with a possibly significant shift towards Ship B. To be more specific, people were expected to have a tendency to select Ship B as the ship of Theseus, since each of them would have a high level of bodily interaction and engagement while resolving the paradox. Moreover, the fact that there was no visible functionality of the ships but the aspect of compositional and material identity (that is the case for Ship B) was expected to influence the participants during their decision-making process. The responses for the Ship of Theseus question have been provided in the Figure below.

Table 5.1 Distribution of participants' responses to the identity question, according to the 5 (3)-point Likert scale

Likert scale	*N(all)*	*N (Sum Ship A+B)*
1 (strongly agree to Ship A)	7	23
2 (weakly agree to Ship A)	16	
3 (indeterminate)	6	6
4 (weakly agree to Ship B)	14	
5 (strongly agree to Ship B)	8	22
Total	51	51

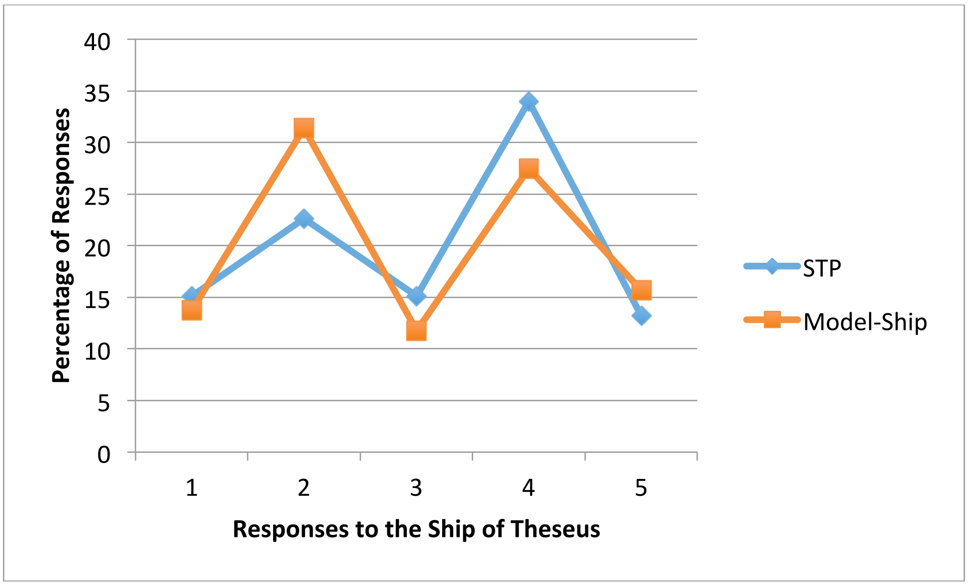


Figure 5.2 The distribution of the responses to the paradoxical Ship of Theseus narration for Model Ship (MS) and Spatiotemporal Proximity (STP) conditions. Ratings of 1 and 2 were considered as strong and weak "Ship A" ratings, ratings of 3 as "undecided" and ratings of 4 and 5 as weak and strong "Ship B" ratings.

The results of the embodied condition were then compared with those of the baseline, STP condition. The statistical analyses of obtained results clearly show that there is no effect of condition in either direction when compared to the baseline conditions according to the results of an independent-samples Mann-Whitney *U* test. As the following graph demonstrates, there is a clear M-shape as in the results of baseline condition. Moreover, there was also no significant difference due to the results of Pearson chi-square test performed ($\chi^2(4)=1.453$; $n=167$ $p>.835$). These results indicate that these conditions do not significantly diverge from each other in the final judgments of the participants despite the fact that these M-shapes seem to have a slightly different pattern regarding the weak responses for Ship A versus Ship B. Thus, these results clearly illustrate that H_1 and H_2 are rejected.

These results indicate that it is unlikely that the participants have been influenced by the bodily experience with the model ships specifically introduced for this condition. For this experimental condition, the main emphasis has been on the introduction of a wooden model ship during the resolution of the given paradox. By allowing bodily interaction and simulating the assembly processes by handling these model ships, it was assumed that the participants tended to select Ship B as the ship of Theseus. There have been two main reasons for this assumption. First of all, the initially presented ship and Ship B had the same physical appearance. There is possibly no effect of the time passed (the duration for disassembly process was narrated as 25 years and at a close port that was set as the baseline condition). Secondly, during the assembly process of the model ships, there was no visible functionality of the ship A and the functionality has been the main issue for the participants to select the ship A. However, almost the same percentage of participants selected Ship A that was in contrast to what was expected in the first hypothesis (thus, H_1 was rejected). The statistical analyses performed for comparing the textual condition and modal condition with wooden ships demonstrated that there is no significant difference between the conditions. In other words, the expected deviation with the wooden model ships when compared to the baseline condition did not take place. Thus, the second hypothesis was also rejected.

To sum up, the bodily experience with wooden model ship condition has been developed as a multi-modal condition including bodily, in particular, motor experience that would support simulation processes, as postulated by embodied/grounded cognition theories. It was initially hypothesized that having some bodily, sensuous interaction with the artifacts might possibly have an influence on participants' reasoning processes. Despite the fact that Barsalou (2010) has conceded that some higher-order cognitive processes might be performed at an amodal and symbolic level as, for example, in syllogistic reasoning, the identity judgments could be evaluated differently from such symbolic processes, since this type of reasoning process might not be based only on a solid formal ground. However, as our results suggest, it might be the case that also this type of reasoning processes, namely paradox resolution, is based more on conceptual processing and thus the participants could be influenced by the conception of the target, here identity, and not so much by the concrete handling of the two model ships.

CHAPTER 6

MODAL CONDITION I: VISUAL DEMONSTRATION VIA EYE-TRACKING

Eye movements have been used as an important and reliable indicator of online reasoning and decision-making processes. Given a task, people tend to attend more to one of the options among the others or a specific area within the provided context (Glöckner & Herbold, 2010). In the present study, eye-tracking methodology has been used in order to understand the online processing of participants in the context of their decisions in a paradoxical reasoning task known as "Ship of Theseus". In this classical paradox, participants have to decide whether Ship A (whose original parts have been fully exchanged with novel parts over time) or Ship B (which has been re-assembled from its original parts) is the Ship of Theseus. Prior to the paradoxical question the entire story line has been demonstrated in a visual slide show. On the last slide, both Ships A and B are depicted side by side and below them a text asks for participants' final decision on a 5-point Likert Scale, allowing for graded responses (1+2: Ship; 3: undecided; 4+5: Ship B). Participants' eye-movements were monitored *via* an eye-tracking device during the display of this last slide. Three areas of interest (AOI) were defined: Ship A, Ship B, and text. Results from 43 participants show that final decisions as well as strong vs. weak decisions for Ship A or Ship B could be dissociated depending on the Fixation Durations and Visit Durations for the specific AOIs. While all participants tended to focus mostly on the textual area, weak respondents did so more reliably than strong respondents, who focused relatively longer on the pictures of the ships. Thus, eye-tracking patterns might be successfully used as a supportive tool in understanding online conceptual reasoning and decision processes.

6.1 Introduction

Human cognitive processes have been investigated using many different techniques. In particular, eye-tracking patterns has become highly appreciated for its ability to track participants' behavior online. Measures from eye-tracking devices have been correlated with different cognitive processes and have been demonstrated to provide fruitful insights into the online processing when combined with data acquired by conventional off-line methods (Yoon & Narayan, 2004). For instance, fixation duration has been found to be a reliable indicator of information processing (Pomplun, Ritter, & Velichkovsky, 1996; Rayner, 1998). Moreover, visit durations have been found to be an indicator of a general interest in a given AOI when compared to others. Yet, understanding eye-tracking patterns might also be considered as a useful tool for studying higher cognitive processes such as reasoning and decision-making. In a series of experiments Ball et al. (2006) provided insight into the online processes during resolution of deductive syllogisms *via* eye-tracking methodology, beyond other empirical data from behavioral tasks. In reasoning tasks, especially when participants are faced with ill-posed or paradoxical problems, participants' response times might differ depending on the nature of the task and the given context (Rips et al., 2006). Thus, relying solely on response time may not be a sufficient measure for the online process itself.

On the other hand, theories of grounded cognition have presented robust empirical evidence against the widely accepted "sandwich" model of earlier theories of cognition. The sandwich model explains cognition as processes sandwiched between perception and action (Hurley, 2001). Additionally, since cognitive processes have assumed to be relatively modular, they were mostly studied without taking perception and action into account (Barsalou, 2010). However, the grounded cognition perspective clearly rejects this view of the sandwich model and its proponents argue that cognition could only be fully understood with covering the other domains including perceptual and motor processes (Aydede & Robins, 2009; Clark, 2008). Proponents of grounded cognition perspective argue that cognition is highly dependent on these modalities. A typical example is that mentally simulating the color of a non-present object the visual system of color simulation is functionalized by the cognitive system (Simmons et al., 2007). Moreover, it has been found out that people are highly susceptible to the mode of presentation that has extensive applications including psychology, marketing and economics. In other words, decision-making processes could be influenced by perceptual stimuli within this grounded cognition framework.

This work aims to understand how participants reason during the resolution of a given paradox, namely, the Ship of Theseus. In the present experiment, participants follow a visual slide show of the story line, presented on a computer monitor in front of them as shown in Figure 6.1 below. The other presented materials for the visual demo are included in the Appendix C. One of the purposes of this condition is to present a modular setting with this visual demo that will possibly influence the reasoning processes as well as the final decision of the participants. The slides contain the text about the paradox, the visual demo showing the disassembly and reassembly processes of the original ship over a total of 36 slides, within 36 seconds, and finally the paradoxical question which ship was the Ship of Theseus: Ship A or Ship B? Participants were asked to respond on a 5-point Likert scale from 1 (strongly agree that it is Ship A) to 5 (strongly agree that it is Ship B). There are also weak agreement positions (2 and 4) as well as an indeterminate, undecided position (3). Participants' eye-movements on that last slide were recorded *via* an eye-tracking device (Tobii X-2 60 Mobile Eye-Tracker).

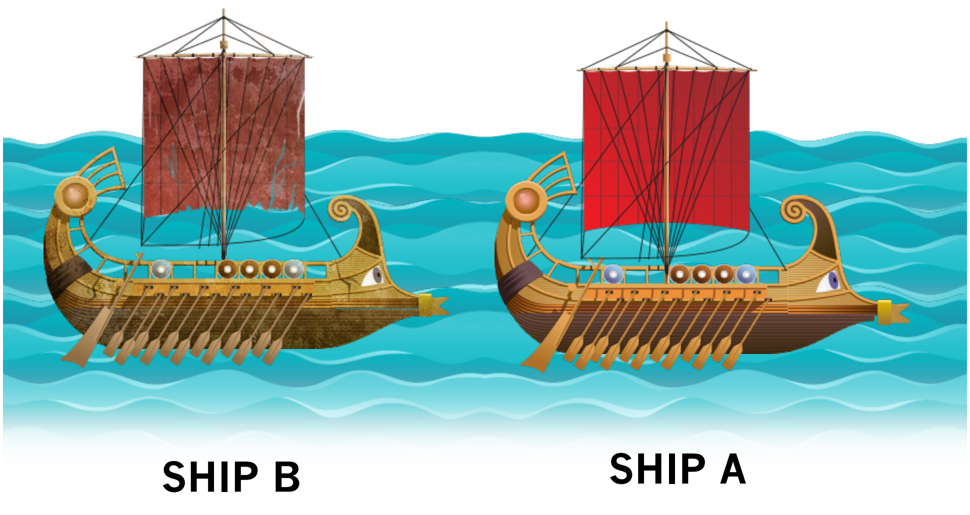


Figure 6.1 The visual images of Ship A and Ship B as illustrated during the experiments.

6.2 Research Questions and Hypotheses

For this study, the following hypotheses have been formulated initially:

H_1: Participants' eye gazes during the identity judgment for SOT while watching the static visual demonstrations of the ships will differ significantly depending on their final response. They will tend to look more to the later selected ship rather than to the other ship.

H_2: Participants with weaker positions (tendency to agree with Ship A or Ship B as opposed to strong agreement) will have higher levels of fixation duration, fixation counts, visit duration and visit counts, as compared to participants with stronger positions (disregarding intermediate positions).

H_3: Participants with weaker positions will have higher response times (regarding the duration between the onset of the question and the response) as compared to participants with strong positions.

6.3 Experimental Design and Method

43 undergraduate and graduate students (22 females; age-range 19-30 years) from METU were admitted to the experiment. Participants first completed a Conceptual Tendency Test (CTT) which is a questionnaire tapping the core concepts related to the paradox, namely "sameness/identity". Responses of this questionnaire have been used as a predictor of participants' decision for the paradox. After the presentation of the CTT, participants were presented with the visual demonstration of the paradoxical Ship of Theseus narration, as described above. At the end of the visual demo, participants were asked the identity question on a slide that also contained visual images of the two ships (Ship A and Ship B; see Figure 6.1). They were given unlimited time to respond on a 5-Likert scale, where ratings of 1 and 2 were considered as (strong and weak) "Ship A" responses, ratings of 3 as "undecided" ones, and ratings of 4 and 5 as (weak and strong) "Ship B" responses.

6.4 Results

We counted how many of the n = 43 participants responded to the identity question "Which ship is the Ship of Theseus: Ship A or Ship B?" in which of the five categories of the Likert-scale (Table 1). As can be seen, more responses are given to Ship A (11 strong, 13 weak) as compared to Ship B (5 strong, 8 weak). Only a small number of subjects (5) are "undecided" (please see Table 1).

Table 6.1 Distribution of participants' responses to the identity question, according to the 5-point Likert scale

Likert scale	*N(all)*	*N (Sum Ship A+B)*
1 (strongly agree to Ship A)	11	24
2 (weakly agree to Ship A)	13	
3 (indeterminate)	5	5
4 (weakly agree to Ship B)	8	
5 (strongly agree to Ship B)	5	13
Total	43	43

In Table 1, please note that 1+2 responses count as "Ship A" responses and 4+5 responses as Ship B responses. *N(all)*: count over entire sample, according to weak and strong judgments, including intermediate responses; *N(Sum Ship A+B)*: summing over weak and strong responses while omitting indeterminate responses. This distribution suggests that overall, participants seem to prefer to conceive of Ship A, all of whose original parts had been renewed over time, as the Ship of Theseus, rather than of Ship B, which was reassembled from the old original parts. These results stand in contrast with other findings of ours using other presentation modalities. If the paradox is presented in written form, as narration, the distribution of answers shows a more symmetric "M"-shape, i.e., few participants give strong judgments for either ship, but more weak judgments. The number of "undecided" responses is generally low.

6.4.1 Response to Ship of Theseus

The final decisions of the participants for the paradoxical Ship of Theseus narration have sso far resulted in an M-shaped pattern as shown in the previous chapters 4 and 5. This M-shaped pattern has been suggested as the expected pattern for the Ship of Theseus responses. However, the visual demonstration condition presented in this chapter resulted in some deviation from this expected pattern with a shift towards Ship A.

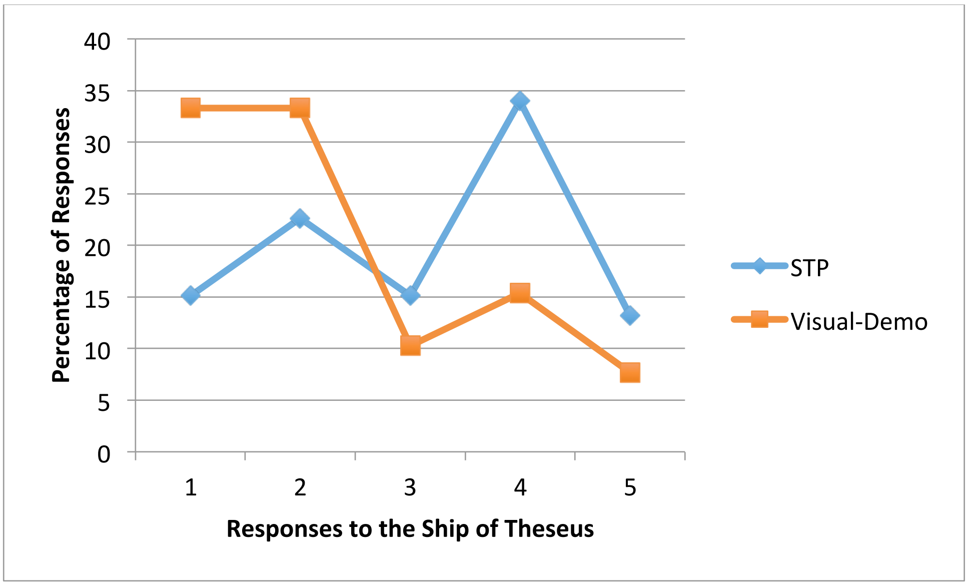


Figure 6.2 The percentage-wise patterns of the responses to the paradox are demonstrated above. VD is used for visual demo condition (orange line); STP for spatiotemporal proximity condition (blue line).

This observed shift towards ship A has been found to cause a statistically significant difference in overall response pattern relying on the results of an independent samples Mann-Whitney *U* test when compared to the baseline condition (STP). Moreover, the follow-up test for finding the homogenous subsets based on rating classifies the other conditions as homogenous subsets but the response pattern from visual demo condition significantly diverges from this pattern. This finding indicates that some of the participants were most probably influenced by the presentation of a visual demo of the disassembly and reassembly processes as well as the decision screen that might have caused a bias towards Ship A. As in the wooden model ship condition (chapter 5), participants were informed about the illustrative purposes of the visual demo and that they were required to respond according to the narration.

6.4.2 Heat Map for Decision Screen

As concerns the eye-tracking analysis, three AOIs were defined: "Ship A", "Ship B", and "text". Figure 1 shows these AOIs along with a heat map based on the absolute fixation durations in these AOIS, for all participants.

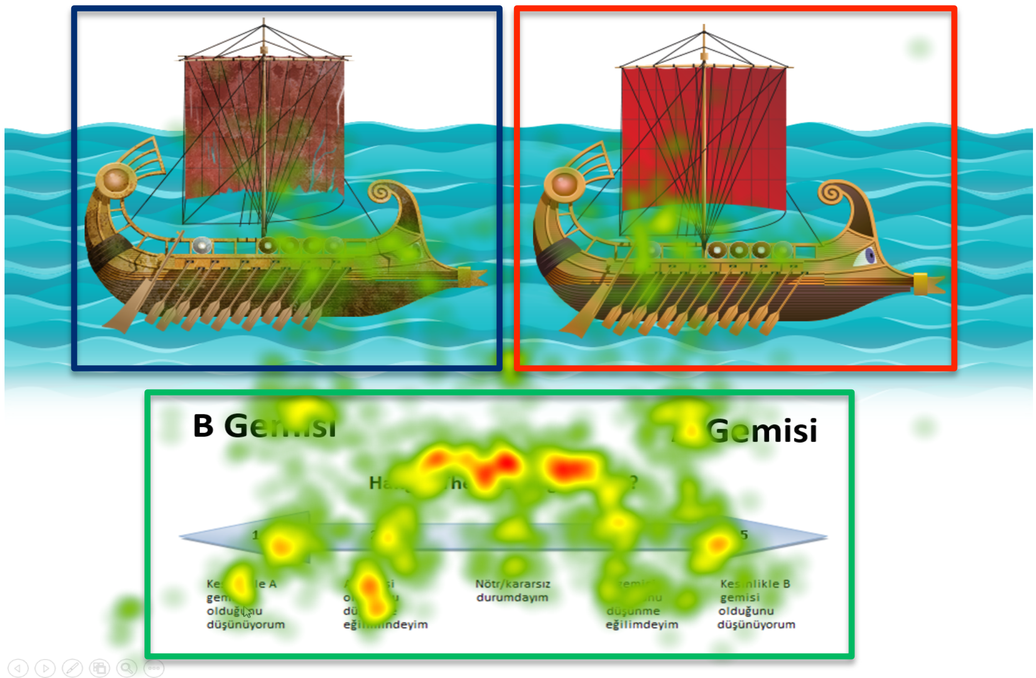


Figure 6.3 AOIs for "Ship A" (red frame, right), "Ship B" (blue frame, left), and "text" (green frame, bottom) as well as heat map of eye gazes for the identity judgments.

The heat map presented above visually indicates that participants focused more on the text, comprising the question and the rating scale rather than on the visual images of the ships. Participants seem to look more at Ship A that is the ship on the right hand side of the slide than at Ship B. The responses for the identity judgments were grouped into two categories that were used as "quasi-independent" variables in the following statistical analyses. The first category is ship preference: "1+2" answers were considered as "Ship A" and "4+5" answers as "Ship B". The indeterminate position "3" was not included in the statistical analyses, however. The second category is judgment strength: "1+5" answers were considered as "strong" ('S') and "2+4" answers as weak ('W'). Since there was no response time limit, the response times of the participants differed widely from 9.8 to 52.59 seconds. The statistical analyses for the reaction times have illustrated that there are no significant differences between weak and strong judgments as well as ship A and ship B judgments.

6.4.3 Fixation Duration

A 3x2x2 Mixed ANOVA was run with AOI (text, Ship A, Ship B) as within-subject variable and identity judgment (Ship A, Ship B) and judgment strength (W, S) as (quasi-independent) between-subject variables for raw average fixation durations. There was a main effect of AOI ($F(2,38)=4.124$, $p<.02$, $\eta_p^2 = .176$). Subsequent tests of within-subjects contrasts (Helmert) showed that the first contrast (text vs. Ship A+B) was significantly higher for the Ship B respondents than the Ship A respondents ($F(1,34) = 7.974$, $p<0.008$, $\eta_p^2 = .190$). Participants' fixation durations were significantly longer when they looked at the text area (M=0.282, SE=0.017) as compared to Ship A (M=0.226, SE=0.013) and Ship B (M=0.234, SE=0.234) areas. The second contrast (Ship A vs. Ship B) was not significant. This result may be due to the different way in which information is processed while reading the text vs. looking at the pictures of the ships. Fixations may be longer in the text area because information is integrated serially for a given certain duration whereas fixations may be shorter in the figure areas because participants may not actually explore the figures of the ships in much detail but just glance at them quickly, in addition to studying the text. Furthermore, there was a significant interaction between identity judgment x judgment strength (F(1,34)=14.170, p<.001, η_p^2 = .294). Participants who voted strongly for Ship A fixated longer on average (M=0.267, SE=0.014) as compared to participants who voted only weakly for Ship A (M=0.234, SE=0.014); however, participants who voted strongly for Ship B tended to fixate shorter on average (M=0.206, SE=0.021) as compared to participants who voted weakly for Ship B (M=0.283, SE=0.015). Weak respondents to Ship B had the longest fixation durations. Since longer fixations had been found for the text area, this result may reflect the fact that these participants relied more on the text in particular. Overall, the results of the raw fixation durations provide some insight into the different information processing between text and pictures and the reliance of strong and weak respondents on textual vs. pictorial information; however, not into the processing of the specific pictures of Ship A and Ship B.

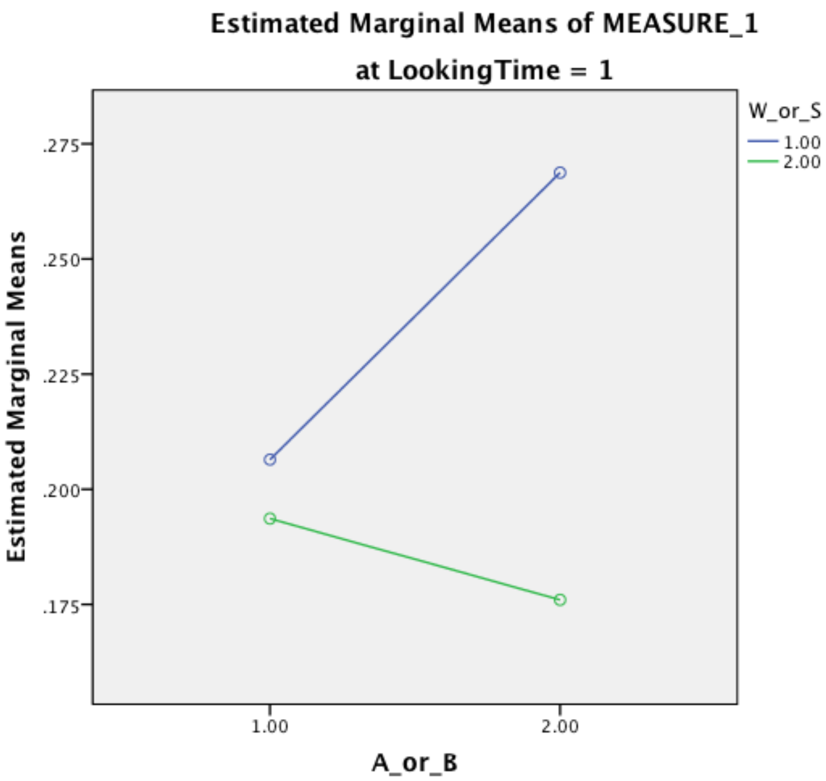


Figure 6.4 The figures below illustrate the average fixation durations among the AOIs during the presentation of the decision screen for the text AOI. The ones with 1 indicator are for the Ship A respondents and 2 for Ship B respondents. Moreover, the blue lines are for weak judgments (either 2 or 4) and green ones for strong judgments (1 or 5).

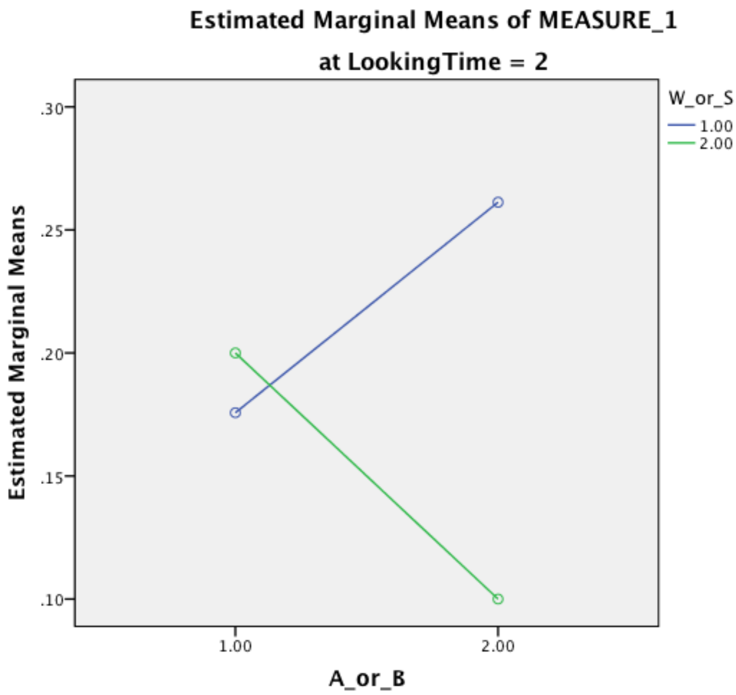


Figure 6.5 The figures below illustrate the average fixation durations among the AOIs during the presentation of the decision screen for the ship A AOI. The ones with 1 indicator are for the Ship A respondents and 2 for Ship B respondents. Moreover, the blue lines are for weak judgments (either 2 or 4) and green ones for strong judgments (1 or 5).

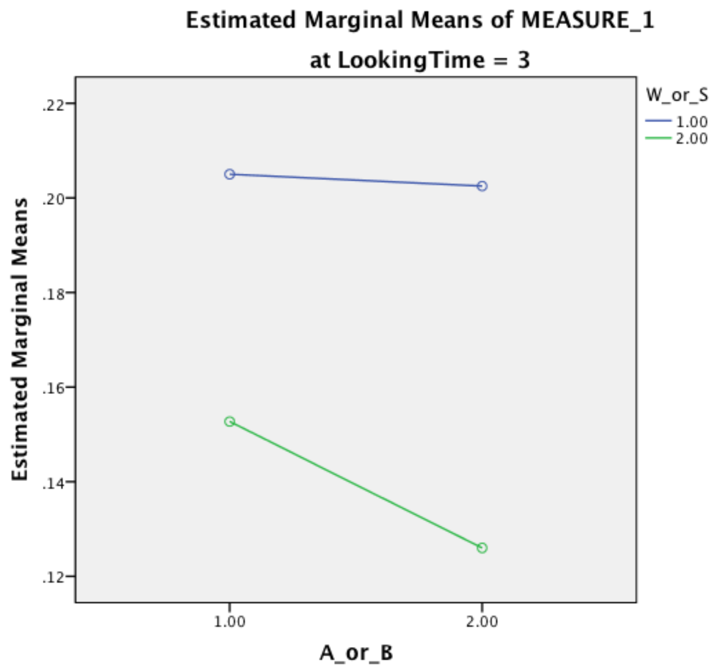


Figure 6.6 The figures below illustrate the average fixation durations among the AIOs during the presentation of the decision screen for the ship B AOI. The ones with 1 indicator are for the Ship A respondents and 2 for Ship B respondents. Moreover, the blue lines are for weak judgments (either 2 or 4) and green ones for strong judgments (1 or 5).

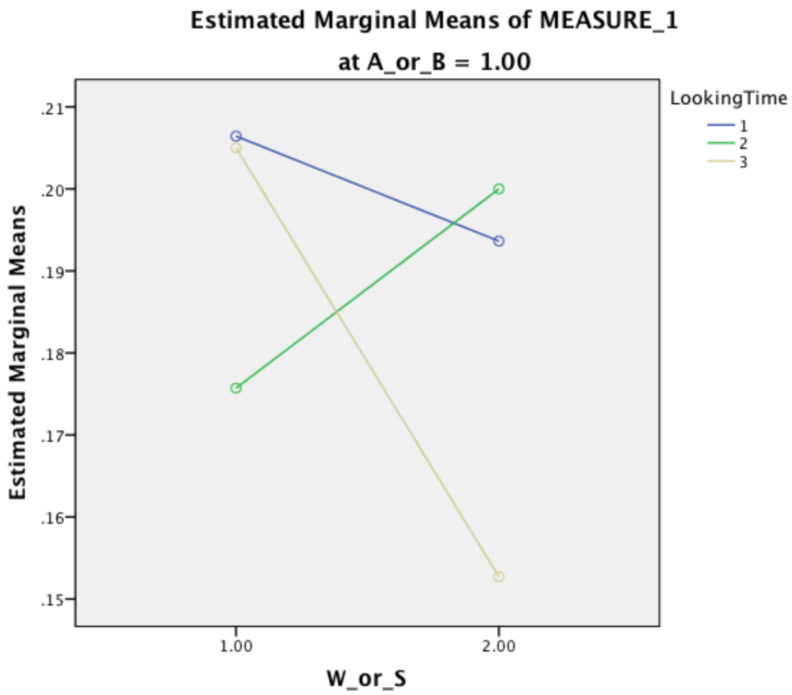


Figure 6.7 The figures below illustrate the average fixation durations among the AOIs during the presentation of the decision screen for the Ship A respondents. The lines with blue (1) indicator are for text, green (2) for ship A and yellow (3) for ship B (as different AOIs). The x-axes of the figures represent two different cases: 1 for weak judgments and 2 for strong judgments for the paradoxical Ship of Theseus narration.

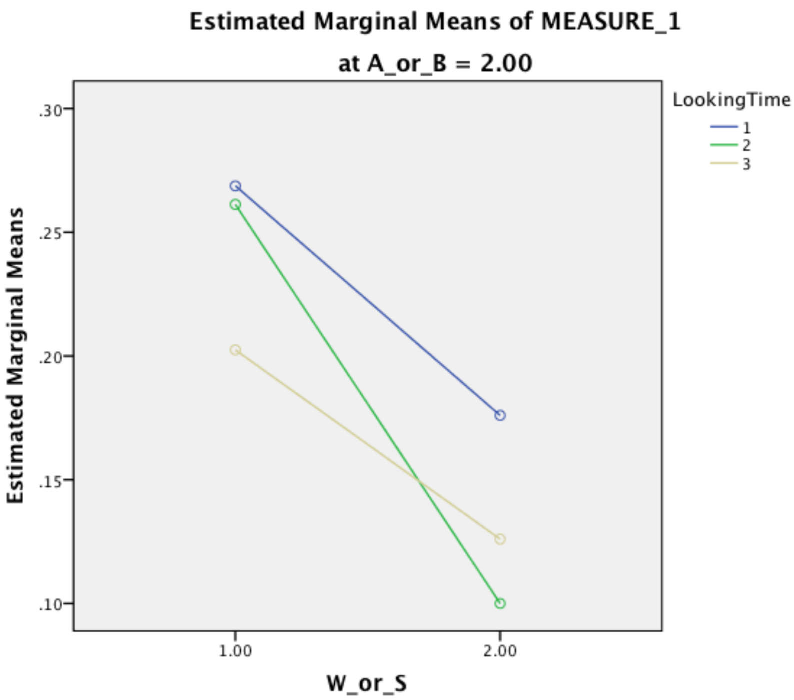


Figure 6.8 The figures below illustrate the average fixation durations among the AOIs during the presentation of the decision screen for the Ship B respondents. The lines with blue (1) indicator are for text, green (2) for ship A and yellow (3) for ship B (as different AOIs). The x-axes of the figures represent two different cases: 1 for weak judgments and 2 for strong judgments for the paradoxical Ship of Theseus narration.

6.4.4 Visit Duration

A 3x2x2 Mixed ANOVA was run with AOI (text, Ship A, Ship B) as within-subject variable and identity judgment (Ship A, Ship B) and judgment strength (W, S) as (quasi-independent) between-subject variables for raw average visit durations. There was a main effect of AOI ($F(2,68)=87.634$, $p<.000$, $\eta_p^2 = .720$). There is also an interaction effect for AOI * A_or_B ($F(2,68)=7.467$, $p<.001$, $\eta_p^2 = .180$). Subsequent tests of within-subjects contrasts (Helmert) showed that the first contrast (text vs. Ship A+B) was significant ($F(1, 34) = 92.602$, $p<0.000$, $\eta_p^2 = .731$). Participants visited the text area significantly longer on average (M=4.560, SE=0.556) as compared to Ship A (M=3.917, SE=0.557) and Ship B (M=3.363, SE=0.543). This result indicates that overall, participants visited longer on average the text area, as compared to the ship areas. The second contrast (Ship A vs. Ship B) was also significant ($F(1, 34) = 7.467$, $p<0.001$, $\eta_p^2 = .180$). The Ship A respondents had a higher visit duration on the visual images when compared to Ship B respondents. Strong ship B respondents tended to visit the Ship A image significantly more than the Ship B image. This interaction is similar to the one reported above on the average fixation durations. Participants, in particular strong respondents, tend to visit the textual area more often and then fixate on this area longer as compared to the two ship areas.

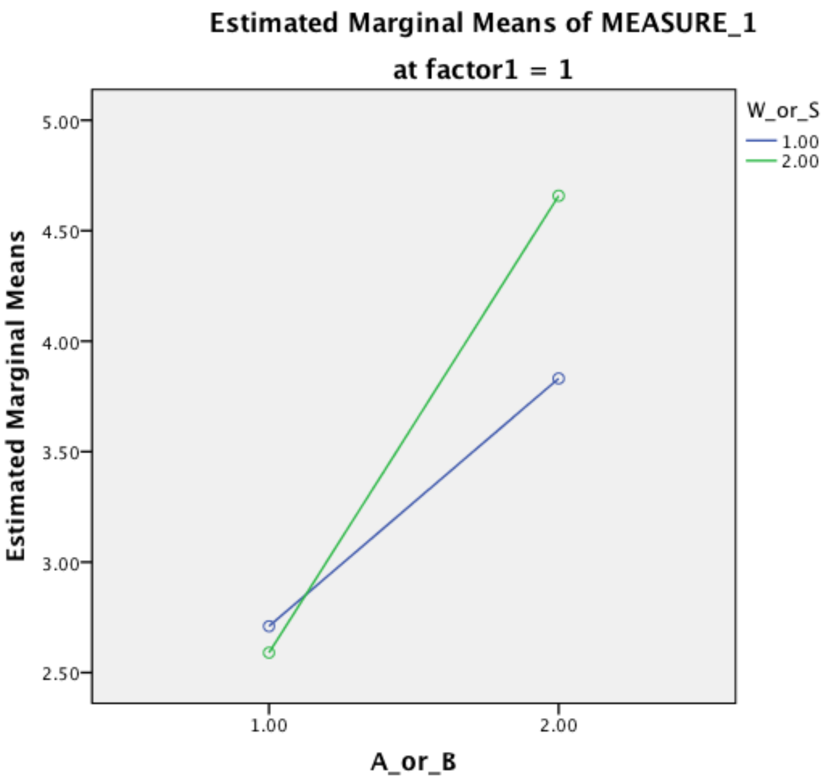


Figure 6.9 The figures below illustrate the average visit durations among the AOIs during the presentation of the decision screen for the text AOI. The ones with 1 indicator are for the Ship A respondents and 2 for ship B respondents. Moreover, the blue lines are for weak judgments (either 2 or 4) and green ones for strong judgments (1 or 5).

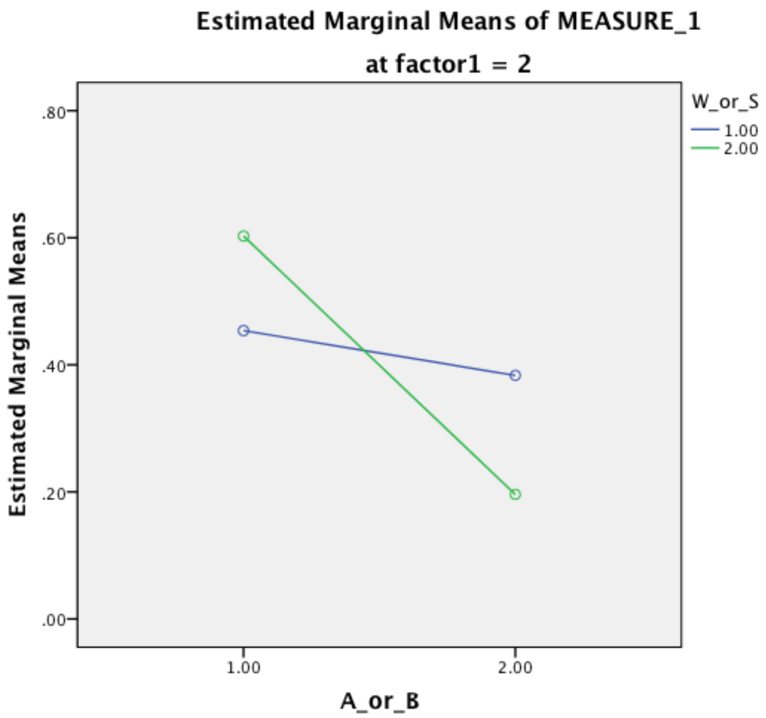


Figure 6.10 The figures below illustrate the average visit durations among the AIOs during the presentation of the decision screen for the ship A AOI. The ones with 1 indicator are for the ship A respondents and 2 for ship B respondents. Moreover, the blue lines are for weak judgments (either 2 or 4) and green ones for strong judgments (1 or 5).

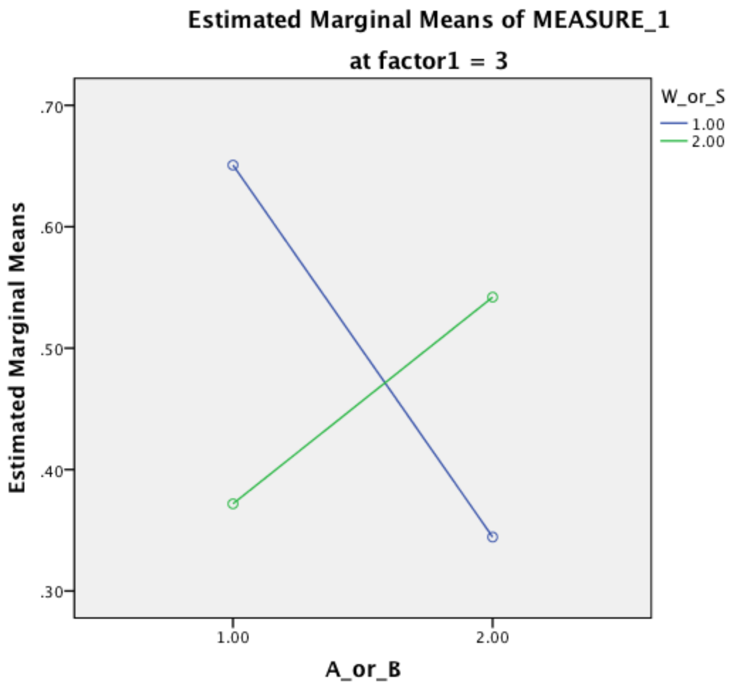


Figure 6.11 The figures below illustrate the average visit durations among the AIOs during the presentation of the decision screen for the ship B AOI. The ones with 1 indicator are for the ship A respondents and 2 for ship B respondents. Moreover, the blue lines are for weak judgments (either 2 or 4) and green ones for strong judgments (1 or 5).

6.5 Discussion

This eye-tracking study has focused on the online processing of a paradox in the philosophy literature, the Ship of Theseus. After seeing a visual slide show depicting the disassembly and reassembly process of the original ship into a new Ship A and an old Ship B, participants were asked to make an identity judgment on a 5-point Likert scale. This approach is novel in two respects: (1) It presents the classical paradox in the visual modality and (2) it uses online eye-tracking methodology in order to reveal underlying perceptual processes involved in conceptual reasoning processes. The obtained results shed light on these reasoning processes especially in terms of dissociating different perceptual patterns of participants with weak and strong judgments. In particular visit durations of the various AOIs (text, Ship A, Ship B) seem to provide insightful information concerning the difference in participants' judgment strength, regardless of their final decision for Ship A or Ship B. Participants with weak judgments have been observed to prefer visiting the text area more often as compared to participants with strong judgments. In other words, strong respondents tend to focus less on the textual but relatively more on the pictorial information, as compared to weak respondents. Thus, our H_2 was confirmed, as concerns visit counts; however, not as concerns other eye-tracking measures. On the other hand, raw average fixation durations provide some insight into the different perceptual processes involved in textual vs. pictorial information processing, in general. Fixation durations tend to be longer if participants process textual information as compared to pictorial information. Furthermore, this influence was qualified by the participants' decisions for Ship A and Ship B. In particular weak Ship B respondents tended to have higher fixation durations than all other participants, hinting at their greater reliance on textual information. However, it should also be noted that none of the other eye-tracking measures, such as average and total visit durations revealed any significant effects, neither on raw nor on normalized data. This means that in general the time spent on the critical slide ("response time") is not affected by participants' strength of identity judgments, weak or strong judgments. Thus, our H_3 was not confirmed. This null result must be treated with caution, however, it may shed some doubt on the general idea that perceptual online measures such as eye-tracking measures may be tightly related and thus directly reflect underlying conceptual processes. Obviously, participants who finally chose Ship A or Ship B did not necessarily look longer to Ship A or Ship B, respectively, as has initially been hypothesized with the first hypothesis, H_1. Rather, all of them studied the identity question and the response scale on the slide most intensely. This may hint at the fact that for decisions concerning a conceptual judgment verbal reasoning processes may be more dominant– despite the fact that our visual demonstration invited participants to base their judgments on perceptual grounds more than in the classical textual version of the paradox. Yet, modality may affect participants' conceptual reasoning and decision processes, as the comparison of the two modalities (text only vs. visual demo) suggest. In the classical textual modality (STP condition), participants tended to select Ship A and Ship B equally frequently, however, they gave more often weak judgments. In the visual modality, as reported here, participants tended to select Ship A more often than Ship B and their judgments tended to become stronger. This empirical finding can be explained with respect to the main claims of grounded cognition framework that assumes the cognitive processes are highly susceptible to perceptual processes and mode of presentation possibly during reasoning. These and further questions will be followed up in the general discussion part.

CHAPTER 7

NEUROPHYSIOLOGICAL ASSESSMENTS I: EEG/ERP EXPERIMENTS

Event-related potentials (ERPs) have long been shown to be possible indicators of different human cognitive processes taking active roles in linguistic processing such as semantic violations, world-knowledge violations, and syntactic violations, however, they are not restricted to linguistic processing (Kutas & Federmeier, 2011). This empirical study has initially been aimed at understanding the cognitive and linguistic processing of identity judgments. One of the research questions is whether it is possible to demonstrate the online processing of identity judgments via EEG/ERP method. The initial research question has been formulated as to compare two experimental conditions: propositions using "same" (*aynıdır*) and "different" (*farklıdır*). It was initially hypothesized that there will be a significant difference with respect to the event-related potentials at around 400 milliseconds relying on the behavioral differences observed in the experiments (specifically response time differences). The obtained ERP results show that there is N400 neural patterns for the *farklıdır* condition when compared to the *aynıdır* condition, indicating that participants indeed behave differently to these two categories of propositions. There are several possible cognitive and linguistic implications of these finding to be further discussed in chapter 9.

7.1 Introduction

Cognitive processes have already been studied extensively via various brain imaging methods in order to discover relevant biomarkers for understanding the processing of mental events (Bermudez, 2014). Several paradigms about the cognitive mechanisms related to linguistic as well as non-linguistic processing have been developed through those empirical studies. One major research field has been related to linguistic processing with EEG/ERP methodology (Frederici, 2011; Frederici & Singer, 2015). Language could simply be accepted as a cognitive tool used for exchanging information about the world. Online language comprehension involves the derivation of a phrase or a sentence as well as retrieval of the necessary words from the mental lexicon. The obtained findings might indicate different neural patterns for the given sets of linguistic stimuli. Semantic violations during reading a sentence have been shown to cause a negative event-related potential (ERP) at around 400 milliseconds known as N400 signal in the literature, (Friederici et al., 2003; Ruschemeyer, Zysset, & Friederici, 2006). For instance, a visually presented sentence such as "The table is sour" would cause this specific negative potential as the target word (for this sentence, sour) is read when compared to a baseline case like "The table is wooden" (Hagoort et al., 2004).

A similar ERP pattern has been observed for sentences with negative-truth value, in other words, world-knowledge violation cases. A suitable example would be: "The capital city of France is Madrid" instead of "The capital city of France is Paris". Hagoort et al. (2004) performed an EEG/ERP study by which they compared neurophysiological responses for world knowledge violations, semantic violations, and correct sentences on 30 participants. The obtained results from a representative electrode (Cz; grand average) indicated a significant difference with higher N400 amplitudes for sentences with world-knowledge and semantic violations when compared to correct sentences. There is no significant difference among the N400 amplitudes for these similar responses: world knowledge violations and semantic violations. However, the effect sizes seem to be different on average with world knowledge violations having greater effect sizes as compared to semantic violations. Moreover, the mean differences of topographic distribution (obtained from spline isovoltage maps) for semantic N400 effect and world knowledge N400 effect have shown to be similar. The examples for the stimuli demonstrated during the study by Hagoort et al. (2004) are given in Figure 7-1 below.

Correct sentence:	The Dutch trains are yellow and very crowded.
World knowledge violation:	The Dutch trains are white and very crowded.
Semantic violation:	The Dutch trains are sour and very crowded.

Figure 7.1 The illustration of three conditions from Hagoort et al. (2004)'s study.

Multi-word utterances are interpreted by means of combinatorial operations in relation to the meanings of the words, sentence-level and discourse processing (Hagoort et al., 2009). Beyond the specific incidences for triggering an N400 with an impressive range of stimulus types (written, drawing, objects, spoken and written words), a relatively recent account for the multi-modal nature of linguistic processing claims that semantic unification occurs with the neural integration of left frontal and temporal cortices (Willems et al., 2007). There have been several neuroimaging research studies in search of identifying this semantic unification network. These empirical studies cover semantic and pragmatic anomalies with their relevant counterparts (Hagoort et al., 2004; Newman, Pancheva, Ozawa, Neville, & Ullman, 2001; Kuperberg et al., 2000, 2003; Kuperberg, Sitnikova, & Lakshmanan, 2008; Ni et al., 2000; Baumgaertner, Weiller, & Buchel, 2002; Kiehl, Laurens, & Liddle, 2002) as well as comparing cases with and without semantic ambiguities (Hoenig & Scheef, 2005; Rodd, Davis, & Johnsrude, 2005; Zempleni, Renken, Hoeks, Hoogduin, & Stowe, 2007).

The main interest of the present research is to understand the possible processing differences at the neural level during identity judgments. Identity judgments have long been at the center of philosophical debates, e.g., is a car still the same after being fixed after a serious accident? Beyond the philosophical debates on the nature of objects and the concept of identity, it has also been a matter of interest how laymen respond to the identity question under different circumstances. Such examples for identity judgments are "A bicycle that has its pedals removed is the same" (statement with "same"); "A piece of paper bent over 3 times is different" (statement with "different"). The relevant academic literature on N400 signals has demonstrated that these brain potentials are widely observed during the onset of unexpected events and/or stimuli. Moreover, the semantic incompatibility of the phrases within a sentence like the semantic violation cases are also possible causes of N400 signals. Relying on the behavioral findings that show that participants tend to respond to propositions with *farklıdır* later than to propositions with aynıdır, there might be a semantic compatibility difference between *aynıdır* and *farklıdır* judgments. This presumed difference might therefore be reflected in different brain potentials.

7.2 Research Questions and Hypotheses

The main research questions have been formulated to compare the processing of different forms of judgments: judgments on statements including world knowledge violations as compared to statements without such violations, as well as identity judgments using *aynıdır* vs *farklıdır*, via EEG/ERP method. Are there processing differences at the neural level during world knowledge violations as compared to no such violations, and are there processing differences during identity judgments for *aynıdır* versus *farklıdır*? In relation to these research questions, the following hypotheses have been developed:

H_1: The sentences with world-knowledge violations (such as "The capital city of Turkey is Istanbul") will give a clear N400 signal when compared to their correct counterparts.

H_2: The identity judgments with *farklıdır* will give N400 signals when compared to the identity judgments with *aynıdır*.

Note that the world knowledge conditions are taken as the baseline experiments on the background of which the identity judgments can be compared. It is expected that no violation of world knowledge will be comparable to *aynidir* judgments and violation of world knowledge will be comparable to *farklidir* judgments. Note further that in this analysis we do not study the effect of participants' agreement with the proposition, e.g., if their judgment conforms to or diverges from the proposition. This is a more complex analysis that must await future treatment.

7.3 Experimental Design

Depending on the research questions and hypotheses, 4 experimental conditions were prepared: (1) propositions with *aynıdır*, (2) propositions with *farklıdır*, (3) propositions with positive truth-value ("*doğru*", correct sentences), and (4) propositions with negative truth-value ("*yanlış*", world-knowledge violations). For each condition, 24 sentences were presented, yielding a total of 96 sentences. Each sentence was presented in 5 slides. Thus, each sentence was decomposed into words or word groups. Each slide was presented for 1350 millisecond and there was a blank screen presented for 150 milliseconds between two slides. The examples for each of the conditions are presented below:

[Türkiye] [Cumhuriyeti] [Devleti'nin] [başkenti] [Ankara'dır.] (*doğru*)
[Türkiye] [Cumhuriyeti] [Devleti'nin] [başkenti] [Adana'dır.] (*yanlış*)
[Üst üste] [üç kere] [katlanan] [kağıt] [aynıdır.] (*aynıdır*)
[Üst üste] [üç kere] [katlanan] [kağıt] [farklıdır.] (*farklıdır*)

After the onset of the target word, which was also the final word, participants were asked to give their responses on the 5-Likert Scale via a serially connected response box within 5 seconds. The sentences were presented in a fixed random order. Since each sentence was presented approximately for 10 seconds including the fixation duration, the overall duration for the experiment was 960 seconds in total (that is 16 minutes). After the presentation of all of the 96 sentences, the participants were asked to respond to the Paradoxical Ship of Theseus narration in the standard textual modality, on the 5-point Likert Scale.

7.4 Method and Data Collection

Advanced EEG/ERP equipment (Micromed) has been used for data acquisition with its software Systemplus Evolution. The EEG/ERP system used for data collection contains 19-channel that has been compatible with the universal standards with a sampling frequency of 1024 Hz. The data analyses of raw EEG/ERP data have been performed in the Fieldtrip environment on MATLAB. The data was then preprocessed via highpass band filter of 1 Hz and lowpass band filter of 100 Hz. Moreover, a notch filter has been applied with the frequency range of 48-52 Hz. Then the Independent Component Analysis (ICA; fastica) has been applied in order to remove the noise within the data such as eye blinks and other artifacts. During the application of ICA, the user needs to select some of the given components that should be removed. Then a timelocked analysis has been performed in order to observe the ERP signal during the presentation of the target word for each of the 4 conditions: *aynıdır*, *farklıdır*, correct sentences (*doğru*) and sentences with world-knowledge violation (*yanlış*). The obtained results are explained in detail in the next section.

7.5 Results

The obtained results are presented in two parts. First of all, the behavioral results are presented in section 7.5.1 and then the neurophysiological results are explained in detail in section 7.5.2.

7.5.1 Behavioral results

The responses for the paradoxical Ship of Theseus narration are presented in Table 2 below. These responses show the usual M-like pattern.

Table 7.2 Distribution of participants' responses to the Ship of Theseus question, according to the 5-point Likert scale.

Likert scale	*N(all)*	*N (Sum Ship A+B)*
1 (strongly agree to Ship A)	4	13
2 (weakly agree to Ship A)	9	
3 (indeterminate)	6	6
4 (weakly agree to Ship B)	13	
5 (strongly agree to Ship B)	3	16
Total	35	35

The statistical analyses (Kruskall-Wallis) performed also show that these behavioral responses to the paradoxical Ship of Theseus narration have a similar M-pattern with the baseline textual condition ($\chi^2(2)=0.56$, $p>.96$). Thus, it can be argued that there is no effect of condition on the behavioral results for paradoxical Ship of Theseus narration.

7.5.2 Electrophysiological results

The results of EEG/ERP experiments are demonstrated in two parts. First of all, the results for the control condition (correct sentences versus sentences with world-knowledge violation) are shown with the relevant statistical analyses. This control condition has been important to show that the requirement for scientific validity and reliability of the performed experiments has been provided. In the second part, the results of the test condition comparing *aynıdır* versus *farklıdır* propositions are demonstrated with the statistical analyses performed. Before the comparison of these conditions, the obtained data has been filtered through several steps.

7.5.2.1 EEG/ERP Results of the Control Condition

There were two sub-conditions for the control condition: (1) correct sentences and (2) sentences with world-knowledge violation. The ERP signals for the two conditions (specifically the first 1000 milliseconds of the presentation of the final word) have been averaged with the application of time-locked analyses via Fieldtrip. The sentences with world-knowledge violation show a clear N400 signal mainly for the central and parietal channels as indicated by the studies in the literature. The statistical test of these two conditions shows a statistically significant distinction mostly from 360 to 440 milliseconds. The comparisons of the block averages as well as the minimum values of these durations indicate a significant difference for 8 of the 19 electrodes that are shown in the topographic maps below. These results support the findings in the literature showing that the N400 might be a possible neurophysiological marker not only restricted to semantic violations but also valid for cases with world-knowledge violation. Below, in Figure 7.3, the related ERP signals for the main 19 channels are presented.

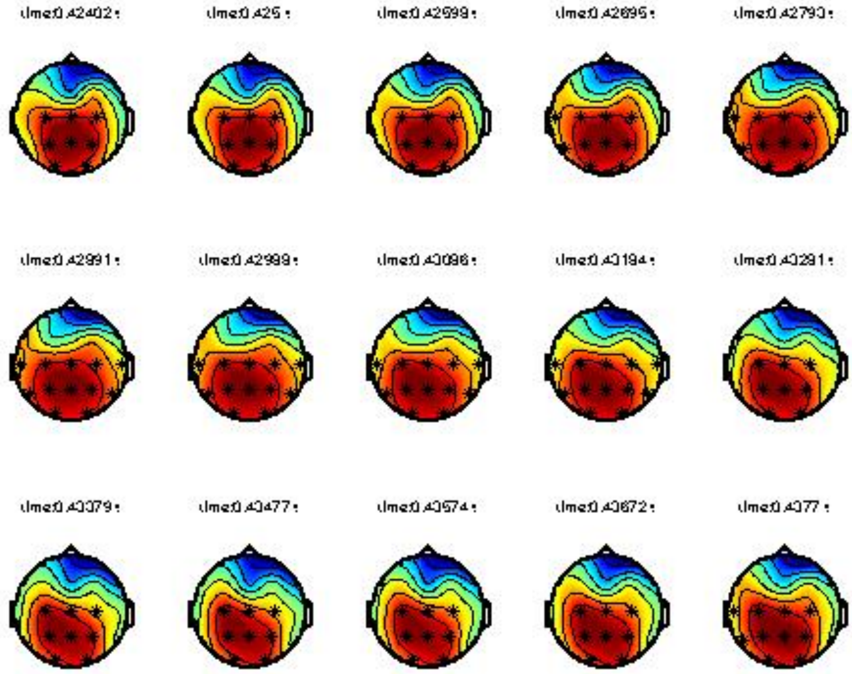


Figure 7.3 The topographical maps for *doğru* and *yanlış* comparison with respect to temporal domain in 5 milliseconds. The channels marked with a cross show the statistically significant differences for *doğru* and *yanlış* comparison.

7.5.2.2 EEG/ERP Results of the Test Condition

There were two sub-conditions for the test condition: (1) sentences with *aynıdır* and (2) sentences with *farklıdır*. The ERP signals for the two conditions (specifically the first 1000 milliseconds of the presentation of the final word) have been averaged with the application of time-locked analyses via Fieldtrip. The sentences with farklıdır show a N400 signal for the frontal and central channels as initially expected. The statistical comparison of these two conditions shows a statistically significant distinction mostly from 350 to 450 milliseconds related to the onset of the N400 signal. The comparisons of the block averages of these durations indicate a significant difference between *aynıdır* and *farklıdır* cases for 15 of the 19 electrodes (see Table 7.3). These results demonstrating a clear N400 effect indicate a possible semantic incompatibility during the semantic unification process for the sentences with *farklıdır* when compared to the sentences with *aynıdır*. In other words, the significant difference between these sub-conditions might reveal a semantic processing difference. This potential difference in ERPs might be due to the semantic incompatibility of *farklıdır* sentences that have already been shown to have longer reaction times as opposed to the *aynıdır* sentences. One possible explanation could be related to a possible anomaly during the semantic/conceptual unification process. In other words, the participants tend to find the *farklıdır* cases incongruous while they tend to find the *aynıdır* cases congruous. Below, in Figure 7.4, the ERP signals for the test condition (*aynıdır* versus *farklıdır*) for the main 9 channels are presented. Please note again that these differences were obtained ignoring the actual agreement or disagreement of the participants with the proposition.

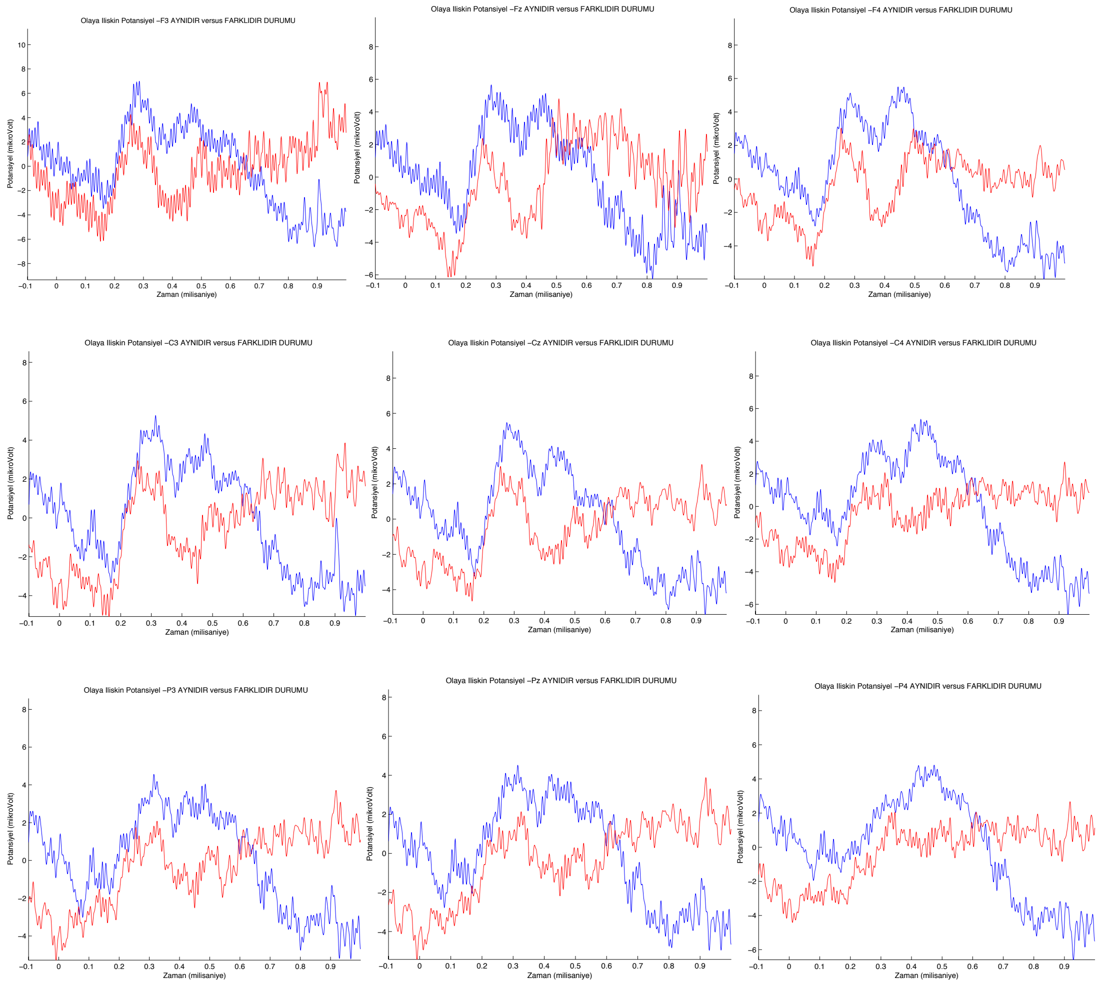


Figure 7.4 Event-related potentials (ERPs) for the 9 main electrodes for comparing *aynıdır* (same; in blue) versus *farklıdır* (different; in red) conditions with x- and y-axes respectively with potentials (microvolts) and time (milliseconds).

Table 7.3 Results for paired-samples t-test for *aynıdır* versus *farklıdır* conditions across different channels (from 390 to 430 milliseconds)

Channels	**Paired Differences**					**t**	**df**	**Sig. (2-tail.)**
	Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
				Lower	**Upper**			
Fp1	7.31679	31.64668	2.44159	2.49642	12.13716	2.997	167	.003
Fp2	8.25447	35.49060	2.73816	2.84860	13.66034	3.015	167	.003
F7	3.29511	23.32665	1.79969	-.25797	6.84818	1.831	167	.069
F3	7.06742	31.47837	2.42861	2.27269	11.86215	2.910	167	.004
Fz	5.75596	22.53533	1.73864	2.32342	9.18851	3.311	167	.001
F4	6.08798	23.93408	1.84655	2.44238	9.73357	3.297	167	.001
F8	4.05096	24.09298	1.85881	.38116	7.72077	2.179	167	.031
T7	2.78016	22.00515	1.69773	-.57163	6.13195	1.638	167	.103
C3	5.04791	23.19314	1.78939	1.51517	8.58065	2.821	167	.005
Cz	5.67601	23.37161	1.80316	2.11608	9.23593	3.148	167	.002
C4	5.39891	23.02459	1.77639	1.89184	8.90597	3.039	167	.003
T8	3.61598	21.56318	1.66364	.33151	6.90044	2.174	167	.031
P7	3.31107	22.33001	1.72280	-.09020	6.71233	1.922	167	.056
P3	4.29803	23.01954	1.77600	.79174	7.80433	2.420	167	.017
Pz	4.39042	23.43911	1.80837	.82021	7.96063	2.428	167	.016
P4	4.02514	22.81075	1.75989	.55065	7.49964	2.287	167	.023
P8	3.17983	22.23097	1.71516	-.20635	6.56601	1.854	167	.066
O1	3.52834	22.73738	1.75423	.06502	6.99165	2.011	167	.046
O2	3.22369	22.81541	1.76025	-.25151	6.69890	1.831	167	.069

The topographical maps, shown in the Figure 7.5, are demonstrated for the comparison between *aynıdır* and *farklıdır* conditions. The topographical maps are presented within the temporal dimension. The channels marked with a cross are the ones having statistically significant difference for *aynıdır* and *farklıdır* conditions. Time flows from left to right. As can be seen from the figures, the potential difference rises with the frontal channels that are supportive for the semantic/conceptual unification issue. However, the semantic violation and world-knowledge violation cases result with a potential difference emerging in the parietal and central channels. It is also important to highlight that the time zone for this significant potential difference starts from 390 milliseconds and lasts until 436 milliseconds. This is exactly the critical time zone for the N400 signal that is in line with the scientific findings in the literature.

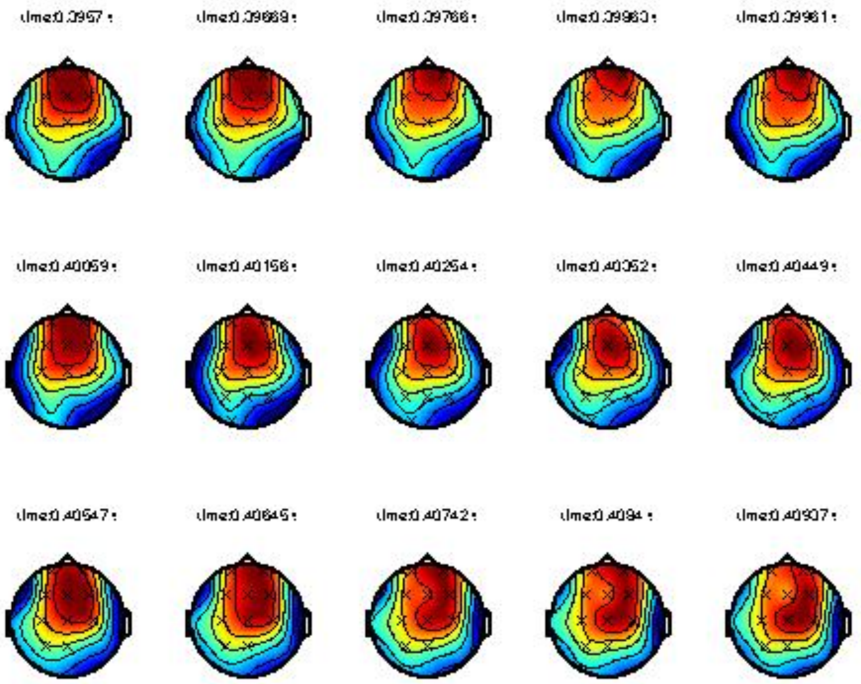


Figure 7.5 The topographical maps for *aynıdır* and *farklıdır* comparison with respect to temporal domain in 5 milliseconds. The channels marked with a cross show the statistically significant differences for *aynıdır* and *farklıdır* comparison.

7.6 Discussion

Sameness, or identity judgments, are both philosophically and psychologically interesting processes by which several factors including context and the way the question is described could be influential. Despite the fact that these processes might be embedded within and influenced by a given context, different types of processing might be occurring at a linguistic level due to semantic compatibility differences among conditions. Given the observed reaction time differences between "same" and "different" judgments, the predicted differences at the neurophysiological level have become an interesting research question. This EEG/ERP experiment has been conducted for observing possible semantic processing differences specifically for the concepts "same" (*aynıdır*) and "different" (*farklıdır*). The ERP paradigm developed for linguistic processing has been used for the present experimental design and procedure as well. Instead of using ordinary filler sentences, the control condition was prepared in relation to the world-knowledge violation findings mainly by Hagoort *et al.* (2004). Thus, the control condition was used for demonstrating the reliability of the present study. The participants were asked to give responses depending on their degree of belief on a 5-point Likert Scale in order to increase their attention level and provide them to keep track of the presentation of the sentences.

The obtained results show that the world-knowledge violation condition when compared to the correct sentence condition caused an N400 signal over the central and parietal channels that are in line with the findings by Hagoort *et al.* (2004). Moreover, the results from the test condition illustrate a similar ERP pattern when the *farklıdır* (different) condition is compared to the *aynıdır* (same) condition. This difference in ERP patterns has been one of the main findings of the current study that should be discussed in further detail. First of all, this ERP difference has been expected as stated explicitly with the second hypothesis of the study.

Since the reaction times for *farklıdır* responses has been significantly longer than the *aynıdır* responses, it is possible to suggest that this delay in response times might be related to a relative difficulty in semantic processing. This finding, however, should not be referred to as a type of semantic plausibility as Kutas & Feidermeier (2011) mentioned because that N400 signal is probably not an indicator of semantic plausibility. However, the potential difficulty for *farklıdır* sentences might be linked to a processing problem during the semantic/conceptual unification process (Hagoort et al., 2009). This finding could be explained in terms of the cloze probability of the *farklıdır* sentences that might be significantly lower than the cloze probability of *aynıdır* sentences. In other words, participants could be responding to *aynıdır* words as a continuation given the preceeding context for identity judgments but not for *farklıdır* cases which might interrupt this continuation (Kutas & Feidermeier, 2011). Secondly, one might argue that this difference might be related to the direction of the responses provided by the participants. To be more specific, if *farklıdır* responses were highly composed of strong disagreement judgments when compared to *aynıdır* responses, then it might be a possible arguable case that the participants' degree of beliefs has caused this difference in ERP signals. However, the ERP studies in the relevant literature demonstrate that the content of the responses (whether they agree or disagree) do not cause such an ERP pattern of N400 (Banks, 2011).

A semantic unification network has been claimed to include several regions especially from the left hemisphere like left inferior frontal cortex, left superior/middle temporal cortex, and the left inferior parietal cortex but not limited to it. It also comprises the homologues from the right hemisphere that have also been demonstrated to be activated during semantic unification (Hagoort et al., 2009). Concerning the channels by which the N400 signal are observed during test condition, it should be noticed that these channels that are from the frontal and parietal regions might have probably been activated by the triggers in the semantic unification network. The topographical maps presented in the Figure 7-5 illustrate the significant potential differences. The figures presented in the Appendix clearly demonstrate the dominance of the frontal channels that have been associated with the semantic/conceptual unification network (Hagoort et al., 2009).

To sum up, in this study we first established the reliability of our procedure by contrasting world-knowledge violating with non-violating propositions. The finding of an N400 in case of world-knowledge violation is in line with the seminal study of Hagoort et al. (2004). More importantly, the same ERP difference, an N400, between "*farklıdır*" vs "*aynıdır*" propositions has been found in this study. This difference might be due to semantic incompatibility of the former. In other words, people might be experiencing difficulty in processing of *farklıdır* while integrating the final word with the whole proposition that triggers the N400 signal. This neurophysiological finding is consistent with the behavioral results, namely that *farklıdır* judgments take longer time to respond to.

CHAPTER 8

NEUROPHYSIOLOGICAL ASSESSMENTS II: FNIRS EXPERIMENTS

Prefontal cortex has been one of the important brain regions that are known to be involved during reasoning and decision-making processes. The empirical studies performed with neuroimaging methods have already shown that conflicting situations cause higher prefrontal activation as well as an activation increase in the anterior cingulate cortex (ACC) (Botvinick et al., 2004; Kerns et al., 2004). This study has focused on demonstrating the possible prefrontal influences on participants' identity judgments when being exposed to propositions of the CTT. The obtained optical brain imaging (fNIRS) results have indicated that participants might experience higher levels of conflict for the propositions that they strongly disagree with as opposed to the propositions they strongly agree with during the onset of identity judgments, especially for the first 6 seconds. This finding has been associated with middle and left prefrontal activations (mostly at a significant level or at least at a marginally significant level) during strong disagreement as opposed to strong agreement responses. On the other hand, there seems to be no significant difference between responses for strong and weak positions (regardless of agreement and disagreement). Moreover, the indeterminate responses ('3' responses) were observed to cause higher levels of activations in the prefrontal regions that are associated with conflict resolution in the scientific literature (Botvinick et al., 2004; Kerns et al., 2004). Additionally, the behavioral data relying on reaction times of the participants show that there are significant differences related to the content of the responses. Interestingly enough, propositions with *farklıdır* are responded to significantly later than propositions with *aynıdır*, as has been shown in previous chapters of this thesis already, but no significant prefrontal activation difference was found out that might have supported this behavioral finding. Moreover, the participants tended to respond to the propositions in the CTT with an inverted-V shape pattern meaning that indeterminate positions (3 responses) required the highest reaction times than the tendency to agree/disagree responses (2 and 4); the strong agreement/disagreement responses (1 and 5) were the quickest ones.

8.1 Introduction

Identity judgments have long been at the center of philosophical debates, e.g., is a car still the same after being fixed after a serious accident? Beyond the philosophical debates on the nature of objects and the concept of identity, it has also been a matter of interest how laymen respond to identity questions under different circumstances. The present study focuses on a famous paradox from ancient Greece, the Ship of Theseus (Hall, 1998). Various response patterns to this paradox have been predicted by a Conceptual Tendency Test (CTT) tapping the concept of "sameness". The main aim of this section is to test the neural correlates of identity judgments in relation to participants' decisions via optic brain imaging methodology. Optical brain imaging (fNIR) has been increasingly used in various research environments ranging from medicine to neuroergonomics and neuromarketing (citations). This method is capable of detecting changes in neural activation among the prefrontal cortex during a given cognitive task (Izzetoglu et al.; Ayaz et al.).

The human prefrontal cortex has been considered as a critical region that plays a role during the processes related to higher-order cognition. These higher-order processes include reasoning, decision-making and other deliberative processes (Fuster et al., 2013). It is also notable that this region is the newest brain region in terms of evolutionary history and possibly the unique region for the human kind, as compared to non-human animals. Prefrontal cortex has been found to play a role during conflict monitoring and cognitive control as well as the anterior cingulate cortex (Botvinick et al., 2004). More specifically, the empirical evidence supports the view that the conflict-related activity induced by the anterior cingulate cortex possibly causes higher level of prefrontal activity (Kerns et al., 2004). The fMRI results of experiments performed with the Stroop color-naming task indicate that there are behavioral adjustments for the conflict cases possibly related to the activation increase in dorsolateral prefrontal cortex (dlPFC). Although not clear yet, the study by Kerns et al. (2004) favors the hypothesis that ACC modulates the PFC for the execution of control by activating specific signal pathways. Moreover, it has also been suggested that underdetermined responses cause higher ACC activation that might probably be linked to PFC (Thompson-Schill et al., 1997; Barch et al., 2000). In addition, there is neuroimaging evidence indicating that higher cognitive workload requires higher mental effort (as in conflict situations) which may be correlated with the increase of activation in prefrontal cortex. Accordingly, through an integrative neuroscience perspective, the neurophysiological changes in activation levels of ACC and PFC might be used as indicators of conflict resolution processes in the current thesis.

Thus, PFC appears as a functional and useful site by which it might be possible to acquire insights about the conflict resolution processes. In this dissertation, conflict monitoring and resolution processes are studied in the context of identity judgments. Identity judgments might be considered as a type of reasoning process that involves conflict resolution. To illustrate, many people cannot come to very certain conclusions while trying to decide whether a paper bent over three times is the same paper. It has initially been hypothesized that participants have higher levels of activation in the left prefrontal regions for conflicting cases as opposed to non-conflicting cases. The main underlying assumption is that participants will experience higher mental effort in those cases where they cannot arrive at a final decision easily but remain 'undecided'. Moreover, the scientific literature includes a couple of studies that demonstrate that sentences with world-knowledge violations activate left inferior prefrontal cortex (LIPC), a pattern that is also observed for semantic violations (Hagoort et al., 2004), see chapter x above. This neural site (LIPC) has been considered to take action during the verification of linguistic expressions as well as the computation of meaning through some kind of integration process (Hagoort et al., 2004). For the cases including world-knowledge violations (e.g. "The capital city of Turkey is Adana"), it is expected to observe more left prefrontal activations when compared to the correct sentences (e.g., "The capital city of Turkey is Ankara". Similarly, it might be possible to monitor whether the neural activations related to disagreement and agreement cases diverge from each other to a certain extent. Despite the fact that the identity judgments in this study might not be evaluated as the same as world-knowledge violation condition, still the neural processing of disagreement cases might behave in a similar fashion as opposed to the agreement cases. Moreover, for most of the cases, it could be argued that identity judgments require the integration of world-knowledge as in the case of a piece of paper bent over three times.

Thus, the following hypotheses have been generated for the current brain imaging study:

H_1: The level of neural activations (among the left PFC) for disagreement responses would be higher than the agreement responses, since disagreement cases would be more conflicting than others. This assumption has been developed due to the fact that world-knowledge violations appear to activate the left frontal regions.

H_2: The level of neural activations among the left PFC for *farklıdır* propositions are higher than the propositions with *aynıdır*, since *farklıdır* propositions might possibly cause

semantic incompatibility that might be more conflicting as shown with the N400 signal in the EEG/ERP experiments.

H_3: The reaction times for undecided responses would be higher than the other responses, since indeterminate cases would be perceived as more conflicting than others. Moreover, the reaction time of weak responses will be higher than of strong responses, in terms of the degree of confidence of the participants.

8.2 Experimental Method

The optical neuroimaging device has been developed to measure the level of blood oxygenation and blood volume. This physiological measurement has been shown to reflect the changes in the brain physiology and has been accepted as a reliable indicator of neural activity (Obrig et al., 2000; Bunce et al., 2000). This method has several advantages over the other brain imaging methods on the practical level such as its non-invasive nature, its safety, and mobility features. This method, functional near infrared spectroscopy (fNIRS), sends infrared light from its source diffused through the intact scalp and relies on receiving the infrared light reflected from the brain tissues.

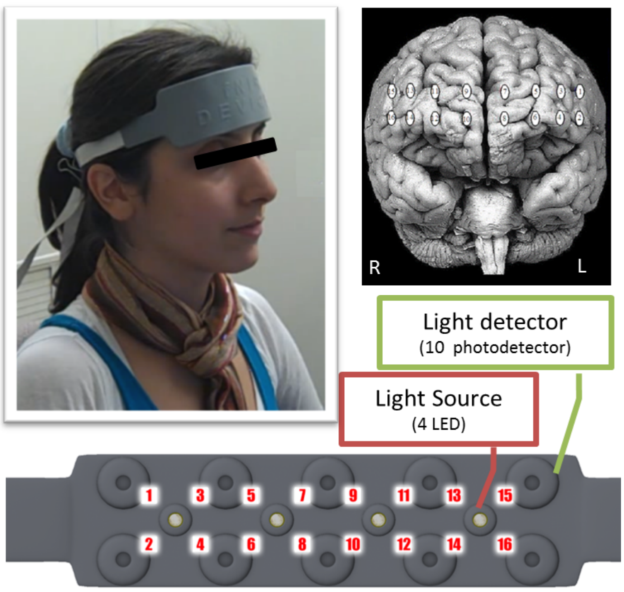


Figure 8.1 fNIR sensor (top, left), projection of measurement locations (optodes) on brain surface image (top, right), optodes identified on fNIR sensor (bottom). The locations of 16 regions on the cortical surface monitored by fNIR are displayed in Figure 1 above, which correspond to Brodmann areas 9, 10, 44 and 45.

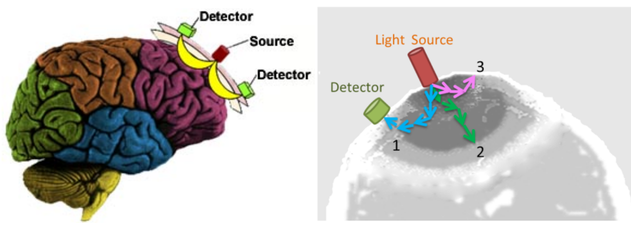


Figure 8.2 The banana shaped path which includes the photons scattered back to the photo-detector (left). Representative paths (right), enumerated as 2 and 3 correspond to photons absorbed by the tissue and scattered out of the scalp without reaching the detector, respectively.

The relative ratios of specific chromophores in the neural tissue (i.e. oxygenated and deoxygenated hemoglobin in the capillary beds) as well as the changes in their concentration are tracked by and monitored via this optic brain imaging technology (Jobsis, 1977). Since oxyhemoglobin and deoxyhemoglobin are two high absorbers of infrared light within the 700-900nm range, as many biological tissues, they are also susceptible to the near infrared light sent by the fNIRS device (Cope et al., 1988). The relative changes of these molecules are approximated and then monitored due to their level of absorption. There are several scientific studies that demonstrate the reliability of this method via simultaneous use with fMRI (Ayaz, 2010). Moreover, there are numerous empirical studies that illustrate the functioning of the human prefrontal cortex during various cognitive tasks with fNIRS methodology (Ayaz et al., 2012; Shimokawa et al*.,* 2010; Mitsuda et al., 2012).

8.3 Experimental Design and Procedure

8.3.1 Participants

24 participants (12 males) composed of undergraduate and graduate students from Middle East Technical University. Their ages ranged from 20 to 32. Psychiatric medication within the last 3 months was an exclusion criterion. Moreover, all of the participants were right-handed.

8.3.2 Stimuli

Participants were initially asked to rate a set of propositions (the CTT) that are directly related to the core concept involved in the paradox. Participants responded on a scale from 1 to 5 (where 1 corresponds to total agreement, 3 to neutral, and 5 to total disagreement). There were 24 proposition pairs half of which were phrased in terms of "same" ("A" for Turkish "*ayni*" ("same")), and half in terms of "different" ("F" for Turkish "*farkli*" ("different")), e.g., A: "A bicycle that has its pedals removed is the same"; F: "A piece of paper bent over 3 times is different". Each proposition was presented for 10 seconds. After the presentation for 10 seconds, the proposition disappeared from the screen and the participants were required to respond within 8 seconds. As they responded, the fixation screen appeared and presented for 8 seconds. For the cases that the participant does not respond during the decision screen for 8 seconds, the fixation screen appears after 8 seconds and the responses of the participants were recorded as 'undecided'.

After the presentation of all propositions, participants were then given the paradoxical Ship of Theseus narration in the normal STP condition, in which the ship was renewed/reassembled over a baseline period of time (25 years) and at a neighboring port. Participants were given unlimited time to respond on a 5-point Likert scale, where ratings of 1 and 2 were considered as strong and weak "Ship A" ratings, ratings of 3 as "undecided/indeterminate" and ratings of 4 and 5 as weak and strong "Ship B" ratings.

8.4 Data Analyses

The oxygenated hemoglobin levels during the presentation of each proposition for 10 seconds have been extracted. The previous 4 seconds (the duration just before the onset of the proposition) have been denoted as the baseline duration. The average activation levels for each block have been calculated for each of the 16 optodes. These mean values have been tested in relation to the responses of the participants (case-wise) as well as condition-wise differences (like *aynıdır* and *farklıdır*).

8.5 Results

The obtained results have been analyzed under 3 sub-sections: (1) Behavioral responses, (2) Reaction times, and (3) Neurophysiological results. The results have been investigated in order to find possible answers for the following questions: (a) Are the response patterns of the participants similar to the other (textual and modal) conditions? In other words, would they perform in line with the previous statistical models? (b) Do reaction times of the participants differ in relation to the response direction (agreement, disagreement), degree of belief (weak, strong), and condition (*aynıdır* versus *farklıdır*)?

8.5.1 Behavioral Results

Each of the 24 participant responded to the Conceptual Tendency Test (CTT) as well as to the paradox with the 5-Likert Scale. A clear M-pattern is visible for this condition that was expected in the light of previous empirical data.

Table 8.1 Distribution of participants' responses to the identity question, according to the 5-point Likert scale.

Likert scale	*N(all)*	*N (Sum Ship A+B)*
1 (strongly agree to Ship A)	2	11
2 (weakly agree to Ship A)	9	
3 (indeterminate)	3	3
4 (weakly agree to Ship B)	7	
5 (strongly agree to Ship B)	3	10
Total	24	24

The results of condition-wise statistical comparison indicated that there was no effect of condition when the response pattern of fNIRS condition is compared to the textual (baseline) condition ($\chi^2(2)=2.962$, $p>.832$).

8.5.2 Reaction Time Results

The reaction time responses have been analyzed regarding the two main conditions of all of the experiments.

8.5.2.1 *Aynıdır* versus *Farklıdır*

The behavioral response pattern presented in Figure 8.1 suggests that participants tended to respond to the sentences with *farklıdır* later than to the sentences with *aynıdır*. This finding was confirmed in a paired-samples *t*-test with *farklıdır* propositions having longer response times than *aynıdır* propositions ($t(-2.821, 4)$; $p<.048$). The longer RT for *farklidir* might be an indicator of the processing difficulty experienced by the participants when they try to resolve the *farklıdır* propositions mostly for the disagreement positions as opposed to *aynıdır* propositions. This possible difference in processing might be due to the fact that *farklıdır* might be involving a very short inhibitory process during the semantic/conceptual unification process possibly due to the fact that people have tendency to think on identity judgments with *aynıdır* rather than *farklıdır*.

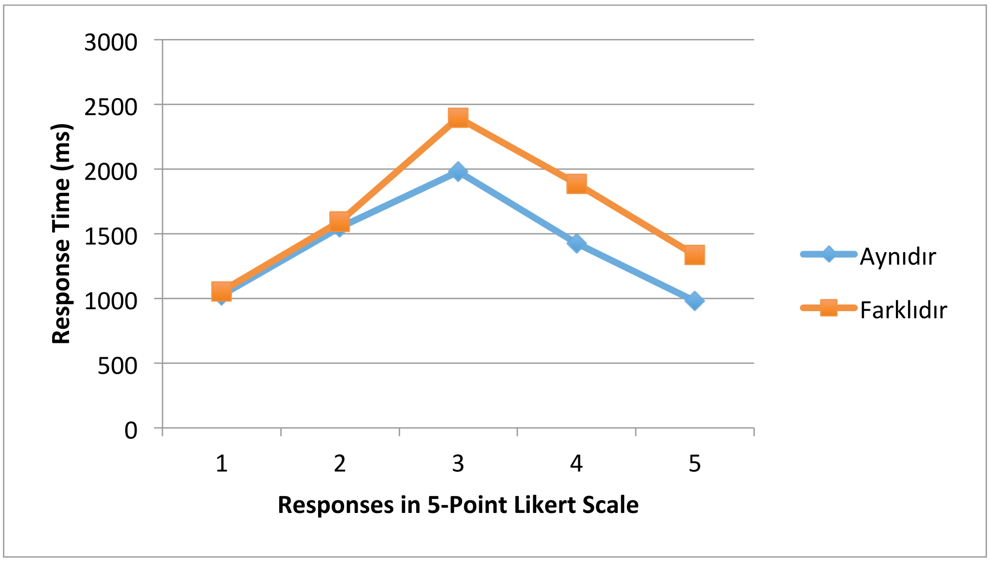


Figure 8.3 The response-wise reaction times for comparing *aynıdır* and *farklıdır* conditions.

8.5.2.2 Weak judgments versus strong judgments

The second statistical test has been performed via one-way ANOVA in order to observe possible reaction time differences for weak versus strong judgments of the participants. The weak judgments have been the ones with the tendency to agreement and disagreement positions (these were 2 and 4 in the scale). The strong judgments are the ones with the strong agreement and disagreement positions (these were 1 and 5 in the 5-Likert Scale). Thus there were two response groups to be analyzed. The results show that participants tend to respond slower to the propositions when they are at a weak position (mean RT = 1594.54) than at a strong position (mean RT = 1056.61) at a highly significant level ($F(1, 994) = 47.372$; $p<.000$). Figure 8.2 below demonstrates the mean reaction times for weak and strong judgments.

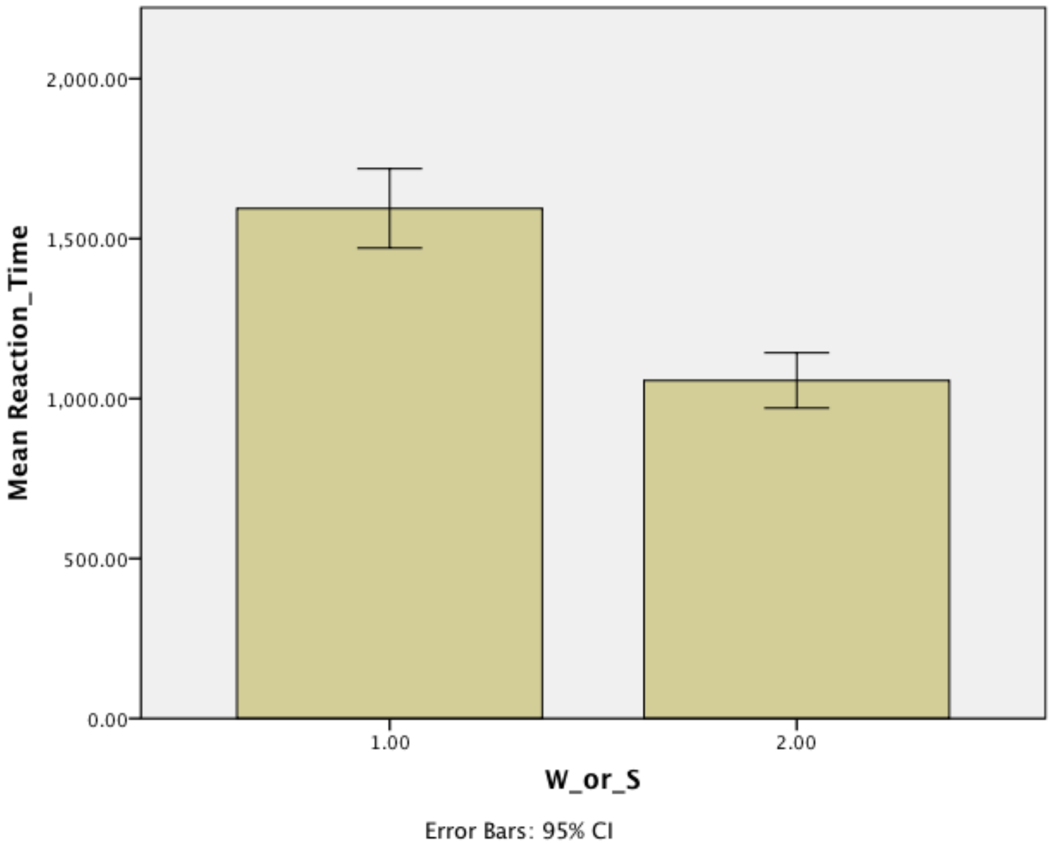


Figure 8.4 Reaction time averages for weak and strong responses. (1 stands for weak responses and 2 for strong responses). Again, please improve the figure, as the one above.

8.5.2.3 Response-wise reaction times (5-Scale)

The third statistical test for reaction times has been performed in order to provide a response-wise discrimination. The results of the one-way ANOVA test show a symmetric inverted-V pattern meaning that participants are quicker for the strong positions than for the weak positions and the indeterminate position has been observed to be the slowest (mean RT = 2226.50) at a significant level ($F(4,1045) = 17.527$; $p<.001$). These results indicate a response delay for the undecided cases in line with our initial hypothesis, since undecided participants would tend to think more until they settle in their response. Figure 8.5 below illustrates the inverted V-shape pattern for the response-wise reaction times.

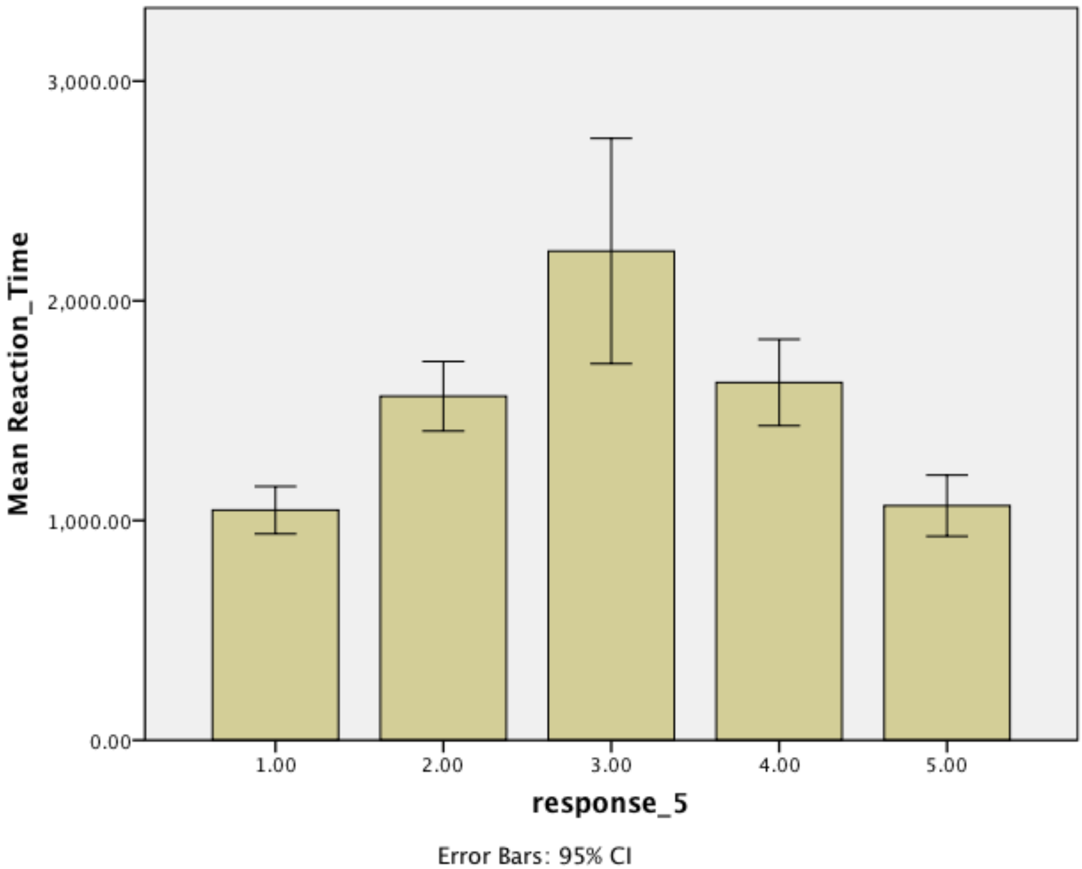


Figure 8.5 The figure below represent the reaction time averages with the standard errors for the responses in the 5-Likert scale. (1 stands for the strong agreement and 5 for strong disagreement responses).

8.5.3 fNIRS Results

The details of the data acquisition process were explained briefly in the previous section. A low-pass filtration was performed to the raw fNIR data for 16 optodes (2 wavelengths) with a finite impulse response. The linear phase filter order has been set to 20 and cut-off frequency to 0.1 Hz. This filtration process is efficient in removing the high frequency noise that is due to the physiological rhythms such as respiration and cardiac cycle (Ayaz et al., 2012). Then the exclusion of the saturated channels, if necessary, were done with respect to the condition if the light intensity at the detector has been higher than the analog-to-digital converter limit. Then a motion artifact detection and removal filter (SAM) was applied in the sliding windows (Ayaz, 2011). Thus, the artifacts due to the movements of the participants during the experiments were removed. With the use of markers for time synchronization, the fNIR data epochs for task and rest periods have been extracted. The Modified Beer-Lambert Law was applied to the task durations (in which the propositions are presented) with respect to the previous resting screen (that is accepted as the baseline) with the use of fnirSoft software (Ayaz, 2010). After the data set was filtered and prepared, the data set was analyzed with regards to different aspects of the conditions and responses.

8.5.3.1 Agreement versus Disagreement Cases

One of the key aspects for the current study has been to find out any dissociation with respect to the response-wise differences. There has been no significant difference among any of the channels with respect to the agreement versus disagreement positions. For the agreement cases, both of the tendency to agree and strong agreement cases are clustered and for the disagreement case, both of the tendency to disagree and strong disagreement cases have been brought together. There was only one channel V8 ($F(1, 872) = 2.805$; $p<.094$) that was marginally significant.

8.5.3.2 Strong Agreement versus Strong Disagreement Cases

For the next analysis, only the strong cases were compared (R1: strong agreement and R5: strong disagreement). Statistical tests showed several significant and marginally significant channels. On average, strong disagreement cases had higher levels of activation for several optodes including V1 ($F(1, 370) = 3.677$; $p<.056$), V2 ($F(1, 450) = 5.081$; $p<.025$), V3 ($F(1, 427) = 3.236$; $p<.073$), V4 ($F(1, 387) = 7.180$; $p<.008$), V5 ($F(1, 359) = 3.500$; $p<.062$), V6 ($F(1, 351) = 3.836$; $p<.051$), V7 ($F(1, 441) = 2.844$; $p<.092$), V8 ($F(1, 437) = 3.160$; $p<.076$), and V10 ($F(1, 371) = 4.210$; $p<.041$). These empirical findings are also in line with our initial hypothesis, since the strong disagreement cases cause higher level of activation mostly on the left part of the prefrontal cortex. Figure 8.6 below shows the average activation levels for the 6 channels in relation to the strong responses (1: strong agreement and 5: strong disagreement).

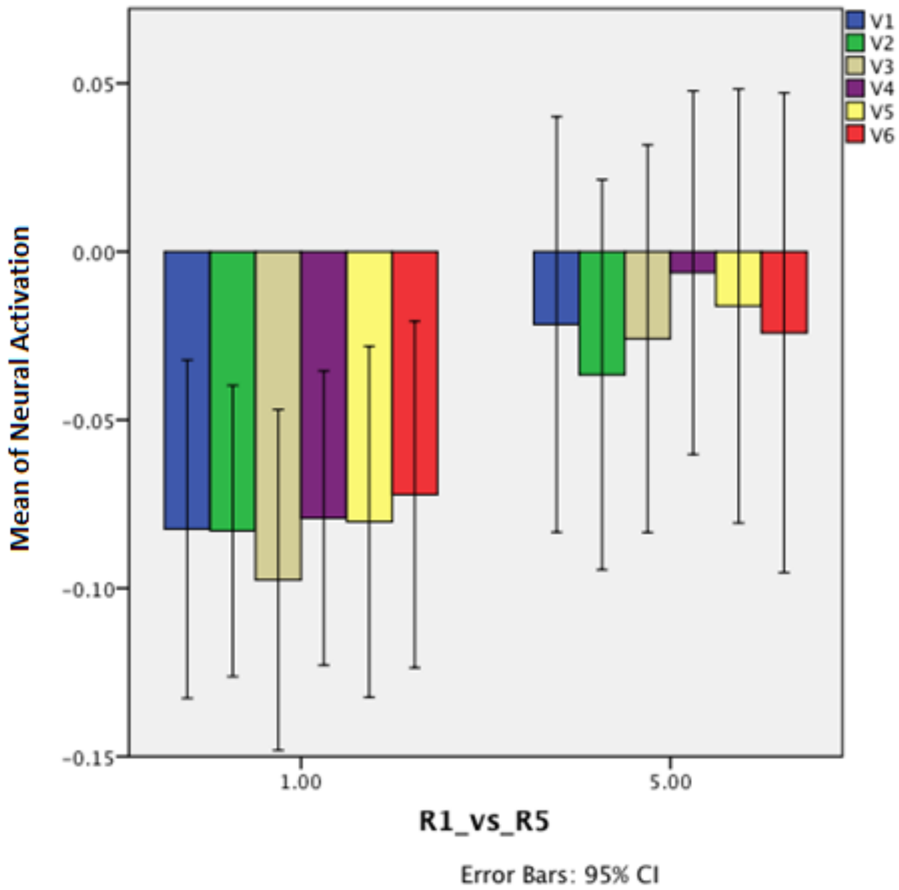


Figure 8.6 Neural activation means with confidence interval (95%) for the strong agreement (illustrated with “1” in the left of the figure) and strong disagreement cases (illustrated with “5” in the right of the figure). (R1 stands for strong agreement and R5 for strong disagreement responses).

8.5.3.3 Weak judgments versus strong judgments

Another interesting research question has been related to monitoring possible processing differences between weak and strong judgments. There have been observable and significant reaction times differences for weak versus strong judgments. The results of one-way ANOVA test has indicated that one channel, V8 ($F(1,791) = 2.937$; $p<.084$), had a marginally significant level of activation difference between weak and strong judgments. As initially expected, weak judgments caused more neural activation among the channel (V8). That is most probably due to the fact that weak judgments are perceived as more conflicting than strong ones and thus require higher levels of mental effort whereas strong judgments might be processed rather with ease.

8.5.3.4 Indeterminate Cases versus Others

The next analysis was aimed at comparing the indeterminate (undecided) cases and the remainder of the responses. It has been initially hypothesized that these indeterminate cases would cause a higher level of activation than the other cases, since the participants had to engage more in order to resolve the identity judgment. One-way ANOVA tests revealed that 4 channels showed a significant level of activation difference: V3 ($F(1, 999) = 8.422$; $p<.004$), V4 ($F(1, 850) = 9.541$; $p<.002$), V5 ($F(1, 827) = 4.003$; $p< .046$), and V6 ($F(1, 754) = 8.134$; $p<.004$). As initially hypothesized, the undecided cases caused significantly more activation over the remaining response categories, see Figure 8.7 below. Since all of these channels are considered to be associated with neural activation within the dorsomedial region of prefrontal cortex, these results are consistent with the idea that they are involved in conflict resolution.

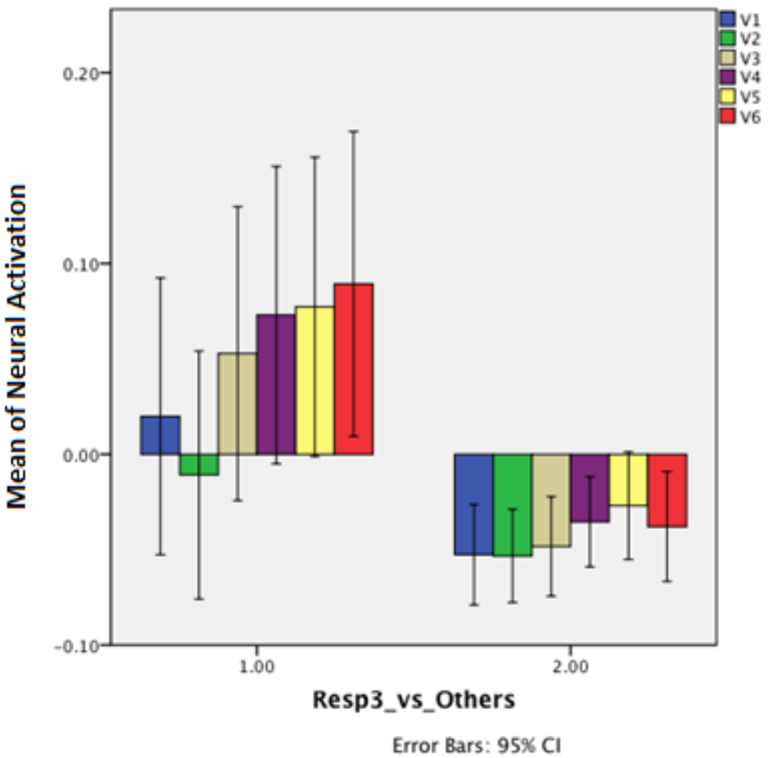


Figure 8.7 Neural activation means with confidence intervals (95%) for the undecided responses (illustrated with "1", in the left of the figure below) and all other cases (illustrated with "2"; in the right of the figure below). "Resp3" stands for the undecided cases and "Others" for the other responses.

8.5.3.5 *Aynıdır* versus *Farklıdır*

Moreover, it has initially been predicted that the *farklıdır* condition might possibly cause more activation than the *aynıdır* condition, as suggested by their delayed reaction time. There has been supporting evidence from EEG/ERP experiments, specifically on the semantic/conceptual unification process, inspiring this hypothesis. However, the obtained results show that there is no significant difference in activation levels for *aynıdır* versus *farklıdır* conditions regardless of the responses from the participants. Therefore, it might be claimed that the delay in responding to *farklıdır* propositions is related to the semantic incompatibility when compared to *aynıdır* propositions but this does not necessarily cause a high level of conflict.

8.6 Discussion

The current study has been conducted in order to observe the possible neural activation patterns of the human prefrontal cortex during identity judgments in relation to the responses of the participants. An experimental design with fNIRS method has been devised in order to detect the possible neural correlates of the decision-making processes during identity judgments. Depending on the technical capabilities of the fNIRS device, the prefrontal cortex was investigated as the participants were engaged in the Conceptual Tendency Task. There was no significant difference observed between *aynıdır* and *farklıdır* conditions – despite differential response times between them. One possible explanation is that although farklıdır cases might be considered as a semantic negation of aynıdır case, the potential influence might be too short (instantaneous) to be observed via neurophysiological methods like fNIRS or fMRI. An alternative explanation might be related to the anterior cingulate cortex region that might have been activated during *farklıdır* condition as opposed to *aynıdır* condition. However, detecting neural signals from this region is not in the scope of the fNIR device. This assumption might only be tested via the application of fMRI method by which it is possible to observe the neural activations in the subcortical regions.

There was also no significant difference between agreement and disagreement judgments. On the other hand, as it was initially hypothesized, there might be a significant difference between strong agreement and strong disagreement cases by which the strong disagreement cases (as opposed to strong agreement cases) caused a higher level of prefrontal activation over the left prefrontal region that has been associated with a possibly on-going conflict resolution process. In other words, the strong disagreement cases have possibly been perceived to be more conflicting as compared to strong agreement cases. This finding is quite understandable in the sense that people might need to find further supportive arguments when they do not agree to a given premise or argument. However, agreement cases, in other words affirmative positions, might not require such a process of generating supportive arguments. Thus, there might be an asymmetric influence between strong agreement and strong disagreement cases that might also be connected to the "frontal lobe hypothesis", as derived from conflict monitoring studies as well as findings from world-knowledge violations in the relevant neuroimaging literature. Thus, the second hypothesis of this study (H_2) has been supported to a certain extent because of the removal of the weak agreement and weak disagreement responses from the data set, since the inclusion of these responses did not turn out to give statistically significant difference. It is arguable that both of the weak positions, either agreement or disagreement responses, could be regarded as mildly undecided responses and that the participants might possibly experience conflict resolution to varying degrees. Thus, this potential variation in the conflict resolution process might have prevented us to observe a divergence among agreement and disagreement positions.

On the other hand, the other research question has been to understand the neural patterns of the indeterminate cases in which the participants could not decide on a response (since she got stuck in-between two or more options). This could be accepted as a very good instance for a conflicting case. The main assumption has been that these indeterminate cases (with the given response 3 as well as no response cases) will cause higher levels of neural activation among the left frontal regions. The empirical findings suggest that there have been significant levels of activation difference among the middle-left frontal channels when the indeterminate cases are compared to the all other cases. It is also important to mention that the confidence intervals for the indeterminate cases have been found out to be higher than in the other cases. One possible reason is that the number of such indeterminate cases has been relatively low. As the number of cases increases, the standard error might possibly decrease. Moreover, it is also arguable that each of the indeterminate cases might involve different levels of processing difficulty and conflicting situation. In other words, one of these cases might have been highly conflicting for the participant but another one might be less challenging and conflicting. Such variation in the neural patterns might be explained with these facts.

The last issue has been about the reaction time patterns of the participants regarding their responses. As initially expected, the strong judgments (response 1 and 5) are responded quicker than the others and there is no significant difference when these ones are compared. Moreover, the participants were observed to respond to the one with indeterminate/undecided (position 3) most slowly. When the strong and weak judgments are grouped separately and compared, it is also remarkable that there is a significant difference for the response times. Thus, people are observed to respond later when they have a weaker position and latest when they have an undecided position. It has also been found out that the participants tended to respond to the *farklıdır* propositions slower than to the *aynıdır* propositions. This finding supports the earlier empirical behavioral evidence that the *farklıdır* propositions are processed differently than the *aynıdır* propositions. Relying on the empirical evidence from the EEG/ERP experiments, the *farklıdır* concept might cause a semantic incompatibility situation during identity judgments when compared to the *aynıdır* concept. This semantic incompatibility might arise during the semantic/conceptual unification process as evidenced by the N400 signal, as explained in Chapter 7. However, the level of processing difficulty and conflicting situation may not be high enough, since there is no difference observed in neural patterns via optic brain imaging method.

To sum up, this empirical study has investigated the neural correlates of identity judgments in relation to the responses of the participants via optic brain imaging method. The obtained findings indicate a potential difference in neural activation related to conflict monitoring. The cases most strongly involving conflicting situations seem to cause a higher level of neural activation in the left prefrontal cortex (mainly including *dorsolateral* and *dorsomedial* regions) which is consistent with the academic literature. Moreover, the obtained results from the response time measurements have shed light on participants' level of confidence [certainty] in their judgments. A model depending on both the neural activation patterns as well as response times might be suitable for monitoring and predicting the reasoning and decision-making processes underlying participants' identity judgments.

CHAPTER 9

CONDITION-WISE COMPARISON and COMPUTATIONAL MODELING

In this chapter, the responses obtained from the behavioral tasks and the generated cognitive models are elaborated in detail from a comparative perspective. First of all, the responses to the Ship of Theseus question among different conditions are compared and contrasted. In this respect, the result patterns for one condition, namely the Visual Demonstration, were found to differ from the response patterns of the other conditions. Secondly, the predictive models including discriminant analysis, decision tree analysis, and neural network analysis were performed with the data sets obtained from Conceptual Tendency Tests during the experiments (excluding, however, the visual demonstration condition). Lastly, these models are compared with respect to their predictive success and the critical propositions within the models.

9.1 Condition-wise comparison

The responses to the Ship of Theseus question were compared in order to observe and test whether there are possible differences in response patterns. It was initially hypothesized that the bodily experience and visual demonstration conditions would cause a shift in the final decisions of the participants because of the potential effects of grounding their judgments in perception. However, it is noticeable that there is a general response pattern that has been dubbed "M-shaped" pattern in this thesis. The response pattern of the wooden model ship condition is also similar to this M-shaped response pattern but the response pattern obtained from the visual demonstration condition did not seem to reflect this pattern. For the visual demonstration condition, the responses were observed to shift mostly towards the Ship A as initially expected (33% weak responses for Ship A, 33% strong responses for Ship A). This pattern illustrated in Figure 9.1 occurred possibly because of the impact of the visual demonstration.

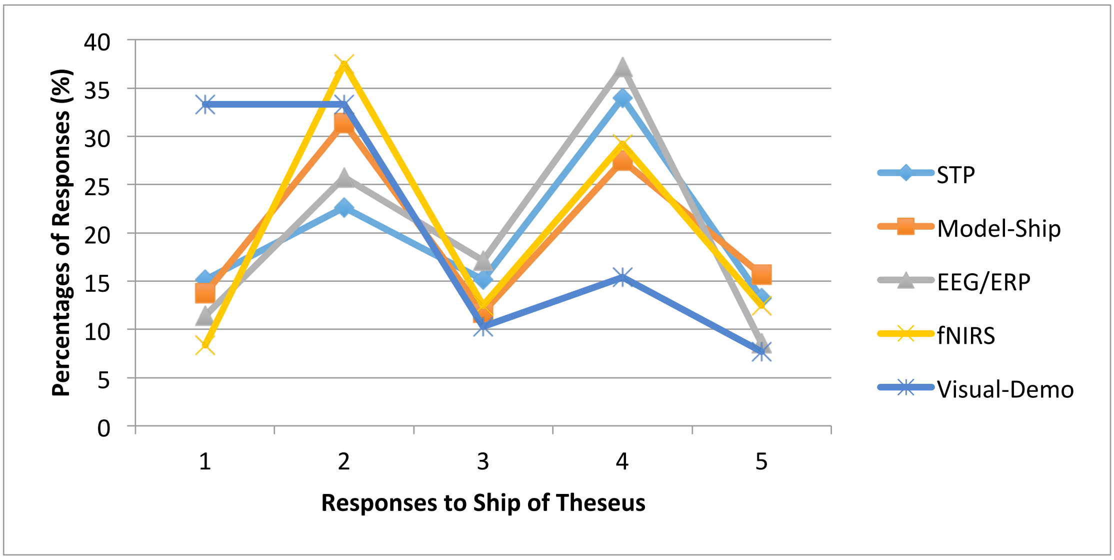


Figure 9.1 The patterns of the responses to the paradox in percentage are demonstrated. Visual demo condition (light blue line); model ship condition (red line); spatiotemporal proximity condition STP (dark blue line); fNIRS (purple line); EEG/ERP (green line). Responses 1 and 2 are for Ship A (strong and weak judgments, respectively); Response 3 is for the undecided position; Responses 4 and 5 are for Ship B (weak and strong judgments, respectively).

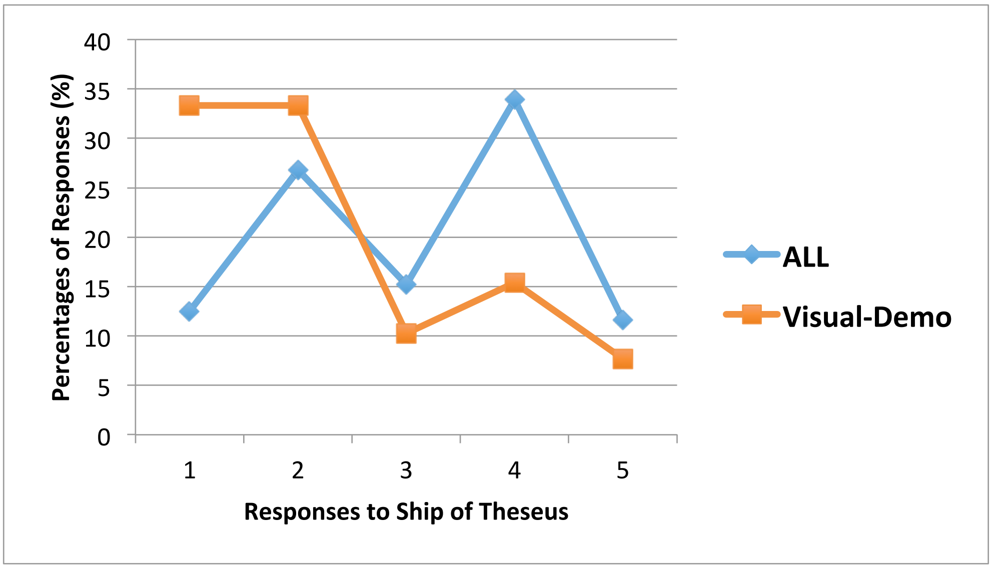


Figure 9.2 The patterns of the responses to the paradox in percentage are demonstrated. VD is used for visual demo condition (red line); all the other conditions are lumped together and shown as "ALL" (blue line). Responses 1 and 2 are for Ship A (strong and weak judgments, respectively); Response 3 is for the undecided position; Responses 4 and 5 are for Ship B (weak and strong judgments, respectively).

The condition-wise comparisons performed with Kruskal-Wallis test showed that the responses to the Ship of Theseus question in the Visual Demo condition significantly differed from the responses of the other conditions (V=9.168; df=3; p<.040). This difference in response patterns are also tested with the homogenous subset test that is a follow-up test of Kruskal-Wallis. It has also been shown that the response patterns in the visual demonstration condition deviates significantly from all the other conditions. To be more specific, the outputs from this follow-up test based on the Likert ratings have classified all of the conditions except the visual demo condition as a homogenous subset but the response pattern from the visual demonstration condition significantly differed from this pattern and was classified as a distinctive subset.

Table 9.1 Homogeneous Subsets based on ratings as a follow-up test of Kruskal-Wallis

Homogeneous Subsets based on Rating

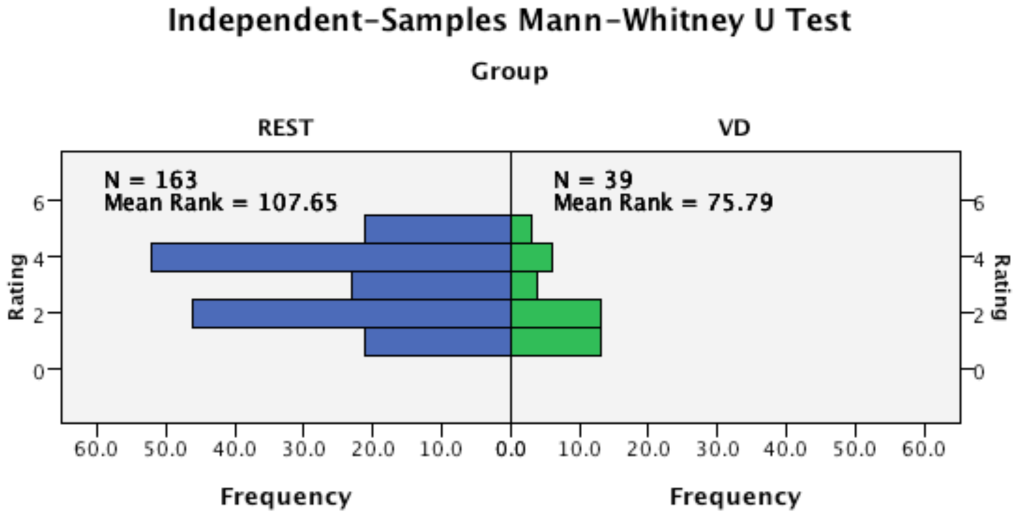
		Subset	
		1	2
Sample[1]	VD	64.154	
	MS		88.912
	fNIRS		89.271
	STP		91.491
Test Statistic		.[2]	.102
Sig. (2-sided test)		.	.950
Adjusted Sig. (2-sided test)		.	.950

Homogeneous subsets are based on asymptotic significances. The significance level is .05.

[1] Each cell shows the sample average rank of Rating.

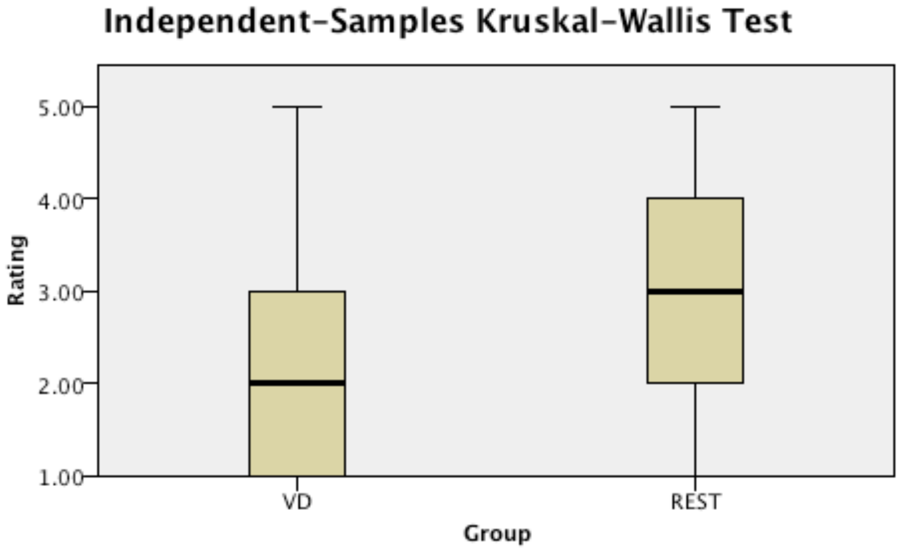
[2] Unable to compute because the subset contains only one sample.

When the response pattern of the Visual Demonstration condition is compared to all the other conditions (named as REST), the independent-samples Mann-Whitney *U*-Test and Kruskal-Wallis tests demonstrate that these samples are significantly different as shown in Figure 9.4 and Figure 9.5, respectively.



Total N	202
Mann-Whitney U	4,181.000
Wilcoxon W	17,547.000
Test Statistic	4,181.000
Standard Error	318.381
Standardized Test Statistic	3.149
Asymptotic Sig. (2-sided test)	.002

Figure 9.3 The results of the Mann-Whitney *U*-Statistics indicating that the response pattern of the Visual Demo condition is significantly different from the other conditions (lumped together under the label REST).



Total N	202
Test Statistic	9.915
Degrees of Freedom	1
Asymptotic Sig. (2-sided test)	.002

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because there are less than three test fields.

Figure 9.4 The results of the Kruskal-Wallis Statistics indicating that the response pattern of Visual Demo condition is significantly different than the other conditions (lumped together under the label REST).

This observed shift towards the Ship A response for the Visual Demonstration condition has a statistically significant difference in the overall response pattern relying on the results of independent samples Mann-Whitney *U*-tests when compared to the baseline condition (STP). Moreover, the result of statistical tests for pairwise comparisons support the idea that the responses in the visual demo condition have a different distribution pattern when compared to the baseline conditions. As can be seen in the following figure for the pairwise comparisons of groups, the average sample rank of the Visual Demo condition differs significantly from the rest of the experimental conditions.

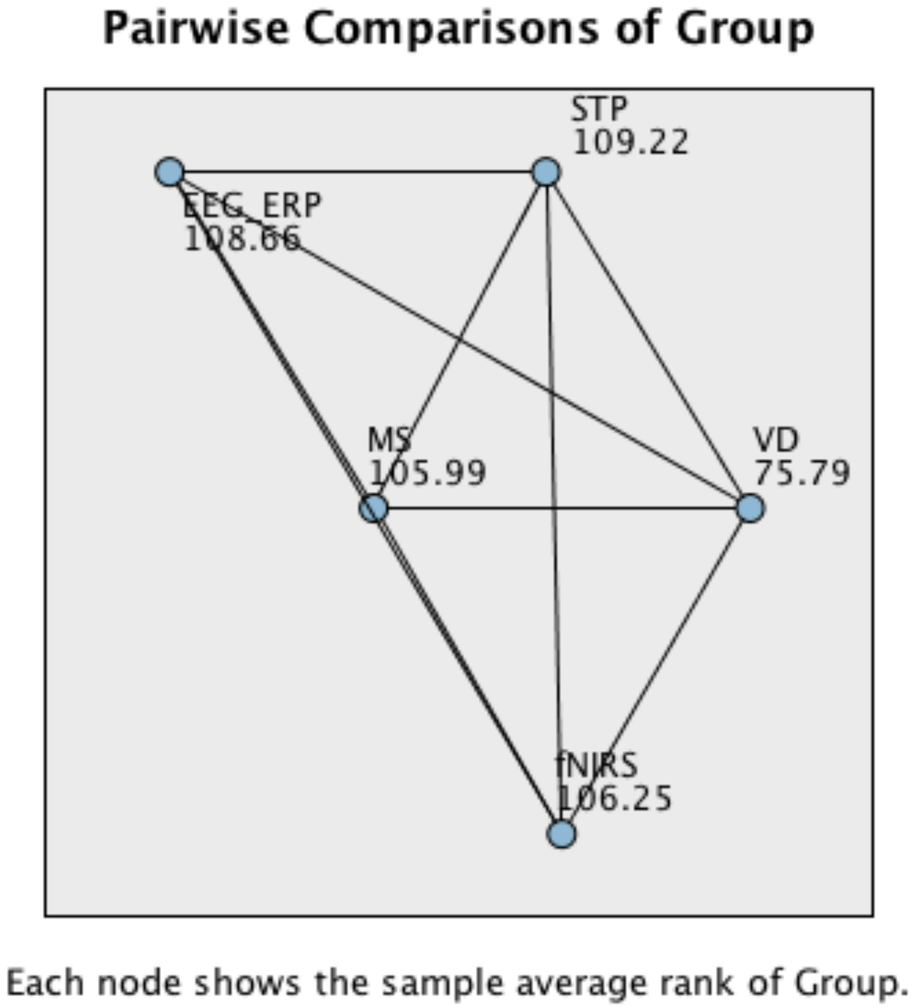


Figure 9.5 Pairwise comparisons of the response patterns to the Ship of Theseus from different experimental conditions.

Lastly, the results of the Pearson Chi-square test also support the view that the response pattern of the Visual Demonstration condition differs significantly from the rest that included the overall responses from the other conditions. The relevant table for demonstrating the results of the statistical analysis is presented below.

Table 9.2 The results of the Chi-square Test for comparing V-D to the rest

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.154[a]	4	.016
Likelihood Ratio	11.442	4	.022
Linear-by-Linear Association	9.696	1	.002
McNemar-Bowker Test	.	.	.[b]
N of Valid Cases	202		

a. 1 cells (10.0%) have expected count less than 5. The minimum expected count is 4.63.

These findings from the statistical tests support the claim that participants were influenced by the visual demonstration of the Ship of Theseus narrative during the experiment. To be clearer, the visual demonstration composed of the disassembly and reassembly processes might be a potentially influential factor on the participants. However it should be kept in mind that it might as well be the case that the decision screen (consisting of two visual images of the ships and the text) might have caused a perceptual bias towards Ship A, since Ship A always appeared on the right-hand side of the screen, throughout the experiment, suggesting spatiotemporal continuity with the original ship. Furthermore, participants had been initially informed about the merely illustrative purposes of the visual demonstration. This instruction, however, pertains to both ships, and therefore cannot explain the different response pattern observed. We will come back to the possible reasons for this shift, including the perceptual effect of the condition, in the next chapter (Chapter 10).

9.2 Computational models of the CTT data

One of the initial aims of this dissertation has been to provide a quantitative model based on the Conceptual Tendency Test CTT to predict the responses to the critical Ship of Theseus question. The fundamental reason for providing a predictive model for the Ship of Theseus was to understand whether there are discernable patterns in the cognitive underpinnings of the identity judgments as well as whether phrasing the propositions with *aynıdır* and *farklıdır* would make a difference. The first computational models performed with the STP data provided an initial basis for the next steps. Then the next issue was to lump the behavioral CTT data from the STP, the wooden model ship and the fNIRS conditions together, in order to contrast them collectively with the visual demonstration condition. The CTT data from EEG/ERP condition was not included due to the fact that there were several missing CTT data possibly due to the fact that the experiment was run at a quite fast pace and some participants therefore missed to respond to some of the propositions in the CTT. On the other hand, the CTT from the visual demo condition was not included it yielded a significantly different response pattern, as presented in detail above. Thus, it is not plausible to include this data set.

9.2.1 Discriminant Analysis (DA)

Discriminant Analysis (DA) is a statistical method based on linear combinations of features that are used for characterizing or distinguishing two or more events. The classification of performed for the dependent variables (here, Ship A or Ship B responses). DA is also similar to ANOVA and regression analysis. The analyzed features are the propositions in the CTT. The classification between the dependent variables is aimed to provide an explicit model in terms of these items in the CTT. DA is commonly used for classification of two or more sets (Klecka, 1980). Therefore, it allows determining the possible predictors among the items within the CTT. One of the main assumptions of DA is that the covariance matrices of the dependent variables (Ship A and Ship B responses) are homogeneous, i.e., equal across groups (the set of predictors). This assumption is tested by Box' Test, which turned out to be significant, see Table 9.3 below, indicating that this assumption is violated. However, it is advised to ignore Box' Test when sample sizes are equal because then Box' Test becomes unstable in this case (Field, 2013, p. 643).

For performing the discriminant analysis method on the data set, the responses were classified as Ship A and Ship B responses. Thus, the weak and strong judgments for Ship A were lumped together as well as for Ship B and the undecided responses were eliminated. It is important to note that a set of propositions was selected on which this analysis was performed. This selection ensured that Wilks' Lambda was at an acceptable significance level. If all of the 48 propositions are selected for DA, then the predictive success increases up to 81.4%. However, the significance level of Wilks' Lambda was .331, i.e., it was insignificant, indicating a possible overfit of the model. Thus, the most important propositions were chosen mainly in terms of the test of equality of means. Thus, the final LDA was run with the following propositions: 24F, 17F, 22F, 6A, 18F, 2A, 12F, and 10F.

These 8 propositions provided an DA model with 74.3 % of predictive success (*p*=.003, see Table 9.5 below). The structure matrix presents the weights and direction of the propositions in the model, see Table 9.6 below). The canonical correlation is calculated as .508 that shows the association between the set of independent variables, i.e., the responses to the propositions. The discriminant scores are also calculated with the use of this correlation value.

Table 9.3 Results for the Box's M test

Box's M		.281
F	Approx.	.279
	df1	1
	df2	36955.001
	Sig.	.598

Tests null hypothesis of equal population covariance matrices of canonical discriminant functions.

Table 9.4 Results for the Eigenvalue Test

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.348[a]	100.0	100.0	.508

a. First 1 canonical discriminant functions were used in the analysis.

Table 9.5 Results for the Wilks' Lambda Test

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1	.742	31.178	13	.003

Table 9.6 Structure matrix for the discriminant analysis. This is calculated with pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. Variables ordered by absolute size of correlation within function.

	Function
	1
P24F	.431
P17F	-.424
P6A	.313
P18F	.296
P2A	-.245
P10F	-.214
P15A	-.211
P2F	.169
P20F	.132
P11A	-.074
P8A	.065
P23F	.064
P23A	.063

Table 9.7 Classification Results for the Linear Discriminant Analysis (LDA)

Ship A or Ship B			Predicted Group Membership		Total
			Ship A	Ship B	
Original	Count	Ship A	40	16	56
		Ship B	13	44	57
	%	Ship A	71.4	28.6	100.0
		Ship B	22.8	77.2	100.0

a. 74.3% of original grouped cases correctly classified.

The outputs from the Structure Matrix indicate that there are several important predictors for this linear discriminant model. Ship A respondents tended to reject that P24F (a yellow banana turned into brown) is true, that is, they did not agree that a banana turning brown meant that it was a different banana, since it can still be evaluated as an object within the banana category despite the fact that its color had changed. They may argue that it is still an edible fruit as such, thus it is still 'functional'. On the other hand, Ship B respondents tend to accept that P24F is true, since the banana has experienced a considerable change. They may argue that its physical features are not restricted to its color but also consider a change in internal composition and thus its essence. On the other hand, P17F (a reassembled robot after full disassembly) turned out to be another crucial predictor for this model. Ship A respondents tend to accept that this robot can be evaluated to be different possibly due to the fact that there is no emphasis on its ongoing functionality. Rather, Ship B respondents tend to reject that this robot is different probably because of having all parts recombined and there is no change due to its parts. The third proposition in the Structure Matrix, P6A, is about a piece of paper bent over three times. Ship A respondents tended to reject that P6A is true that means a piece of paper bent over three times is not the same. This clearly illustrates that these functionalist participants probably assumed that this piece of paper is not functional anymore because of being bent over. However, Ship B respondents tended to accept that this piece of paper is the same in spite of the physical distortions it had possibly because of the belief that it can be turned into its initial shape if it is necessary – after all, its essence has been preserved. Ship A respondents tended to reject that a person with a prosthesis leg instead of a normal leg is different (P18F). In other words, they have a tendency to accept the person as remaining the same possibly due to the role of the prosthesis leg to preserve the very function of a leg. On the other hand, Ship B respondents tended to accept that a person with a prosthesis leg was different, possibly because of their essentialist perspective, since one of the essential parts of an individual, her leg, had been changed.

9.2.2 Decision Tree Analysis (DTA)

Decision tree analysis is a widely used method in the fields of operations research for providing decision support systems. Decision tree analyses have been useful for modeling the possible behavior patterns of a system and it is also used to provide an algorithm derived from tree-like graphs that are used as visual support tools. They are easier to understand and explain the facts from which the decision rules are inferred. When the decision tree analysis was applied to the current data set, it resulted in a model consisting of 8 propositions that have 80.5% predictive success for Ship A or Ship B judgments. The most significant predictor of the model was P17F (a reassembled robot that is fully disassembled) again, as in the previous statistical and computational models. However, there are other propositions also that are highly relevant for this model, see Figure 9.6.

Table 9.8 The classification success of the Decision Tree Analysis

Observed	Predicted		
	Ship A	**Ship B**	**Percent Correct**
Ship A	51	5	91.1%
Ship B	17	40	70.2%
Overall Percentage	60.2%	39.8%	80.5%

Growing Method: CHAID; Dependent Variable: Ship A or Ship B

The model is more successful to classify Ship A respondents than Ship B respondents, as can be seen in the Table 9.8 above. It could therefore be argued that the model might have an internal bias towards the Ship A option. Alternatively, it might be argued that some of the Ship B respondents demonstrated response patters in the CTT very similar to Ship A respondents which might have caused their misclassification. Therefore, a question regarding this misclassification appears: is the possible that the group of Ship B respondents is not a homogenous group and there might be a minority group among the Ship B respondents that are more similar to Ship A respondents? Or is this misclassification caused by the decision tree analysis? Since the Box's M test for discriminant analysis indicated that the equality of covariance matrices of canonical discriminant functions are not equal ($p>.598$), it is possibly the case that the group of Ship B respondents is relatively homogeneous. The decision tree model provides the highest value as a predictive model and it is also easier to understand the decisions of this model through the visual diagram, see Figure 9.6. However, its functionality and generalizability should be inspected in more detail because this kind of model should not be limited to explain the current data set successfully but it should provide an insightful account that is compatible with the theoretical background and should claim validity and generalizability with larger data sets. Despite the fact that these are general claims that any model should fulfill, it is specifically important for the present case that includes conceptual tendency tests including ambiguous propositions.

P17F is the terminal node, which showing its critical role in the statistical analyses and at the same time its construct validity since the proposition is highly similar to the the Ship of Theseus question. Moreover, it is also remarkable that some of the classifications rely on only one or two propositions such as the weak disagreement responses to P17F that have been classified as Ship A respondents. However, the output of this node shows 50% percent of predictive success (that has the predictive success at the chance level), since 14 of 28 participants chose the Ship A as Ship of Theseus. On the other hand, the indeterminate responses to P17F has been linked to another node, P10A (an object that has its molecules conserved for 1000 years) and the final output gave 100% successful classification with respect to their response. Although this seems to be a very successful classification, it should also be remarked that there is only 1 participant in the group who strongly agreed with P10A given that she has an indeterminate position to P17F. Thus, it is highly crucial to note that the model's predictive success might not provide similar level of success with a larger data sets. Here, we should highlight potential problems related to the generalizability issue. Moreover, although this decision tree model provides a very practical and predictively successful account for the overall framework, a possible argument could be raised with respect to the reduction problem, since the model generally attempts to reduce the decisions to very few propositions, e.g., to 1, 2 or 3 propositions. This raises an important issue for a predictive model especially if the propositions are formed from identity judgments with such a loose and ambiguous conception as sameness. A model based on 2 or 3 propositions might be misleading. Moreover, the decision tree provides an account for determining local patterns of behavior but it is not possible to observe and infer general patterns of the responses.

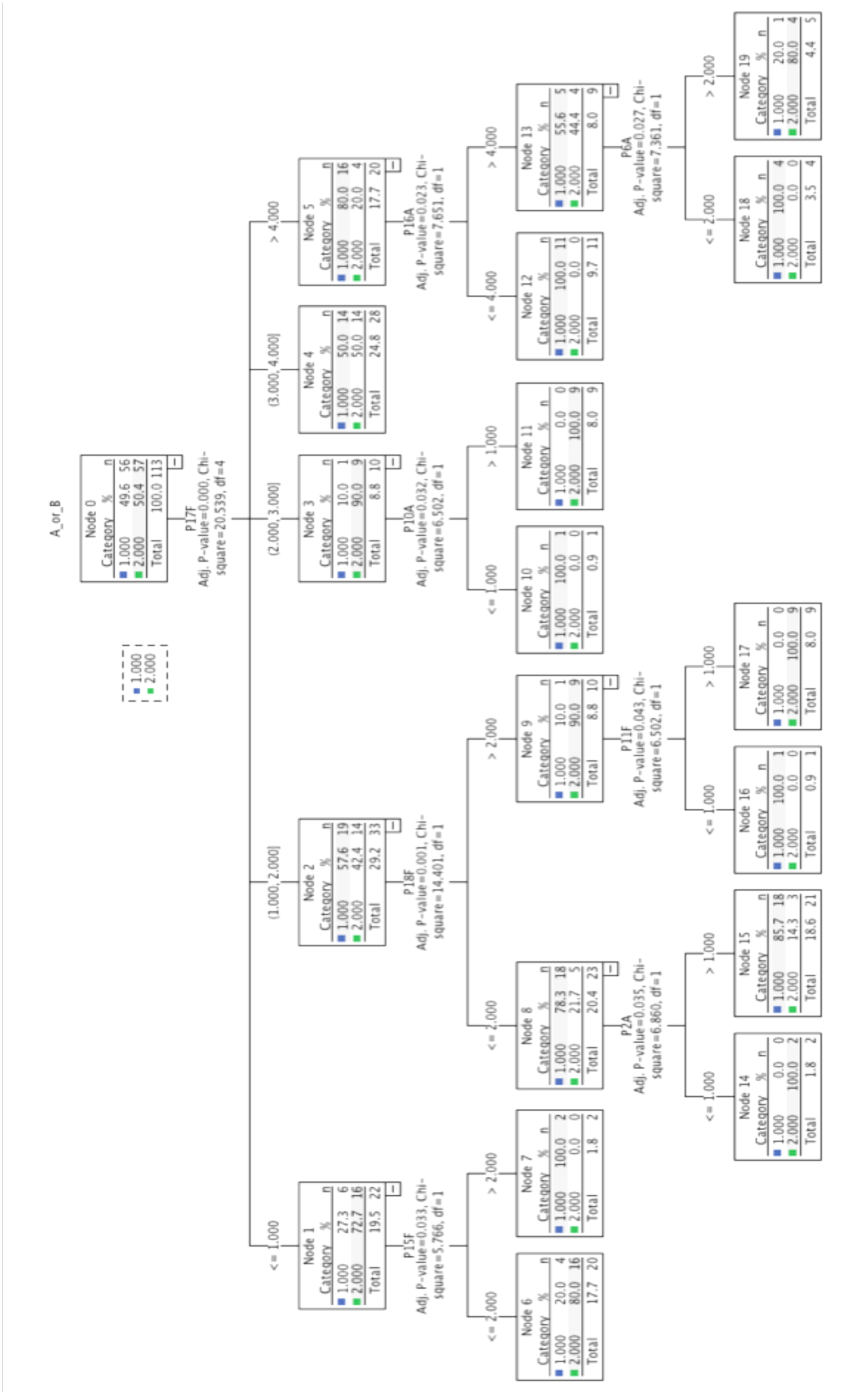


Figure 9.6 The output of the performed decision tree analysis

9.2.3 Neural Network Analysis (NNA)

Neural Networks are known as a class of statistical learning methods that are inspired by the working principles of the human brain and more specifically neurons. The main target is the estimation of the relevant functions relying on the patterns in large data sets. As neurons in the brain are interconnected with each other, in neural network models the units/nodes have connections and the strength of these connections are expressed in terms of adjustable numerical weights. Thus, through a learning process, the interconnections between the units are adjusted for the learned item. For the current data, a multi-layered perceptron was chosen. A multi-layered perceptron composed of three main parts (input neurons, hidden layer, and output neurons) is a more complicated but successful model of the human brain network. In this dissertation, we are interested in detecting the response patterns of our participants in the CTT successfully by Neural Network Analysis and then to predict the responses to the Ship of Theseus. Neural Network Analysis (multilayer perceptron) was performed with the following parameter settings:

Table 9.9 Parameter Settings for the Neural Network Analysis

50% of the cases were used for training and the rest for test
Activation function: Hyperbolic tangent
Type of training: Online
Number of hidden layers: 2
Number of units: Automatically computed
Initial learning rate was set to 0.1
Lower boundary learning rate was 0.001
Learning rate reduction in epochs: 10
Momentum: 0.5
Interval center: 0.5
Interval offset: +/- 0.5
Maximum training epochs was computed automatically

Table 9.10 Model Summary of the Neural Network Analysis

Training	Sum of Squares Error	8.969
	Percent Incorrect Predictions	18.3%
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	0:00:00.04
Testing	Sum of Squares Error	12.096
	Percent Incorrect Predictions	28.3%

Dependent Variable: Ship A or Ship B
a. Error computations are based on the testing sample.

Table 9.11 Classification Summary of the Neural Network Analysis

Sample	Observed	Predicted		
		Ship A	**Ship B**	**Percent Correct**
Training	**Ship A**	23	8	74.2%
	Ship B	3	26	89.7%
	Overall Percent	43.3%	56.7%	81.7%
Testing	**Ship A**	19	6	76.0%
	Ship B	9	19	67.9%
	Overall Percent	52.8%	47.2%	71.7%

Table 9.12 Independent Variable Importance Analysis for the Neural Network Analysis

Indep. Var.	Importance	Normalized Importance
P24F	.081	87.3%
P17F	.092	99.4%
P6A	.073	79.1%
P18F	.070	75.9%
P2A	.085	91.1%
P10F	.093	100.0%
P15A	.069	73.9%
P2F	.091	97.5%
P20F	.068	72.9%
P11A	.080	86.1%
P8A	.072	77.2%
P23A	.070	74.9%
P23F	.057	61.5%

The results obtained from the Neural Network Analyses indicate that the subset of propositions including P10F, P17F, P2F, and P2A have greater importance for the NNA model, with over 90% of normalized importance. Firstly, it is important to note that 3 of 4 of these variables are *farklıdır* propositions. In addition, some of these propositions had already relatively high importance in the discriminant analysis and the decision tree analysis. In spite of the similarities in the critical propositions within these models, there are also differences regarding the propositions in the model that will be further discussed in the following, to get a better understanding of the model. P10F (a non-living object preserved for a thousand years is different) is the most crucial predictor of this NNA model. Ship A respondents tend to accept that P10F is true, since the functionality of the object is not clear and they possibly concluded that it is out of function. On the other hand, Ship B respondents tend to reject this proposition. It is understandable that they tend to evaluate an object not to be different since all of its parts (even molecules are preserved) – thus, its essence is preserved. P17F (a reassembled robot after full disassembly is different) also figures importantly in the current NNA; it has already been explained above in the linear discriminant analysis section. The next two propositions are from P2. Both *aynıdır* and *farklıdır* versions are found to be highly significant for the model. P2 is about whether monozygotic twin are the same/different. For the case of P2F, Ship A respondents tend to believe that monozygotic twins are different relying on the fact that they are separate individuals. On the contrary, Ship B respondents tend to focus on the physical similarities and, in fact, genetic identity, and provide a judgment in terms of essence: in this respect monozygotic twins are same from a qualitative sense of identity. However, Ship A respondents tend to have a numerical sense of identity for the monozygotic twin case in terms of individuation. In this respect, for functionalists, it might be the case that individuation, sortals, might be one of the essential factors during their identity judgments. On contrary, the essentialists do not seem to focus on this and they possibly tend to accept the split icebergs as the same but for a functionalist, it might not be the case, since any function relying on a unit that carries out this function will not exist by the distortion of individuation as in the split of the iceberg case. To sum up, Ship A respondents tend to be more sensitive about the functionality and structure of the presented objects rather than the physical features and their essential qualities. If there is no direct emphasis on the ongoing functionality they might assume that it is possibly not functional anymore and may have lost its structure. Ship B respondents tend to focus on the preserved physical features and similarity of an object with respect to its initial and final positions (at different times). Going back to the eye-tracking results, it might be claimed that since the Ship B respondents in the visual demonstration condition tried to resolve the identity question regarding the text since the Ship A had the very similar appearance with the original ship. On the other hand, if there is more than one object, then they shift their focus towards the comparison of these objects on the grounds of physical similarity or essential qualities.

9.2.4 General Evaluation and Comparison of the Computational Models

Three different computational models were generated from the CTT data to predict participants' responses to the Ship of Theseus question. The very initial aim was to provide a strong predictive model for the Ship of Theseus narrative as a baseline model. Then, it would be possible to infer whether the experimental conditions caused any change among the responses to the Ship of Theseus question. A strong model would be able to indicate responses that might deviate from the expected pattern. However, since only one of the experimental manipulations, the visual demonstration, yielded a significant change in pattern, we renounced this initial aim. Rather, all experiments that yielded qualitatively similar response patterns, were considered together and a general model was generated for them. In this context, it is crucial to highlight the bimodal distribution observed as the general response pattern in the Ship of Theseus narrative. Thus, it seems to be the case that overall the responses of the participants demonstrated a general pattern which we dubbed "M-shaped" response pattern, even across different modalities of presentation – except the Visual Demonstration condition. Secondly, the generated statistical/computational models provided insight into the difficulty of providing statistically valid and generalizable models, since the participants experienced conflicting tendencies during the challenging propositions in the CTT. Besides that, the models based on the CTT to predict the outcome to the Ship of Theseus question indicated that it is possible to provide models whose predictive success ranges from 71.7% to 80.5%. The decision tree model is the best model in terms of predictive success (up to 80.5%) but it seems to face problems of generalizability and explanatory adequacy, since – although the model may classify the current data successfully – it may fail to do so on a different data sheet. Thus it might be the case that the predictive success of the model decreases as the data set gets larger. Moreover, P17F, P15F, P18F, and P10A appeared as the most crucial predictors within this model. On the other hand, Linear Discriminant Analysis resulted in a model of 74.3% predictive success. The strongest predictors were P24F, P17F, P6A, and P18F in decreasing order. Thirdly, the Neural Network Analysis resulted in a model of 71.7% predictive success. The most critical propositions of this NNA model are P10F, P17F, P2F and P2A. It is remarkable that, in all models, 3 of 4 predictive propositions are *farklıdır* propositions that might point to a distinctive role of considering "differences" rather than "sameness" for predicting the responses to the Ship of Theseus question. One may argue that the roles of the *farklıdır* and *aynıdır* predicates might highly differ depending on the presented context and the role of *farklıdır* might have higher significance for answering the Ship of Theseus quesetion. On the other hand, it is remarkable that P17F but not P17A has gained a crucial role in all of the models. This is understandable to the extent that this proposition is highly similar to the Ship of Theseus case itself, since it questions the sameness of a reassembled robot after full disassembly. The distinction between *aynıdır* and *farklıdır* regarding their roles in the computational models is an important issue to be further discussed in the next chapter.

CHAPTER 10

GENERAL DISCUSSION

This dissertation was initially focused on the role of conceptual processing during identity judgments especially through the perspective of embodied/grounded cognition. One of the other main research questions has been to manipulate the reasoning processes and final decisions of the participants to the Ship of Theseus narration by presenting different behavioral tasks composed of perceptual factors that might have an influence on the cognitive process and final decisions of the participants. It was also our interest to grasp the conceptual underpinnings of the participants through a Conceptual Tendency Test composed of 24 same (*aynıdır*) and 24 different (*farklıdır*) judgments. As a methodological limitation, it should be borne in mind that we used a language-based measurement and thus had to allow for possible language interference by obtaining verbal responses on a 5-point Likert scale during the identity judgments. This, however, is a commonly used methodology in other studies in the relevant academic literature.

10.1. Evaluation of the Empirical Findings from the CTT

Since identity is considered as a vague concept especially because of the insufficient consensus on this concept, judging identity in terms of "same" and "different may be controversial since they are in semantic opposition and might be interpreted differently depending on the context. The results of the identity judgments as well as the responses to the Ship of Theseus question may point to a possible conceptual instability in the sense that participants may be overloaded with *aynıdır* and in particular with *farklıdır* judgments during the CTT. The main underlying reason might be the vagueness, ambiguity, and abstractness of the identity judgments; thus the participants are possibly pushed towards two opposing poles. The Ship of Theseus narration might have caused a conceptual instability similar to the perceptual instabilities, underlying the visual illusions such as the Necker Cube, where people experience perceptual instability over two alternative interpretations of the cube. However, the conceptual instability while deciding on the paradoxical Ship of Theseus narration appears to be different in the sense that the processing of identity involves both modal and amodal components whereas the perceptual processing of visual illusion relies only on modal components. Unless a strict and philosophical sense of identity has been defined and applied, as Chisholm (2004) did, identity judgments seem to be performed on different criteria that are highly context-dependent and ambiguous. It is an empirical fact that people violate the rules of basic principles of identity during their judgments. Thus, one might accept both parts of a split iceberg as being the same as the original one (Rips, 2011). Thus, sameness judgments seem to be made on the basis of a common sense meaning of identity and possibly the similarity aspect of identity dominates the judgment. We were interested in observing how participants tended to disambiguate the given set of propositions. Our related research question was whether there are strong intuitive tendencies with regards to functionalist or essentialist perspectives. Thus, throughout this study, participants were not provided a basic sense of identity to apply on their judgments but instead were instructed to respond intuitively in the Conceptual Tendency Test (CTT) composed of 48 propositions half of which were *aynıdır* (same) and half of which were *farklıdır* (different) judgments.

Despite the vagueness of the identity concept that might cause ambiguity depending on the context, participants have strong tendencies to agree on some of the cases like the sameness of two water molecules. The sameness judgments were most probably made in terms of their similarity with respect to qualitative identity, since both of these water molecules are considered to have high physical and functional similarities. These observations about the same and different judgments demonstrate that participants generally might not be seeking for the identity in a strict and philosophical sense. They might focus on the kind domain but disregard numerical identity especially for unobservable instances like two water molecules. Thus, it is highly plausible that the meaning of sameness they applied is very similar to the one we often use it in our daily language. Moreover, similarity has been defined as one of the strongest forces during identity judgments. In the case of the water molecules, participants tend to respond regarding the basic-category levels of these objects (Hall, 1998), here, "water". However, application of the similarity concept seems to be highly domain-specific, and participants do not tend to carry it over to the human domain, and here specifically to the cases of personal identity. For instance, a person after organ transplantation is generally not perceived as the same even though she will still be perceived as human (Blok et al. 2001). In other words, participants are highly sensitive in their same and different judgments in the human domain, specifically for personal identity judgments. Meanwhile they could apply the same concept to other domains much more easily. A possible explanation for this response pattern in personal identity judgments might be provided in terms of individuation by names. If no names are provided, personification might have been disregarded. If the proposition explicitly mentioned a specific person (i.e. Tim or Susan) undergoing organ transplantation surgery, the results might have been indicating that Tim (or Susan) is accepted as the same (in the "same" condition, or, in the "different" condition, not as different, respectively).

10.2. The processing differences between *Aynıdır* and *Farklıdır*

The findings from the Conceptual Tendency Test (CTT) imply a number of controversial issues to be discussed in detail. First of all, participants seem to be very sensitive in their concept application of identity (in terms of *aynıdır* and *farklıdır*) to the human domain. They are more likely to apply identity in a 'strict and philosophical sense' that results in disagreement with the propositions involving organ transplantation, memory chip implantation and others as mentioned above (Chisholm, 2004). These findings indicating that individuals (humans) are not considered to persist as the "same" after some transformations are consistent with the findings in the relevant literature (Rosengren et al., 1991). The empirical findings by Rosengren et al. (1991) illustrate that even preschool children tend to judge animals and artifacts to persist as the same objects with respect to the causes of the transformations presented. It might be the case that these judgments are done in terms of a looser and more popular sense of identity for the questions related to animals or artifacts. In this dissertation, sameness judgments about the human domain might have been performed on the basis of a different sense of identicalness. The different senses of the sameness/identity concept have already been explained through a couple of instances by Quine (1963). The empirical findings by Keil (1989) and Blok et al. (2001) also indicate that different senses of identity or sameness could be perceived depending on the experimental procedure and context. To be more specific, people might be focusing on different aspects of identity with respect to the relevant kind domain and how the propositions are framed.

Secondly, there is probably a processing difference for *aynıdır* and *farklıdır* conditions during identity judgments that manifest itself in a number of occasions, where responses to *aynıdır* versus *farklıdır* pairs do not seem to be symmetric on the 5-point Likert scale. However, for most of the propositions *aynıdır-farklıdır* responses are symmetric. The issue of (a-) symmetry then appears to be a specific to certain propositions, e.g. P17 (a reassembled robot after full disassembly), which shows an asymmetric pattern. This observed asymmetry pattern for *aynıdır* versus *farklıdır* responses might be due to the fact that the conceptual vagueness of the identity concept is more dominant for certain kind domains. Additionally, the semantic interpretation of *aynıdır* and *farklıdır* might cause different associations due to the ambiguity arising during these judgments. Thus, differences between *aynıdır* and *farklıdır* responses might occur depending on how participants tend to disambiguate these propositions within the given frames. For the most critical proposition with respect to the proposed cognitive models, P17 (a reassembled robot after full disassembly), participants tend to agree that it is the same after disassembly and reassembly (68.6% agreement versus 24% disagreement positions) for the *aynıdır* condition. One might therefore expect to observe a symmetric pattern for its counterpart in the *farklıdır* condition. However, participants in the *farklıdır* condition slightly tended to agree that the robot was different after these transformations possibly depending on how they disambiguate this proposition (50.4% agreement versus 42.3% disagreement responses). The computational models presented in the previous chapter indicate that Ship A respondents that are considered to be functionalists tend to accept P17F possibly due to the fact that there is no explicit expression on the ship's ongoing functionality. However, Ship B respondents tend to reject P17F possibly because it consists of the same parts after the reassembly. Interestingly enough, Ship A respondents tended to accept P17A even though they were expected to reject it, since they were expected to respond symmetrically with respect to P17F. It might be the case that Ship A respondents tended to focus on the persistence of physical properties but they might have neglected functional aspects or they might have assumed the preservation of the functional properties for the *aynıdır* case.

Thirdly, participants tended to respond to propositions with *farklıdır* more slowly than to propositions with *aynıdır*. Our initial hypothesis was that there would be no difference in reaction times for these conditions. However, two different experimental setups, one standard experimental design with E-Prime and one with OpenSesame (for the fNIRS design), both yielded longer reaction times for *farklıdır* propositions than for *aynıdır* propositions. One of the explanations why identity judgments might have been processed and resolved quicker for *aynıdır* is that the concept of identity is more frequently and strongly associated with the concept of sameness than with the concept of difference. In other words, the effect could arise due to a familiarity effect. More specifically, the nominal concept of "identity" has positive valence as does the adjectival concept "same" – hence, they are congruent in this respect. The adjectival concept "different", however, has negative valence – hence, "identity" and "different" are incongruent. There is empirical evidence in the literature that clearly shows that congruent items are processed more quickly than incongruent items. Not limited to linguistic processing, this difference in processing between congruent and incongruent items has been demonstrated to cause significant reaction time differences as observed in the Stroop Task and Flanker Task (Stroop, 1935; Jensen & Rohwer, 1966; Heil et al., 2000). In other words, people process incongruent items more slowly than congruent items.

The processing of congruent and incongruent words is supported by the semantic/conceptual unification network that is responsible for the assembly of a word unit into the whole sentence. Various factors influence the processing network such as world-knowledge, discourse and sentence-internal semantic information (Hagoort et al., 2009). Interestingly, the anomalies related to the word meaning within this network are found to occur no later than 500 milliseconds after the target word has been presented. Accordingly, the unification process with incongruent items probably causes a conflict within this network that results in a delay in responses when compared to their congruent counterparts. There are several fMRI studies indicating that a semantically incongruent condition as opposed to a semantically congruent condition causes a higher level of activation among the left inferior frontal gyrus (left IFG) that is considered to be one of the brain regions supporting this unification network (Baumgaertner et al., 2002; Friederici et al., 2003; Hagoort et al., 2004; Hoenig & Scheef, 2005; Kiehl et al., 2002; Kuperberg et al., 2000, 2008; Newman et al., 2001; Rueschemeyer et al., 2006). Furthermore, several EEG/ERP experiments were performed to study the semantic processing differences between congruent and incongruent conditions (Kutas & Hillyard, 1980; Hagoort & Brown, 1994; Holcomb, 1993; Van Berkum et al., 1999; Kutas & Federmeier, 2000). These and other related studies demonstrated that various semantic anomalies including world knowledge violations, semantic violations and sensitivity to context trigger an event-related potential referred as N400 in the literature. On the background of these studies, we were interested in learning whether this delay in response time for the *farklıdır* condition would cause a similar activation in the semantic/conceptual unification network

10.3 Evaluation of the Empirical Findings from the Behavioral Tasks in relation to the Mode of Presentation

The presentation of the Ship of Theseus narrative in the behavioral experiments varied according to modality. These modalities are bodily experience with wooden model ships, and visual demonstration via eye-tracking One of the main goals of this dissertation has been to present different factors regarding the Ship of Theseus narrative and to observe whether they affect participants' responses. Cognitive and perceptual factors were considered, according to the grounded cognition framework. For the narrative STP conditions, one may argue that spatiotemporal proximity was a crucial factor during identity judgments, since people take spatiotemporal continuity as one of the main factors for identity, thus, different framings of STP might lead to deviations in the final responses to the Ship of Theseus question (Plous, 1993). On the other hand, perceptual factors were tested in two of the experimental conditions, specifically, bodily experience with wooden model ships and visual demonstration. Despite the fact that identity judgments are considered as a kind of conceptual reasoning processes performed mainly in relation to the conception of identity, these perceptual factors are hypothesized to influence the participants in a way that their conceptual reasoning processes will be affected by the relevant (Simmons et al., 2007). In the bodily experience modality, participants were thus engaged with the provided materials by which their cognitive states could become integrated with their bodily states and physical actions during the disassembly and reassembly processes (Barsalou et al., 2003; Niedenthal et al., 2005).

10.3.1 Textual Condition: Understanding the Effects of Spatiotemporal Proximity

First of all, the influence of spatiotemporal proximity was tested with designing two STP conditions: high and low STP. The basic idea has been to observe the effects of different STP conditions on the reasoning process in the Ship of Theseus narrative. For the low STP condition, the duration of the reassembly process for combining the old parts to construct Ship B was presented as 5 years at the same port. This closeness in time and space as opposed to the high STP condition of 50 years for the reassembly process at a distant harbor has been considered as a significant factor for the reasoning processes considering the emphasis for spatiotemporal continuity in the relevant literature (Scholl, 2007). These durations were proposed deliberately since there was no prior study related to the STP of disassembly and reassembly processes in the literature. In addition, our main criteria was to present a realistic setting for the two STP conditions by which the Ship of Theseus could be rebuilt in one's life time for the low STP condition. These different framings of STP were expected to cause different responses, since people are highly susceptible to external factors that act as cognitive biases during judgments and decision-making (Revlin, 2012; Clark, 2009). However, the obtained results indicate that our participants were not likely to be influenced by the presented framing differences as in these STP conditions. It seems that they were more involved in the other elements of the text and more general conceptual reasoning process might have dominated their identity judgments during reading the text. Thus, this kind of framing did not cause a shift in responses as initially expected most probably due to the fact that participants were not exposed to both STP settings, and thus could not compare among them. Such a comparison may, however, may be necessary in order to highlight the STP factor. This, obviously, was not possible – the narrative could be presented only once. However, it might be the case that a more salient STP difference among the conditions might cause the expected shift in the responses to the Ship of Theseus question. Such changes in settings might be investigated in future studies. After obtaining no differences in the two conditions, the response patterns in these conditions were accepted to be the baseline pattern in the narrative modality, as both gave highly similar outputs. Against the background of this baseline pattern the response patterns from the other conditions were evaluated.

10.3.2 Modal Condition I: Bodily Experience with Wooden Model Ship

Secondly, an experimental condition in which participants were exposed to two wooden model ships was devised. More specifically, this task was aimed to provide bodily engagement of the participants with the wooden model ships while simulating the narration. The visual modality in combination with bodily states and physical actions were considered to 'ground' them during the task and decision-making (Caligiore et al., 2010; Tucker & Ellis, 1998). The initial hypothesis was to test whether participants would tend to prefer Ship B as the Ship of Theseus, since Ship B was disassembled and reassembled within a relatively short period of time while comprising the identical parts of the initially introduced Ship of Theseus. Moreover, Ship A was not presented with any further indication of any functioning features and spatiotemporal continuity which may create a possible bias towards Ship A. The results for the Ship of Theseus responses, however, demonstrate no tendency to prefer Ship B as opposed to Ship A. Rather they had a slightly higher but not significant preference for Ship A. Moreover, there was again the M-shaped pattern when all of the responses to the SOT question were plotted in reference to the 5-point-Likert Scale. Thus, our initial hypothesis was rejected by these empirical findings in the sense that there was no significant shift towards the Ship B response when compared to the baseline (STP) condition. This might be due to the fact that the bodily experience of the disassembly and reassembly processes did not contain any contrastive pieces of information when compared to the information provided in the narration of Ship of Theseus itself. In other words, Ship B is clearly the compositionally identical ship both in the given task and in the narration. Moreover, participants were asked to perform the simulation in-between reading the text specifically during the disassembly and reassembly processes rather at the beginning of the text. Then participants reengaged with the narration and read the remainder of the text and then finally they answered the question at the very end of the narration. Thus, it might be the case that due to this rather serial procedure participants were possibly not influenced sufficiently so as to respond in the hypothesized direction. It was probably not the case that there was no effect due to the bodily experience with the wooden model ships but the problem might be related to transfer their bodily experience to the reasoning task. If the ships had been presented on the screen as a part of the decision screen as in the visual demonstration condition, a higher level of impact might have resulted and possibly driven the response patterns towards Ship B. However, this is hard to say, given that null results are generally difficult to interpret.

10.3.3 Modal Condition II: Visual Demonstration via Eye-tracking

Thirdly, a visual demonstration condition was proposed and developed by which participants' eye movements patterns were also recorded via an eye-tracking device. The visual demonstration included a power-point presentation of the disassembly and reassembly processes with the help of a simple animation. This visual demonstration condition was inspired by empirical studies that indicate the impact of modality-dependent processes on high-level cognitive processes such as conceptual reasoning, in the spirit of the grounded cognition framework (Barsalou, 2008, 2010). Thus, it was initially suggested that the conceptual reasoning process might be affected by perceptual factors of the visual modality. The main aim was to influence participants through the visual demonstration such that their responses would be shifted in the direction of Ship A. Indeed, participants tended to choose Ship A as the Ship of Theseus significantly more often as compared to the baseline condition. Before attributing this result to conceptual reasoning, however, note that the visual image of Ship A was composed of the same parts as the initial ship. This is because the parts had been renewed and, perceptually, looked like the original parts. In this respect, although Ship B is narrated to be composed of the original parts (in bad state), the visual images suggested that Ship A might be containing the original parts. The obtained findings illustrate that visual demo condition successful in changing the decision patterns of the participants significantly in the desired direction. This change observed in the response patterns has most probably been caused by the mode of presentation through the animation of the processes. Since the participants in this condition were exposed to a visual animation illustrating the disassembly and reassembly processes, at least some of the participants might have been manipulated in the sense that they were under the influence of perceptual processes rather than conceptual processes. Judged on the basis of perceptual similarity, Ship A was clearly more similar to the original ship than Ship B. The eye-tracking results support this explanation, since Ship B respondents tended to engage in the textual part significantly more than Ship A respondents. Ship A respondents, on the other hand, focused more on the visual images of the ships rather than the text. Thus, it might be the case that some of the potential Ship B respondents were influenced by these visual factors and their processing was 'grounded' in the sense that they indulged in more visually oriented processing during their identity judgment. It should be remarked that the decision screen was not as in the baseline condition and participants were instructed to make their final decisions based on a screen that consisted of 2 visual images of the ships and the text. There were two main reasons for this kind of presentation. First, it was a deliberate choice aimed to increase the potential level of grounding of the participants, after participants in the wooden model ship condition had been observed not to transfer their presumed bodily experience with the ships to the final decision. Secondly, we were also interested in tracking the eye-movement patterns of the participants in order to observe whether there were crucial differences among Ship A and Ship B respondents. Additionally, it should be noted that the visual demonstration was presented in a single way to all participants. To be more specific, Ship B was always presented on the left side of the screen and Ship A on the right of the decision screen. A counterbalanced presentation was not done because of providing spatiotemporal coherence for Ship A with regards to the initial ship. Lack of counterbalancing might therefore be regarded as an experimental drawback for this condition. Moreover, it might be suggested to use a different experimental setup in which Ship A might be presented with different colors or slightly different shapes in order to rule out the possible confound related to the discussed perceptual similarity with the initial ship.

10.3.4 Evaluation of the M-Shaped Pattern

It is important to highlight the M-shaped pattern as the baseline pattern for the responses to the Ship of Theseus question. Although different framings as presented in the STP conditions and in the wooden model ship condition, did not distort this shape, it might be the case that people might behave differently in different framings like presenting the narration as the Ship of Napoleon (a war-ship in the 1800s) instead of the Ship of Theseus that is an Ancient Greek one. Here, the global temporal frame – contrasting antiquity and industrial times – would have changed. In our framing epoch, antiquity, the general distribution we observed was almost equal when Ship A and Ship B responses are considered. The empirical findings from previous studies have already shown that people might have a tendency to choose the continuant objects when a similar narration is presented with different framings (Hall, 1998). The participants tended to select the continuant one (corresponding to Ship A) over the replica (corresponding to Ship B) when the object was presented as an animal rather than an artifact (Hall, 1998). Similarly, having a human cause for the transformation was observed to decrease the ratings for the continuant one (Hall, 1998). Thus, it is very crucial to underline that the framing is a critical issue to be studied with great care in further studies. Such studies could provide more evidence for one of the most remarkable findings of this dissertation, namely the resilient M-shaped response pattern observed for the Ship of Theseus question. The bimodal response pattern observed in our samples might reflect a very common pattern of reasoning about identity. It is important to notice that although the Ship of Theseus has been referred to as a "paradox" (in a loose sense) in the literature, the way laymen approach the identity question is most possibly not in terms of a paradox. In other words, they might not reason based on a normatively appropriate procedure suitable for resolving a paradox, but rather, it is more probable that they relied on simple heuristics and categorical dimensions during their identity judgments, as captured in the CTT.

10.3.5 Evaluation of the Grounded Cognition Framework

One of the main motivations for this dissertation was to evaluate the grounded cognition framework by manipulating the modalities of presentation of Ship of Theseus narrative and to observe whether these manipulations would affect participants' responses. Within this framework, one of the main claims is that cognitive processes are not amodal but modal, i.e., perceptual, action-based factors may direct participants towards a specific option, either Ship A or Ship B. We found the M-shaped pattern as the baseline pattern to appear in all of the conditions, except the visual demonstration condition.

For the wooden model ship condition, the results for the Ship of Theseus condition indicated that there was possibly no influence of the condition, since the results were highly similar to the baseline condition. Although null results generally do not allow drawing any clear-cut conclusions, here, we will try to provide two possible explanations. First, simulating the narration through the wooden model ships might not have been efficient in changing the situated conceptualization, contrary to our initial expectations. The participants just carried the instructed simulations out in-between the narration. This might have helped to understand the narration better, since they had bodily interaction with these model ships and illustrated the whole disassembly and reassembly processes via these models. Secondly, it might have been the case that the participants were influenced regarding the interaction with the model ships at a local, situated action level but not at a more global, conceptual level. After the bodily interaction with the model ships had ended, the participants turned their head towards the computer screen where the Ship of Theseus narration was presented in the textual modality. It might have been the case that even though some of the participants might have been influenced by the bodily interaction with the model ships, this effect might not have been carried over to the decision phase. Participants might have responded differently, if they had been asked the same identity question embedded in the procedure with the wooden model ships. Thus, their engagement with the model ships and their access to situated conceptualization would not have been interrupted and might have continued influencing their final decision. On the other hand, this might have increased the risk for participants to decide directly regarding the model ships instead of responding to the narration, as they had been instructed before the experiment. Although the obtained findings from the wooden model ship condition do not support the initial hypothesis developed with respect to the grounded cognition framework, this does not rule out that such an effect exists and may become manifest under a more appropriate experimental setting.

For the visual demonstration condition, the participants were presented a short demo of the disassembly and reassembly processes. It was initially hypothesized that the participants will be under the influence of perceptual factors in the visual domain and these factors will cause a shift towards Ship A. In the visual demonstration, it was shown how the various parts got old and were renewed by parts looking identical to the original parts. Thus, we thought to illustrate the narration as faithfully as possible. The results showed that the participants were influenced by this visual demo, as they tended to choose Ship A as the Ship of Theseus. This empirical finding supports our initial hypothesis, especially since the response pattern was significantly different from the baseline condition. Accordingly, it might be claimed that the participants were influenced by the visual illustrations of the two ships and their identity judgments might have occurred on perceptual grounds rather than on conceptual grounds. In other words, watching the visual simulation of the disassembly and reassembly processes possibly overwrote the narration read by these participants. The way they mentally simulated the disassembly and reassembly processes probably changed their response. Thus, the conceptual reasoning process usually occurring at a more abstract, amodal, conceptual level was grounded at a more perceptual level this time. Beyond the abstract form of conceptualization of identity, as supported by participants' (semantic) memory system, perceptual factors such as the physical similarity of the original ship and the continuant Ship A might have exerted a modality effect on their final responses. Thus, regarding our initial expectancy for an M-shaped response pattern (since it is the baseline condition), some of the potential Ship B respondents were possibly influenced by the presented external situation during their identity judgment, rather than their internal states (Kiefer & Barsalou, 2013). It might further be argued that some of the potential weak Ship A respondents might have been reinforced thus finally responding with a strong Ship A position – under the effect of situated conceptualization. However, it is also remarkable that many of the potential Ship B respondents, possibly the ones with strong positions, did not change their decisions and resisted the modality effect. Beyond the prominent role of perceptual representations effective for some participants, one might argue that a representational pluralism approach might provide a better account for the obtained results, since it leaves sufficient space for also amodal symbolsto be used to represent aspects of abstract concepts like identity (Dove, 2009, 2011). Thus, although abstract concepts are argued to cause higher levels activation in the sensory-motor systems of the brain than concrete concepts, it might be the case that there might still be a place for amodal, semantic processing that might resist the influence of the external world, or modality-dependent processing (Kiefer & Barsalou, 2008).

10.4. Evaluation of the Findings from the Neurophysiological Assessments

Two neurophysiological assessments, with EEG/ERP (explained in Chapter 7) and fNIRS (explained in Chapter 8) were performed in order to provide insight into the neural mechanisms during identity judgments. More specifically, the behavioral data obtained during the experiments indicated a number of facts that might be resolved via the use of different neurophysiological techniques. First, we could monitor neural processes potentially causing reaction time differences found in the responses to *farklıdır* and *aynıdır* propositions with the help of EEG/ERP technique. Second, we could monitor the online processing of identity judgments in relation to the condition-wise (*aynıdır* versus *farklıdır*) and response-wise differences with the help of fNIRS.

10.4.1 Monitoring the processing difficulty of *farklıdır* via EEG/ERP

The obtained results from the EEG/ERP experiments suggest that there are significant event-related potential (ERP) differences taking place during the processing of *aynıdır* and *farklıdır*. Our behavioral findings already provided insight into such processing differences, indicating a potential difficulty in processing of *farklıdır* as opposed to *aynıdır*. Our finding is consistent with the empirical findings related to the processing differences of negated items as opposed to their counterparts (Nieuwland & Kuperberg, 2008). As suggested by this literature, processing of *farklıdır* requires a reprocessing stage because of the negative lexical meaning it has. It is also important to highlight the empirical fact that *farklıdır* propositions have been more likely to be agreed with than *aynıdır* propositions, since 17 of 24 *farklıdır* propositions have generally been approved with strong or weak positions whereas only 7 of 24 *aynıdır* propositions have been approved in general. Thus, the processing difficulty of *farklıdır* is most likely not related to the approval or disapproval to these items. There is also empirical evidence that the processing of approval versus disapproval does not cause a significant ERP difference specifically in the case of different syllogistic reasoning problems (Banks & Hope, 2014). Rather, there seems to be an effect of the inherent negative meaning of *farklıdır* on the conceptual-lexical processing level – possibly also on the morphological level.

The EEG/ERP experiments indicated such a processing difficulty for *farklıdır* propositions. They elicited N400 signals among the frontal channels that are why they are also referred to as FN400 in the relevant literature (Voss & Federmeier, 2011). The first possible explanation with respect to familiarity in the sense that participants are more familiar with the *aynıdır* (as opposed to *farklıdır*) during identity judgments is not a very likely option. An explanation related to the processing of negation would be more suitable to explain the FN400 signals found for *farklıdır*. Note that *farklıdır* is the logical negation of *aynıdır* while both have very similar categorical and distributional features. On the one hand, on the prosodic level, both of these predicates are composed of three syllables. On the other hand, on the morpho-syntactic level, there is a difference regarding their roots (*aynı-dır* and *fark-lı-dır*. *Aynı* is in the form of a bare root whereas *fark-lı* is the derived form of the noun root *fark* (difference) by the adjectival suffix - *lı*. Thus, one might argue that there might be a potential influence of this morphological difference on the processing times of these items. However, it seems more plausible to focus on their meaning, since there is a clear N400 signal captured for the *farklıdır* condition that most possibly indicates a processing difference at the semantic level. It is suggested that negation requires the construction of the affirmative case such that a person needs to process "There is an apple on the table" in order to process "There is no apple on the table" (Nordmeyer & Frank, 2014). This approach has been supported by several findings in the experimental literature (Clark & Carpenter, 1974). They demonstrate that the processing of negated utterances is executed while the affirmative counterpart is also processed but the reverse case is not likely to happen (Fischler et al., 1983; Kunios & Holcomb, 1992; Kaup et al., 2007; Ludtke et al., 2008). Thus, the ERP difference found between *aynıdır* and *farklıdır* may be due to the fact that participants have a tendency to treat *aynıdır* as a default case during identity judgments. If they encounter *farklıdır,* this may cause a processing difficulty because of its implicit negative meaning, necessitating a reprocessing stage. Thus, our EEG/ERP results suggest that *farklıdır* is processed as the negated version of *aynıdır* at least during the identity judgments.

Moreover, it is plausible to argue that *farklıdır* causes processing difficulties that could be explained regarding the semantic/conceptual unification network (Hagoort et al., 2009). The semantic/conceptual unification network supports 'the construction of complex meaning from more elementary building blocks' (Hagoort et al., 2009, p.814). Event-related brain potentials and other neuroimaging methods including fMRI are significant tools for understanding the neuroanatomical underpinnings of this network better. Neuroimaging evidence indicates that left inferior frontal gyrus, left superior/middle temporal gyrus, left inferior parietal cortex as well as their right homologues take part in this network (Hagoort et al., 2009). There are several neuroimaging findings illustrating the role of this network during the processing of incongruent versus congruent semantic information like in the world-knowledge violation condition. First of all, the increase in neural activation among left inferior frontal gyrus (left IFG) is observed during the processing of semantically incongruent items as opposed to semantically congruent items (Baumgaertner et al., 2002; Friederici et al., 2003; Hagoort et al., 2004; Hoenig & Scheef, 2005; Kiehl et al., 2002; Kuperberg et al., 2000, 2008; Newman et al., 2001; Rueschemeyer et al., 2006). Secondly, EEG/ERP studies have identified an N400 signal for incongruent conditions when compared to congruent conditions during the processing of semantic information (Kutas & Hillyard, 1980; Hagoort & Brown, 1994; Holcomb, 1993; Van Berkum et al., 1999; Kutas & Federmeier, 2000). It has also been argued that the working of this semantic/conceptual unification network is indicated by the N400 signal detected in the incongruent conditions (Hagoort et al., 2009). Thus, we may conclude that the observed N400 signal for *farklıdır* is due to its negative valence that triggers the semantic/conceptual unification network differently than *aynıdır* sentences. A future research question in this respect could be whether these differences in event-related potentials (ERPs) are domain-specific or domain-general. In other words, does *farklıdır* trigger an N400 signal in relation to the processing of any judgments or sentences and thus generally indicates implicit negation in meaning? Or is it the case that *farklıdır* acquires meaning of negation in relation to the identity judgments as presented during the experiments in the present study?

10.4.2 Conflict Monitoring during Identity Judgments

Lastly, an experimental design using fNIRS method has been proposed in order to detect the possible neural correlates of the decision-making processes during identity judgments. The investigation on prefrontal cortex (PFC) is crucial, since this region has been shown to support executive functions during decision-making, reasoning, thinking and many other higher-order cognitive processes. Another important reason for studying this brain area is related to the role of prefrontal regions, specifically dorsomedial regions of PFC, during response conflict and conflict monitoring processes. We were interested in observing whether the *farklıdır* condition would cause a higher level of conflict than the *aynıdır* condition due to the fact that *farklıdır* appears as the negated form of *aynıdır*, as discussed above. The research question was reformulated in relation to the level of confidence in the responses of the participants. Note that on the 5-point-Likert scale, positions 1 and 5 express "strong" (and thus confident) agreement and disagreement, while positions 2 and 4 express "weak" (and thus less confident) agreement and disagreement, respectively. Position 3 is an undecided, intermediate (and thus least confident) position. Depending on the technical capabilities of the fNIRS device, signals from the prefrontal cortex were monitored as participants were engaged in the Conceptual Tendency Test. The analyses of the obtained fNIRS data indicated that there was no significant difference between *aynıdır* and *farklıdır* conditions across any of the voxels. This negative result does not conform to the positive ERP/EEG findings. It may, however, hint at differences between the two methodologies. The neural activation difference captured through the ERP experiments might be due to a sudden impact of the processing difficulty that possibly led to a very short reprocessing stage. Even though this difference might cause a significant difference in reaction times and affect local integration processes (as our behavioral and EEG data suggests), it might not produce some longer-lasting activation in the prefrontal cortex. This is possibly due to only small activation differences in the neurophysiology of PFC. In other words, it might be the fact that *farklıdır* propositions might not be causing a prominent level of difference in neurophysiology in the PFC when compared with *aynıdır* propositions. This brings us to the other research question – whether there are response-wise differences in the prefrontal cortex.

It was initially hypothesized that the weak responses (that are '2' and '4'; tendency to agree/disagree positions on the 5-point-Likert scale, respectively) will cause higher levels of neural activation specifically across the left medial regions when compared to the strong responses (that are '1' and '5'; strong agreement/disagreement positions on the 5-point Likert scale, respectively). Response-wise analyses indicated that there was no significant difference between the strong and weak responses. However, there was a significant level of activation difference between strong agreement and strong disagreement cases such that the strong disagreement cases caused a higher level of prefrontal activation over the left prefrontal region as opposed to strong agreement cases. The prefrontal region, particularly the dorsomedial part of PFC, has already been associated with conflict monitoring and resolution in the previous studies (Botvinick et al., 2004; Kerns et al., 2004). In other words, the strong disagreement cases were possibly more conflicting when compared to strong agreement cases. This finding is quite understandable in the sense that participants needed to find further supportive arguments when they did not agree with a given premise or argument. However, agreement cases, in other words affirmative positions, might not require as much mental effort during the process of generating supportive arguments for their positions. Similar to the empirical findings obtained from the EEG/ERP experiments, the differences in neural activation patterns observed through fNIRS might also be associated with the semantic/conceptual unification network, but this time in the sense of deliberate affirmation versus rejection of the presented proposition (Hagoort et al., 2009).

It was also hypothesized that undecided responses ('3' on the 5-point-Likert scale) will cause higher levels of activation in the prefrontal regions, since these positions are probably most representative of the conflict situation. Again, the left dorsomedial region of PFC was the area of interest because of its role in conflict monitoring and resolution. The obtained results illustrated that the voxels in this region of interest, V3-V4-V5-V6, were activated significantly more for the cases of undecided responses when compared to other responses. Thus, it could be argued that this method is sensitive to cases in which conflict is experienced during identity judgments. Taken together, it is possibly the case that the undecided position as well as the strong disagreement position cause higher neural activation among the regions related to conflict resolution. This situation of response conflict might be argued to be similar to the world-knowledge violation condition (Hagoort et al., 2004). This experimental setup did not include any world-knowledge violation condition because of the time limitations. The current experiment lasted for 26 minutes plus the preparation period (ca. 6 to 10 minutes). Thus, the world-knowledge violation condition was only tested with ERP/EEG methodology in the other condition. To sum up, the results of the current study show that there is possibly no significant difference between the *aynıdır* and *farklıdır* conditions at the neurophysiological level that could be detected by the *f*NIRS method. However, it might be the case that strong disagreement cases might behave like a deliberate rejection causing a neural activation pattern throughout the dorsomedial regions of PFC whereas strong agreement cases might be evaluated as deliberate affirmative positions in which the neural activation generally does not tend to increase. However, a more conflicting situation is experienced in the undecided responses that tend to cause the highest level of activation.

10.5. Computational Models for Predicting the Responses to the Ship of Theseus

Providing a predictive model from the CTT to the responses to the Ship of Theseus question was one of the main targets for this dissertation. Three cognitive models were built with respect to the response patterns to the propositions in the CTT: (1) discriminant analysis, (2) decision tree and (3) neural network models. In this section, these cognitive models are briefly compared and contrasted regarding their predictive success and their most predictive. More importantly, the possible contributions and risks related to the predictive models are discussed – especially for this kind of studies in which conceptual vagueness and ambiguity are integral parts of the work. The obtained responses to the Ship of Theseus question were classified into two main groups: Ship A and Ship B responses. The weak and strong judgments for Ship A versus Ship B were lumped together to make the model more robust. Moreover, the undecided responses were eliminated because some of the participants might be reluctant to express an explicit response but instead they preferred to stay in a "safer" zone just like the respondents who answered with "both" (to the question of the split icebergs) in the study of Rips (2011). Thus, their data might cause a potential deviation in the final models.

10.5.1 Comparison of the Computational Models

Overall, all three models predicted the two responses quite successfully ranging from 71.7% to 80.5% predictive success. When the results from these cognitive models are compared, the decision tree approach might be evaluated as the most suitable one due to its higher predictive success based on only 8 of 48 propositions. The decision tree model predicted the final outcome of the question as Ship A or Ship B with 80.5% predictive success. The predictor propositions are P17F, P15F, P18F, P11F, P10A, P16A, P2A, and P6A. The content of these propositions were discussed in detail in the previous chapter. Secondly, the discriminant analysis resulted in a first-order mathematical model of 74.3% predictive success while the model is built upon 6 predictor propositions. These predictor propositions for the DA model are P17F, P24F, P22F, P6A, P18F, and P2A. Several trials of neural network analyses resulted in predictive success ranging from 71,7% to 75% when the factors were based on the propositions P17F, P24F, P22F, P6A, P18F, and P2A. In spite of relative instability of these NNA outputs, the model could achieve a more consistent level by optimization of inputs (propositions). It is also important to highlight that all of these three computational models contained a similar set of propositions. P17F (repeat the proposition here) has been the most discriminative one, most likely because of its analogy to the Ship of Theseus. It is also remarkable that Ship A respondents have a tendency to accept this proposition (P17F) possibly on the assumption that the reassembled robot is not functioning.

The decision tree model (DT) could be evaluated as the most parsimonious and therefore preferable computational model, providing the highest predictive success with the use of only few items from the CTT. However, in spite of the higher predictive success, the decision tree analysis is far from providing a good descriptive account for the Ship of Theseus responses. Thus, it is not possible to present general patterns representing some underlying dimensions in the CTT. However, the other computational models provide better accounts in terms of descriptive validity, since the contrast between functionalist and essentialist perspectives can be visualized with the direction of the propositions in the structure matrix and the analysis of independent variable importance. Finally, the difference between propositions with *farklıdır* and *aynıdır* in the generated models should be discussed. As it has been mentioned in the previous chapters, most of the critical propositions that have prime importance in the computational models are often from the *farklıdır* condition. In other words, responses to *farklıdır* propositions have contributed relatively more to the predictive models than responses to *aynıdır* propositions. The reason for this divergence might be related to the associated negative meaning of *farklıdır* as opposed to *aynıdır*. As suggested, this negative meaning has been claimed to cause a reprocessing stage accompanied with a delay in response time as well as an N400 signal. It might be the case that this aspect of *farklıdır* – having negative meaning and instigating reprocessing – directs participants to a more careful evaluation and consideration as compared to its positive counterpart, *aynıdır*.

10.5.2 Criticisms of the Computational Modeling for Ambiguous Propositions

Since the participants were instructed to behave freely in their responses for the CTT, in other words, there were no instructed rules for their judgments, the responses of the participants varied to a considerable extent with respect to how the participants disambiguate the presented propositions. This might hint at a loose conception of identity by which the participants reflected different conceptual tendencies. Despite the fact that the computational models seem to reflect a considerably high level of predictive success, it should be reminded that the loose conception of identity provided in this study definitely caused ambiguity especially for some of the cases like (P6A and P6F) “Two water molecules are the same/different”. In this case, the participants generally agreed to accept that these two water molecules are the same, possibly by regarding their high level of physical similarity. On the other hand, in this case, the identity judgment might also have been based on qualitative identity but not numerical identity. In this respect, one might argue that it is not possible to infer how participants resolved the ambiguous propositions; yet, the obtained results might reflect common intuitive patterns. Lastly, *aynıdır* and *farklıdır* judgments seem to diverge for P17A/F (a reassembled robot after full disassembly is the same/different). In this case, ambiguity may have been resolved probably with respect to different aspects of the presented situation and object. The divergence might have emerged due to the tension between functionalist and essentialist perspectives, as evidenced by the different polarity (positive, negative charge of weights) these items have in the computational models.

CHAPTER 11

SUMMARY and CONCLUSION

The initial motivation of this dissertation has been to understand the cognitive and neural underpinnings of conceptual processes during identity judgments. As a vague and potentially ambiguous concept, identity may be constituted upon various cognitive dimensions. The Conceptual Tendency Test (CTT) was prepared for the purpose of capturing these dimensions. It assessed participants' attitudes towards the central concept of identity in a set of 48 questions, half of which were phrased as "same" (*aynıdır*) and half as "different" (*farklıdır*). A 5-point-Likert scale was used to assess participants' responses (where 1 and 2 referred to strong and weak agreement, 3 to a neutral position, and 4 and 5 to weak and strong disagreement). The results of the CTT revealed participants' senses of identity and the context-dependence of their responses. Thus, they refrained from accepting a person being the same after an organ or face transplantation that could be explained with the possible application of a strict and philosophical sense of identity, in the sense of Chisholm (2004). However, they tended to accept two water molecules under the same conditions to be the same. Thus, their understanding of identity in terms of the dissociation between numerical and qualitative formulations was generally context-dependent. Participants tended to respond symmetrically to the propositions with *aynıdır* and *farklıdır* in general – however, some propositions showed marked asymmetries which may again hint at context-specific factors. Since participants were instructed to respond freely to the propositions (meaning that no strict definition of identity was provided prior to experiments), these results are obviously related to their flexible responses regarding the presented ambiguity and how they disambiguated the given propositions. Relying on their responses in the CTT, the next research question aimed at predicting participants' responses in the Ship of Theseus narration: whether participants could be dissociated into "functionalists/structuralists" (those preferring Ship A, the continuant) and "essentialists" (those preferring Ship B, the replica), respectively. We attempted to establish computational models based on the responses to the CTT in order to predict the responses to the Ship of Theseus question. The three computational models, discriminant analysis, decision tree analysis and neural network analysis, were found to reflect tendencies for distinguishing these two perspectives given the propositions related to the identity judgments. These computational models performed with a predictive success from 71.7% to 80.5%. In future research predictive models with even higher levels of predictive success might be strived for.

The second research question aimed at construing modality-specific conditions in order to manipulate the response patterns of the participants to the Ship of Theseus. According to the embodied cognition paradigm in cognitive science, higher-level cognitive processes are grounded in bodily, perceptual, processes and are thus modality-dependent. Three modalities were contrasted: textual presentation, bodily interaction with wooden model ships, and visual demonstration. The baseline conditions found in the textual modality, indicated an M-shaped pattern of agreement responses (on a 5-point Likert scale, where responses 1 and 2 reflected strong and weak agreement to Ship A, 3 an intermediate, undecided position, and 4 and 5, weak and strong agreement to Ship B). The aim of manipulating the modalities of presentation of the Ship of Theseus in the experiments was to provoke distortions in the overall response pattern specifically in the direction of Ship A (the continuant) for the visual demonstration condition and Ship B (the replica) for the bodily experience in the wooden model ships condition. The results for the wooden model ships condition fell short of demonstrating any influence or insufficient level of influence, since there was no significant shift in participants' responses, as compared to the baseline condition. This might have been due to the experimental design in the sense that their reasoning processes might not be entangled with the bodily factors sufficiently especially during the decision-making stage. On the other hand, the results obtained from the visual demonstration showed a significant difference in participants' responses, as initially hypothesized, in the direction of Ship A responses. This empirical finding could be explained in relation to the grounded cognition framework. Conceptual reasoning processes may be affected by perceptual factors (here, the visual images of the ships and the dynamic visual narration of the disassembly-reassembly process). This potential influence by the perceptual factors was found to distort the M-shaped (baseline) response pattern significantly, suggesting that participants as a group were sensitive to this manipulation of modality. The absence of any shift in participants' response pattern in the bodily-interactive condition suggests that manipulations of modality may be highly context-specific and only effective if precisely coordinated with crucial spatiotemporal aspects of the overall reasoning and decision process. Alternatively, one may have to concede that conceptual reasoning processes are resilient to a considerable degree towards manipulations of modality and that concepts, even vague ones such as identity, rely on stable yet multi-dimensional semantic-conceptual representations.

There are significant findings in relation to the third research question that was about understanding the neural underpinnings of conceptual processes during identity judgments. The behavioral experiments showed that participants responded to *aynıdır* propositions more quickly than to *farklıdır* propositions. This processing difference shifted the research focus towards further neurophysiological assessments. This delay in response times can be explained in the sense that *farklıdır* is the logical negation of *aynıdır*, hence requires additional processing stage. The EEG/ERP findings support this view, since there was a clear N400 signal mainly among the frontal and central channels for *farklıdır* propositions as opposed to *aynıdır* propositions. Further research might be conducted to pinpoint whether this difference related to the processing of *aynıdır* versus *farklıdır* is domain-specific or domain-general, i.e., is not restricted to identity judgment with polar adjectives. An N400 neural pattern was also found for the propositions violating world-knowledge as compared to correct propositions, in the same experiment, hinting at a wider generalizability of the phenomenon. However, the experiments performed with optic brain imaging method (fNIRS) have shown that this contrast between *aynıdır* and *farklıdır* does not seem to cause a significant difference in neural activation patterns at the neurophysiological level across the prefrontal regions, especially around the sites that have been associated with conflict monitoring and resolution. Thus, it can be concluded that propositions with *farklıdır* might not be causing a considerable level of response conflict as opposed to *aynıdır* for the participants but instead – due to the detection of an incongruence in semantic processing – a sudden reaction triggering the semantic/conceptual unification network and resulting in a response delay. However, there are significant differences in neural activation patterns across the dorsomedial PFC regions for the strong disagreement responses as opposed to strong agreement responses. Moreover, the undecided responses ('3' responses on the 5-point Likert Scale) were observed to cause the highest level of neural activation, which could directly be linked to the response conflict hypothesis.

To the best of our knowledge, this is the first study to investigate conceptual processes underlying identity judgments within a grounded cognition perspective. Furthermore, three computational models were designed as predictive models for the identity judgments. They, too, were applied to identity judgments for the first time in the relevant literature and all proved to be successful. Lastly, the contribution from the neurophysiological assessments were essential in supporting our behavioral findings related to reaction time differences between *aynıdır* and *farklıdır* conditions, in the EEG/ERP experiments, and provided an insightful perspective regarding conflict monitoring, in the fNIRS experiments. These neurophysiological studies may prove to be valuable for future research.

REFERENCES

Armstrong, D. M. (1980). Identity through time. In P. van Inwagen (Ed.), *Time and cause* (pp. 67–78). Dordrecht, The Netherlands: Reidel.

Ayaz, H., Izzetoglu, M., Platek, S. M., Bunce, S., Izzetoglu, K., Pourrezaei, K., & Onaral, B. (2006). Registering fNIR data to brain surface image using MRI templates. In *28th Annual International Conference of Engineering in Medicine and Biology Society,* 2671-2674.

Ayaz, H. (2010). *Functional Near Infrared Spectroscopy based Brain Computer Interface*. Unpublished Doctoral Dissertation, Drexel University, Philadelphia, PA, USA.

Ayaz, H., Shewokis, P. A., Curtin, A., Izzetoglu, M., Izzetoglu, K., & Onaral, B. (2011). Using Maze Suite and fNIR to study learning in spatial navigation. *JoVE*, (56), 3443.

Ayaz, H., Shewokis, P. A., Bunce, S., Izzetoglu, K., Willems, B., & Onaral, B. (2012). Optical brain monitoring for operator training and mental workload assessment. *Neuroimage*, *59*(1), 36-47.

Bagger, M. (2007). *The uses of paradox*. Columbia University Press: New York.

Banks, A., & Hope, C. (2014). Heuristic and analytic processes in reasoning: An event-related potential study of belief bias. *Psychophysiology 51,* 290-297.

Barbey, A. K., & Barsalou, L. W. (2009). Reasoning and problem solving: Models. In L. Squire (Ed.), *Encyclopedia of neuroscience* (pp. 35-43). Oxford: Academic Press.

Barsalou, L. W. (1982). Context-independent and context-dependent information in concepts. *Journal of Memory and Cognition, 10*, 82-93.

Barsalou, L. W. (2009). Simulation, situated conceptualization, and prediction. *Philosophical Transactions of the Royal Society of London: Biological Sciences, 364,* 1281-1289.

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology, 59,* 617-645.

Barsalou, L. W. (2013). Mirroring as pattern completion inferences within situated conceptualizations. *Cortex*, *49,* 2951-2953.

Barrett, L. F., Wilson-Mendenthall, C. D., & Barsalou, L. W. (2015). The conceptual act theory: A road map. In L. F. Barrett & J. A. Russell (Eds.), *The psychological construction of emotion* (pp. 83-110). New York: Guilford.

Barsalou, L. W. (2012). The human conceptual system. In M. Spivey, K. McRae, & M. Joanisse (Eds.), *The Cambridge handbook of psycholinguistics* (pp. 239-258). New York: Cambridge University Press.

Barsalou, L. W., & Wiemer-Hastings, K. (2005). Situating abstract concepts. In D. Pecher and R. Zwaan (Eds.), *Grounding cognition: The role of perception and action in memory, language, and thought* (pp. 129-163). New York: Cambridge University Press.

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences, 22,* 577-660.

Barsalou, L. W. (2015). Situated conceptualization: Theory and application. In Y. Coello & M. H. Fischer (Eds.), *Foundations of embodied cognition*. East Sussex, UK: Psychology Press.

Barsalou, L. W. (2008). Cognitive and neural contributions to understanding the conceptual system. *Current Directions in Psychological Science*, *17,* 91-95.

Barsalou, L. W. (2005). Continuity of the conceptual system across species. *Trends in Cognitive Sciences, 9,* 309-311.

Barsalou, L. W. (2005). Abstraction as dynamic interpretation in perceptual symbol systems. In L. Gershkoff-Stowe & D. Rakison (Eds.), *Building object categories* (389-431). Carnegie Symposium Series. Majwah, NJ: Erlbaum.

Barsalou, L. W., Yeh, W., Luka, B. J., Olseth, K. L., Mix, K. S., & Wu, L. (1993). Concepts and meaning. In K. Beals, G. Cooke, D. Kathman, K.E. McCullough, S. Kita, & D. Testen (Eds.), *Chicago Linguistics Society 29: Papers from the parasession on conceptual representations* (pp. 23-61). Chicago: Chicago Linguistics Society.

Barsalou, L. W. (1993). Flexibility, structure, and linguistic vagary in concepts: Manifestations of a compositional system of perceptual symbols. In A. C. Collins, S. E. Gathercole, & M.A. Conway (Eds.), *Theories of memory* (pp. 29-101). London, UK: Lawrence Erlbaum Associates.

Baumgaertner, C., Weiller, C., & Buchel, C. (2002). Event-related fMRI reveals cortical sites involved in contextual sentence integration. *Neuroimage*, *16*, 736–745.

Beall, J. C., & van Fraassen, B. C. (2003). Possibilities and Paradox. New York: Oxford University Press.

Bermúdez, J. L. (2014). *Cognitive science: an introduction to the science of the mind*. Cambridge: Cambridge University Press.

Blok, S., Newman, G., & Rips, L. J. (2005). Individuals and their concepts. In W. K. Ahn, R. L. Goldstone, B. C. Love, A. B. Markman, & P. Wolff (Eds.), *Categorization inside and outside the laboratory: Essays in honor of Douglas L. Medin* (pp. 127–149). Washington, DC: American Psychological Association.

Blok, S., Newman, G., & Rips, L. J. (2005). Individuals and their concepts. In W. K. Ahn, R. L. Goldstone, B. C. Love, A. B. Markman, & P. Wolff (Eds.), *Categorization inside and outside the laboratory: Essays in Honor of Douglas L. Medin* (pp. 127–149). Washington, DC: American Psychological Association.

Bourgeois-Gironde, S., & Giraud, R. (2009). Framing effects as violations of extensionality. *Theory and Decision, 67*(4), 385-404.

Brennan, J., & Martin, E. (2012). Spatial proximity is more than just a distance measure. *Int. J. Hum. Comput. Stud. 70(1)*, 88-106.

Bunce, S. C., Izzetoglu, M., Izzetoglu, K., Onaral, B., & Pourrezaei, K. (2006). Functional near-infrared spectroscopy. *Engineering in Medicine and Biology Magazine (IEEE)*, *25*(4), 54-62.

Butler, J.F. (1736/1935). John Wesley's Defense Before Bishop Butler. *Proceedings of the Wesley Historical Society, 20,* 63-67.

Byrne, R. M. J. (2005). *The Rational Imagination: How People Create Counterfactual Alternatives to Reality.* Cambridge, MA: MIT Press.

Cacchione, T., Schaub, S., & Rakoczy, H. (2013). Fourteen-month-old infants infer the continuous identity of objects on the basis of non-visible causal properties. *Developmental Psychology, 49*(7), 1325-1329.

Carey, S., & Xu, F. (2001). Infants' knowledge of objects: Beyond object-files and object tracking. *Cognition, 80,* 179-213.

Carey, S. (1995). On the origins of causal understanding. In D. Sperber, D. Premack, & A.J. Premack (eds.), *Causal Cognition* (pp. 268-308). Oxford, UK: Clarendon Press.

Carey, S. (1985). Are children fundamentally different thinkers and learners from adults? In S.F. Chipman, J.W. Segal & R. Glaser (Eds.), *Thinking and Learning Skills, 2.* Hillsdale, NJ: Erlbaum, 485-517.

Carey, S. (1985). Constraints on semantic development. In J. Mehler (ed.), *Neonate Cognition* (pp. 381-398). Hillsdale, NJ: Erlbaum.

Carey, S. (1991). Knowledge acquisition: enrichment or conceptual change? In S. Carey & R. Gelman (eds.), *The Epigenesis of Mind: Essays in Biology and Cognition* (pp. 257-291). Hillsdale, NJ: Erlbaum.

Chaigneau, S. E., Barsalou, L. W., & Zamani, M. (2009). Situational information contributes to object categorization and inference. *Acta Psychologica, 130,* 81-94.

Chisholm, R. (1973). Parts as Essential to their Wholes. *Review of Metaphysics*, *26,* 581-603.

Chisholm, R. (1976). *Person and Object*. London: Allen and Unwin.

Chisholm, R. (2004). Identity Through Time. In T. Crane, & K. Farkas, *Metaphysics: A guide and anthology* (pp. 537-551). Oxford University Press.

Cisek, P. (1999). Beyond the computer metaphor: Behaviour as interaction. *J. Conscious. Stud. 6*(1-112), 125-142.

Clancey, W. (1997). *Situated Cognition: On Human Knowledge and Computer Representations*. Cambridge, MA: Cambridge University Press.

Clark, Andy (1999). An embedded cognitive science? *Trends in Cognitive Sciences, 3*, 345-351.

Clark, A. (2008). *Supersizing the Mind: Embodiment, Action, and Cognitive Extension*. Oxford: Oxford University Press.

Clark, Andy & Chalmers, David (1998). The extended mind. *Analysis 58*(1), 7-19.

Clark, A. (1997). *Being There: Putting Brain Body and World Together Again.* Cambridge, MA: MIT Press.

Clark, A. (1999). Embodied, situated, and distributed cognition. In W. Bechtel and G. Graham (Eds.), *A Companion to Cognitive Science*. Malden, MA: Blackwell Publishing.

Clark, A. (1997). *Being There: Putting Brain Body and World Together Again.* Cambridge, MA: MIT Press.

Clark, A., & Chalmers, D. (1998). The extended mind. *Analysis*, *58,* 7-19.

Clark, D. (2009). *Framing effects exposed*. Pearson Education.

Clark, M. (2002). *Paradoxes from A to Z*. New York: TJ International Ltd.

Cope, M., Delpy, D. T., Reynolds, E. O. R., Wray, S., Wyatt, J., & Van der Zee, P. (1988). Methods of quantitating cerebral near infrared spectroscopy data. In *Oxygen Transport to Tissue X* (pp. 183-189). New York: Springer.

Crane, T., & Farkas, K. (2004). *Metaphysics: A guide and anthology*. Oxford, UK: Oxford University Press.

Davidson, D. (1969). The Individuation of Events. In N. Rescher, et al. (Eds.), *Essays in Honor of Carl G. Hempel* (pp. 295-309). Dordrecht-Holland: D. Reidel Publishing.

Dove, G. (2009). Beyond perceptual symbols: A call for representational pluralism. *Cognition, 110,* 412-431.

Dove, G.O. (2011). On the need for embodied and disembodied cognition. *Frontiers in Psychology, 1*(Article 242), 1-13.

Dreyfus, H. (1972/92). *What Computers Can't Do: A Critique of Artificial Reason.* New York: Harper and Row.

Dummett, M. (1981). *The Interpretation of Frege's Philosophy*. Cambridge, MA: Harvard University Press.

Dummett, M. (1991). Does Quantification involve Identity? In H. A. Lewis (Ed.), *Peter Geach: Philosophical encounters*. Dordrecht: Kluwer Academic Publishers.

Field, A. (2013). *Discovering statistics using IBM SPSS Statistics*. (4th Ed.). Los Angeles, London: SAGE.

Fodor, J., & Lepore, E. (1996). The Red Herring and the Pet Fish: Why Concepts Still Can't Be Prototypes, *Cognition, 58,* 253-270.

Frege, G. (1969). *Translations from the philosophical writings of Gottlob Frege*. Trans. Geach, P. & Black, M. Oxford: Blackwell.

Friederici, A. D. (2011). The brain basis of language processing: From structure to function. *Physiol. Rev., 91,* 1357–1392.

Friederici, A. D., Ruschemeyer, S. A., Hahne, A., & Fiebach, C. J. (2003). The role of left inferior frontal and superior temporal cortex in sentence comprehension: Localizing syntactic and semantic processes. *Cereb. Cortex, 13,* 170-177.

Friederici, A. D. & Singer, W. (2015). Grounding language processing on basic neurophysiological principles. *Trends in Cognitive Sciences 19*(6), 329-338.

Garciadiego, A. (1992). *Bertrand Russell and the Origins of Set-theoretic Paradoxes.* Basel: Birkhäuser.

Gerlach, C. (2007). A review on functional imaging studies on category-specificity. *Journal of Cognitive Neuroscience, 19,* 296-314.

Geach, P. (1972). *Logic Matters*. Oxford, UK: Basil Blackwell.

Geach, P. (1973). Ontological relativity and relative identity. In M.K. Munitz (Ed.), *Logic and Ontology*. New York: New York University Press.

Geach, P. (1980). *Reference and Generality* (3rd ed.). Ithaca, NY: Cornell University Press.

Geach, P. (1991). Replies. In H.A. Lewis (Ed.), *Peter Geach: Philosophical encounters*. Dordrecht: Kluwer Academic Publishers.

Gendron, M., Lindquist, K. A., Barsalou, L. W., & Barrett, L. F. (2012). Emotion words shape emotion percepts. *Emotion, 12*, 314-325.

Gentner, D., & Stevens, A. L. (1983). *Mental Models.* Erlbaum, Hillsdale: NJ.

Gibson, J. J. (1966). *The Senses Considered as Perceptual Systems*. Boston, MA: Houghton Mifflin.

Gibson, J. J. (1979). *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin.

Glenberg, A. M. (1997). What is memory for? *Behavioral and Brain Sciences, 20,* 1-55.

Glenberg, A. M. (2010). Embodiment as a unifying perspective for psychology. *Wiley Interdisciplinary Reviews: Cognitive Science, 1*(4), 586-596.

Glenberg, A. M., & Kaschak, M. P. (2002). Grounding language in action. *Psychonomic Bulletin and Review, 9*(3), 558-565.

Glimcher, P. W., & Fehr, E. (Eds.) (2014). *Neuroeconomics: Decision making and the brain*. New York: Academic Press.

Goldberg, R. F., Perfetti, C. A., Schneider, W. (2006a). Distinct and commoncortical activation for multimodal semantic categories. *Cogn. Affect. Behav. Neurosci. 6,* 214-222.

Goldberg, R. F., Perfetti C. A., & Scheneider W. (2006b). Perceptual knowledge retrieval activates sensory brain regions. *J Neurosci., 26,* 4917-4921.

Gopnik, A., & Meltzoff, A. N. (1987). The development of categorization in the second year and its relation to other cognitive and linguistic developments. *Child Development, 58,* 1523-1531.

Haarmann, H. J., Cameron, K. A., & Ruchkin D. S. (2005). Active Maintenance of Sentence Meaning in Working Memory. *International Journal of Psychophysiology, 57*(2), 115-128.

Hagoort, P., & van Berkum, J. (2007). Beyond the sentence given. *Phil. Trans. R. Soc. B, 362,* 801-811.

Hagoort, P., Baggio, G., & Willems, R. M. (2008). Semantic Unification. In M. S. Gazzaniga (Ed.) *The New Cognitive Neurosciences* (5th ed., pp. 615-618). MIT Press.

Hagoort, P., & Brown, C. (1994). Brain responses to lexical ambiguity resolution and parsing. In C. Clifton, Jr., L. Frazier, & K. Rayner (Eds.), *Perspectives on sentence processing* (pp. 45–81). Hillsdale, NJ: Lawrence Erlbaum.

Hagoort, P., Brown, C., & Osterhout, L. (1999). The neurocognition of syntactic processing. In C. M. Brown, & P. Hagoort, (Eds.), *The neurocognition of language* (pp. 273–317). Oxford, UK: Oxford University Press.

Hagoort, P., Hald, L., Bastiaasen, M., & Peterson, K. M. (2004). Integration of word meaning and world knowledge in language comprehension. *Science*, *304*, 438–441.

Hald, L. A., Bastiaansen, M. C. M., & Hagoort, P. (2006). EEG theta and gamma responses to semantic violations in online sentence processing. *Brain and Language, 96*, 90–105.

Hall, D. G. (1998). Continuity and the persistence of objects: When the whole is greater than the sum of the parts. *Cognitive Psychology*, *37*, 28-59.

Harnad, S. (1990). The symbol grounding problem. *Physica D*, *42,* 335-346.

Heil, M., Osman, A., Wiegalman, J., Rolke, B., & Hennighausen, E. (2000). N200 in the Eriksen-Task: Inhibitory Executive Processes? *Journal of Psychophysiology, 14*, 218–225.

Hellige, J. B. (1980). Effects of perceptual quality and visual field of probe stimulus presentation on memory search for letters. *Journal of Experimental Psychology: Human Perception and Performance*, *6*(4), 639–51.

Hellige, J. B. (1996). Hemispheric asymmetry for visual information processing. *Acta Neurobiologiae Experimentalis, 56*(1), 485–97.

Heit, E., Briggs, J., & Bott, L. (2004). Modeling the effects of prior knowledge on learning incongruent features of category members. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30,* 1065–1081.

Hirsch, E. (1982). *The Concept of Identity*. Oxford, UK: Oxford University Press

Hoenig, K., & Scheef, L. (2005). Mediotemporal contributions to semantic processing: fMRI evidence from ambiguity processing during semantic context verification. *Hippocampus*, *15*, 597-609.

Hoenig K., Sim E.J., Bochev V., Herrnberger B., & Kiefer M. (2008). Conceptual flexibility in the human brain: Dynamic recruitment of semantic maps from visual, motor, and motion-related areas. *Journal of Cognitive Neuroscience, 20*(10)*,* 1799–1814.

Holcomb, P. (1993). Semantic priming and stimulus degradation: Implications for the role of the N400 in language processing. *Psychophysiology, 30,* 47–61.

Holper, L., ten Brincke, R. H., Wolf, M., & Murphy, R. O. (2014). fNIRS derived hemodynamic signals and electrodermal responses in a sequential risk-taking task. *Brain research*, *1557*, 141-154.

Horgan, T., & Tienson, J. (1989). Representations Without Rules. *Philosophical Topics*, *17* (Spring), 147-174.

Hsu, N. S., Frankland, S. M., & Thompson-Schill, S. L. (2012). Chromaticity of color perception and object color knowledge. *Neuropsychologia, 50*(2), 327-333.

Huang, Y. X. (2006). Temporal course of emotional negativity bias: An ERP study. *Neuroscience Letters, 398*(1-2)*,* 91-96.

Hurley, S. & Nudds, M. (2006). *Rational Animals?* Oxford: Oxford University Press.

Hutchins, E. (1995). *Cognition in the Wild*. Cambridge, MA: MIT Press.

Hutsler, J., & Galuske, R. W. (2003). Hemispheric asymmetries in cerebral cortical networks. *Trends in Neurosciences*, *26*(8), 429–35.

Jackendoff, R. (1987). *Consciousness and the Computational Mind*. Cambridge, MA: MIT Press.

Jackendoff, R. (1989). What is a Concept, that a Person May Grasp It? *Mind & Language*, *4,* 68–102.

Jackson, F. (1998). *From Metaphysics to Ethics: A Defense of Conceptual Analysis*. Oxford: Oxford University Press.

Jensen, A. R., & Rohwer, W. D. (1966). The Stroop color-word test: A review. *Acta Psychologica, 25*(1), 36-93.

Jobsis, F. F. (1977). Noninvasive, infrared monitoring of cerebral and myocardial oxygen sufficiency and circulatory parameters. *Science*, *198*(4323), 1264-1267.

Johnson-Laird, P. N. (2006). *How we reason*. Oxford: Oxford University Press.

Kahneman, D., & Tversky, A. (1984). Choices, values, and frames. *American Psychologist, 39*, 341-50.

Kan, I. P., Barsalou, L. W., Solomon, K. O., Minor, J. K., & Thompson-Schill, S. L. (2003). Role of mental imagery in a property verification task: fMRI evidence for perceptual representations of conceptual knowledge. *Cognitive Neuropsychology, 20,* 525-540.

Keil, F. C. (1989). Concepts, kinds, and cognitive development. Cambridge, MA: MIT Press.

Kerns, J. G., Cohen, J. D., MacDonald, A. W., Cho, R. Y., Stenger, V. A., & Carter, C. S. (2004). Anterior Cingulate Conflict Monitoring and Adjustments in Control. *Science, 303*(5660), 1023-1026.

Kiefer, M., & Barsalou, L. W. (2013). Grounding the human conceptual system in perception, action, and internal states. In Prinz, W., Beisert, M., & Herwig, A. (Eds.), *Action science: Foundations of an emerging discipline* (pp. 381-407). Cambridge, MA: MIT Press.

Kiehl, K. A., Laurens, K. R., & Liddle, P. F. (2002). Reading anomalous sentences: An event-related fMRI study of semantic processing. *Neuroimage*, *17*, 842–850.

Kintsch, W. (1974). *The representation of meaning in memory*. Hillsdale: Erlbaum.

Kober, H., Barrett, L. F., Joseph, J., Bliss-Moreau, E., Lindquist, K., & Wager, T. D. (2008). Functional grouping and cortical-subcortical interactions in emotion: A meta-analysis of neuroimaging studies. *NeuroImage, 42,* 998-1031.

Kripke, S. (1980). *Naming and Necessity*. Oxford: Basil Blackwell.

Kumagai, M. (2012). Extraction of personal preferences implicitly using NIRS. In *Proceedings of IEEE SICE Annual Conference (SICE 2012)* (pp. 1351-1353).

Kuperberg, G. R. (2007). Neural mechanisms of language comprehension: Challenges to syntax. *Brain Res.*, *1146*, 23–49.

Kuperberg G. R., Holcomb, P. J., Sitnikova, T., Greeve, D., Dale, A. M., & Caplan, D. (2003). Distinct patterns of neural modulation during the processing of conceptual and syntactic anomalies. *J. Cogn. Neurosci.*, *15*, 272–293.

Kuperberg, G. R., Lakshmanan, B. M., Caplan, D. N., & Holcomb, P. J. (2006). Making sense of discourse: An fMRI study of causal inferencing across sentences. *Neuroimage*, *33*, 343–361.

Kuperberg, G. R., McGuire, P. K., Bullmore, E. T., Brammer, M. J., Rabe-Hesketh, S., Wright, I. C., Lythgoe, D. J., Williams, S. C., & David, A. S. (2000). Common and distinct neural substrates for pragmatic, semantic, and syntactic processing of spoken sentences: an fMRI study. *J. Cogn. Neurosci.*, *12*, 321–341.

Kuperberg, G. R., Sitnikova, T., & Lakhmanan, B. M. (2008). Neuroanatomical distinctions within the semantic system during sentence comprehension: Evidence from functional magnetic resonance imaging. *Neuroimage, 40,* 367–388.

Kurtz, R. M. (2006). Introduction to Persistence: What's the Problem? In S. Haslanger & R. M. Kurtz (Eds.) *Persistence: Contemporary Readings*, (pp. 1-26). Cambridge: MIT Press.

Kutas, M. & Federmeier, K. D. (2011). Thirty Years and Counting: Finding Meaning in the N400 Component of the Event-Related Brain Potential (ERP). *Annu. Rev. Psychol., 62*, 621-647.

Kutas, M., & Hillyard, S. A. (1980). Reading senseless sentences: Brain potentials reflect semantic anomaly. *Science*, *207*, 203–205.

Kühberger, A. & Tanner, C. (2010). Risky choice framing: Task versions and a comparison of prospect theory and fuzzy-trace theory. *Journal of Behavioral Decision Making, 23*(3), 314–329.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by.* Chicago: University of Chicago.

Laurence, S. & Margolis, E. (2015). *The Conceptual Mind: New Directions in the Study of Concepts*. Cambridge, MA: MIT Press.

Laurence, S. & Margolis, E. (1999). Concepts and cognitive science. In S. Laurence, & E. Margolis, *Concepts: Core readings* (pp. 1-35). Cambridge, MA: MIT Press.

Levine, D. N., Warach, J., & Farah M. J. (1985). Two visual systems in mentalimagery: A dissociation of "what" and "where" in imagery disorders due to bilateral posterior cerebral lesions. *Neurology, 35*, 1010-1018.

Levy, I., Lazzaro, S. C., Rutledge, R. B., & Glimcher, P. W. (2011). Choice from non-choice: predicting consumer preferences from blood oxygenation level-dependent signals obtained during passive viewing. *The Journal of Neuroscience*, *31*(1), 118-125.

Lewis, D. (1976). Survival and Identity. In A. O. Rorty (Ed.), *The Identities of Persons* (pp. 17-40). Berkeley: University of California Press.

Lewkowicz, D. J & Ghazanfar, A. A. (2009). The emergence of multisensory systems through perceptual narrowing. *Trends in Cognitive Sciences, 13*(11), 470-478.

Locke, J. (1975). *An Essay Concerning Human Understanding*. P. H. Nidditch (Ed.), Oxford: Oxford University Press.

Louwerse, M. M., & Jeuniaux, P. (2010). The Linguistic and Embodied Nature of Conceptual Processing. *Cognition*, *114*, 96-104.

Lowe. E. J. (2009). *More Kinds of Being: A Further Study of Individuation, Identity, and the Logic of Sortal Terms*. Wiley-Blackwell.

Machery, E. (2007). Concept Empiricism: A Methodological Critique, *Cognition*, *104,* 19-46.

Machery, E. (2009). *Doing Without Concepts*. New York: Oxford University Press.

Machery, E. (2010). Precis of Doing Without Concepts. *Behavioral and Brain Sciences, 33,* 195–244.

Machery, E., Mallon, R., Nichols, S. & Stich, S. (2004). Semantics, Cross-Cultural Style, *Cognition*, *92,* B1-B12.

Machina, K.F. (1976). Truth, belief and vagueness. *Journal of Philosophical Logic, 5,* 47-78.

Manktelow, K. I. (1999). *Reasoning and Thinking*. Hove, Sussex: Psychology Press.

Martin A. (2007). The representation of object concepts in the brain. *Annu. Rev. Psychol., 58,* 25–45.

Matthews, R. J. (2007). *The measure of mind: Propositional attitudes and their attribution.* Oxford, UK: Oxford University Press.

Mendelson, E. (1964). *Introduction to mathematical logic*. New York: Van Nostrand Reinhold.

Mendes, N., Rakoczy, H., & Call, J. (2011). Primates do not spontaneously use shape properties for object individuation: A competence or a performance problem? *Animal Cognition, 14,* 407-414.

Mendes, N., Rakoczy, H., & Call, J. (2008). Ape metaphysics: Object individuation without language. *Cognition, 106*(2), 730-749.

Merricks, T. (1998). There are no criteria of identity over time. *Nous, 32,* 106:124.

Merricks, T. (2001). *Objects and Persons*. Oxford, UK: Oxford University Press.

Medin, D. L. (1989). Concepts and conceptual structure. *American Psychologist, 44,* 1469-1481.

Medin, D. L., & Ortony, A. (1989). Psychological essentialism. In S.Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 179–195). Cambridge, UK: Cambridge University Press.

Medin, D. L., & Rips, L. J. (2005). Concepts and categories: Meaning, memory, and metaphysics. In K. J. Holyoak & R. G. Morrison (Eds.), *Cambridge handbook of thinking and reasoning* (pp. 37–72). Cambridge, UK: Cambridge University Press.

Medin, D. L., & Schaffer, M. M. (1978). Context theory of classification learning. *Psychological Review, 85,* 207–238.

Miceli, G., Fouch, E., Capasso, R., Shelton, J.R., Tomaiuolo, F., & Caramazza, A. (2001). The dissociation of color from form and function knowledge. *Nat. Neurosci., 4,* 662–667.

Murphy, G. (2002). *The Big Book of Concepts*. Cambridge, MA: MIT Press.

Newman, A. J., Pancheva, R., Ozawa, K., Neville, H. J., & Ullman, M. T. (2001). An event-related fMRI study of syntactic and semantic violations. *J. Psycholinguist. Res.*, *30*, 339–364.

Newman, G. E., Herrmann, P., Wynn, K., & Keil, F. C. (2008). Biases towards internal features in infants' reasoning about objects. *Cognition, 107*(2), 420-432.

Ni, W., Constable, R. T., Menci, W. E., Pugh, K. R., Fulbright, R. K., Shaywitz, S. E., Shaywitz, B. A., & Gore, J. (2000). An event-related neuroimaging study distinguishing form and content in sentence processing. *J. Cogn. Neurosci.*, *12*, 120–133.

Nichols, S. (2004). Folk concepts and intuitions: From philosophy to cognitive science. *Trends in Cognitive Sciences, 8*(11)*,* 514-518.

Niedenthal, P. M., Barsalou, L., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Review, 9*, 184–211.

Nieuwland M.S., & Kuperberg G. R. (2008). When the truth is not too hard to handle: An event-related potential study on the pragmatics of negation. *Psychological Science, 19*(12), 1213-1218.

Nieuwland, M. S., & Martin, A. E. (2012). If the real world were irrelevant, so to speak: The role of propositional truth-value in counterfactual sentence comprehension. *Cognition, 112,* 102-109.

Noonan, Harold and Curtis, Ben, "Identity", *The Stanford Encyclopedia of Philosophy* (Summer 2014 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/sum2014/entries/identity/>.

Northoff, G., Heinzel, A., de Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain: A meta-analysis of imaging studies on the self. *Neuroimage, 31,* 440–457.

Nozick, R. (1981). *Philosophical explanations.* Cambridge, MA: Harvard University Press.

O'Regan, J. K., & Noë, A. (2001). A sensorimotor account of vision and visual consciousness, *Behavioral and Brain Sciences, 25*(4), 883–975.

Searle, J. (1980). Minds, brains, and programs. *Behavioral and Brain Sciences, 1,* 417-424.

Olin, D. (2003). *Paradox*. Ithaca: McGill-Queen’s University Press.

Osherson, D., & Smith, E. (1981). On the adequacy of prototype theory as a theory of concepts, *Cognition, 9,* 35–58.

Obrig, H., Wenzel, R., Kohl, M., Horst, S., Wobst, P., Steinbrink, J., & Villringer, A. (2000). Near-infrared spectroscopy: does it function in functional activation studies of the adult brain? *International Journal of Psychophysiology*, *35*(2), 125-142.

Parfit, D. (1984). *Reasons and persons.* Oxford, UK: Oxford University Press.

Parsons, T. (2000). *Indeterminate Identity: Metaphysics and Semantics.* Oxford, UK: Clarendon Press.

Patterson, K., Nestor, P. J., & Rogers, T. T. (2007). Where do you know what you know? The representation of semantic knowledge in the human brain. *Nature Reviews, 8,* 976-987.

Pecher, D., Zeelenberg, R., & Barsalou, L.W. (2004). Sensorimotor simulations underlie conceptual representations: Modality-specific effects of prior activation. *Psychonomic Bulletin & Review, 11,* 164-167.

Peirce, C.S. (1902). Vague. In J. M. Baldwin (Ed.), *Dictionary of Philosophy and Psychology* (p. 748). New York: MacMillan.

Plous, S. (1993). *The psychology of judgment and decision making*. New York: McGraw-Hill.

Pomplun, M., Velichkovsky, B.M. & Ritter, H. (1996). Disambiguating complex visual information: Towards communication of personal views of a scene. *Perception, 25*(8), 931-948.

Prinz, J. (2002). *Furnishing the mind: concepts and their perceptual basis*. Cambridge, MA: MIT Press.

Pylkkänen, L., Brennan, J., & Bemis, D. K. (2011). Grounding the cognitive neuroscience of semantics in linguistic theory. *Language and Cognitive Processes, 26*(9), 1317-1337.

Pylkkänen, L., Oliveri, B., & Smart, A. J. (2009). Semantics vs. world knowledge in prefrontal cortex. *Language and Cognitive Processes, 24*(9), 1313-1334.

Quine, W. V. O. (1960). *Word and object*. Cambridge, MA: MIT Press.

Quine, W. V. O. (1963). *From a Logical Point of View*. New York: Harper and Row.

Quine, W. V. O. (1964). Review of P. T. Geach, *Reference and Generality*, *Philosophical Review, 73,* 100–104.

Rayner, K., Reichle, E.D., & Pollatsek, A. (1998). Eye movement control in reading: An overview and model. In G. Underwood (Ed.), *Eye guidance in reading and scene perception* (pp. 243-268). Oxford, England: Elsevier.

Richardson, D. C., Spivey, M. J., Barsalou, L. W., & McRae, K. (2003). Spatial representations activated during real-time comprehension of verbs. *Cognitive Science, 27,* 767-780.

Rips, L. J., Blok, S., & Newman, G. (2006). Tracing the identity of objects. *Psychological Review, 113,* 1-30.

Rips, L. J. (1989). Similarity, typicality, and categorization. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 21-59). Cambridge, UK: Cambridge University Press.

Rips, L. J. (2001). Necessity and natural categories. *Psychological Bulletin, 127,* 827–852.

Rips, L. J. (2011). Split identity: Intransitive judgments of the identity of objects. *Cognition, 119,* 356-373.

Robbins, P., & Aydede, M. (2009). *The Cambridge Handbook of Situated Cognition* (Eds). Cambridge, UK: Cambridge University Press.

Rodd, J. M., Davis, M. H., & Johnsrude, I. S. (2005). The neural mechanism of speech comprehension: fMRI studies of semantic ambiguity. *Cereb. Cortex*, *15*, 1261–1269.

Rosch, E. H., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology, 8,* 382– 439.

Rosch, E. (1978). Principles of categorization. In E. Rosch & B. Lloyd (Eds.), *Cognition and Categorization* (pp. 27-48). Hillsdale, NJ: Lawrence Erlbaum Associates.

Rosch, E., & Mervis, C. (1975). Family Resemblances: Studies in the Internal Structure of Categories. *Cognitive Psychology, 7,* 573-605.

Rosengren, K. S., Gelman, S. A., Kalish, C. W., McCormick, M. (1991). As time goes by: Children's early understanding of growth in animals. *Child Development 62*(6), 1302-1320.

Roy, Deb (2005). Grounding words in perception and action: Computational insights. *Trends in Cognitive Sciences, 9*(8), 389-396.

Rozenblit, L. R. & Keil, F. C. (2002). The misunderstood limits of folk science: An illusion of explanatory depth. *Cognitive Science, 26,* 521-62.

Rumelhart, D. E., & Ortony, A. (1977). The representation of knowledge in memory. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), *Schooling and the acquisition of knowledge*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Ruschemeyer, S. A., Fiebach, C. J., Kempe, V., & Friederici, A. D. (2005). Processing lexical semantic and syntactic information in first and second language: fMRI evidence from German and Russian. *Hum. Brain Mapp.*, *25*, 266–286.

Ruschemeyer, S. A., Zysset, S., & Friederici, A. D. (2006). Native and non-native reading of sentences: An fMRI experiment. *Neuroimage*, *31*, 354–365.

Santos, A., Chaigneau, S.E., Simmons, W.K., & Barsalou, L.W. (2011). Property generation reflects word association and situated simulation. *Language and Cognition, 3,* 83-119.

Scholl, B. J. (2007). Object persistence in philosophy and psychology. *Mind & Language, 22*(5), 563-591.

Schultz, W. (2006). Behavioral theories and the neurophysiology of reward. *Annu. Rev. Psych.*, *57*, 87-115.

Shoemaker, S. (1979). Identity, properties, and causality. *Midwest Studies in Philosophy, 4,* 321–342.

Simmons, K., & Barsalou, L. W. (2003). The similarity-in-topography principle: Reconciling theories of conceptual deficits. *Cognitive Neuropsychology, 20,* 451-486.

Simmons, W. K., Hamann, S. B., Harenski, C. N., Hu, X. P., & Barsalou, L. W. (2008). fMRI evidence for word association and situated simulation in conceptual processing. *Journal of Physiology, 102,* 106-119.

Simmons, W. K., Martin, A., & Barsalou, L. W. (2005). Pictures of appetizing foods activate gustatory cortices for taste and reward. *Cerebral Cortex, 15,* 1602-1608.

Simmons, W. K., Ramjee, V., Beauchamp, M. S., McRae, K., Martin, A., & Barsalou, L. W. (2007). A common neural substrate for perceiving and knowing about color. *Neuropsychologia, 45,* 2802-2810.

Smith, L. B., & Thelen, E. (1993). *A Dynamic Systems Approach to Development: Applications*. Cambridge, MA: MIT Press.

Smith, L. B. & Thelen, E. (*2003*). Development as a dynamic system. *Trends in Cognitive Science, 7*, 343-348.

Solomon, K.O., & Barsalou, L.W. (2001). Representing properties locally. *Cognitive Psychology, 43,* 129-169.

Solomon, K.O., & Barsalou, L. W. (2004). Perceptual simulation in property verification. *Memory & Cognition, 32,* 244-259.

Sorensen, R. (2003). *A Brief History of the Paradox*. New York: Oxford University Press.

Spelke, E. S., Gutheil, G., & Van de Walle, G. (1995). The development of object perception. In D. N. Osherson (Series Ed.) & S. M. Kosslyn & D. N. Osherson (Eds.), *Invitation to cognitive science: Visual cognition* (2nd ed., pp. 297–330). Cambridge, MA: MIT Press.

Spelke, E. S., Kestenbaum, R., Simons, D. J., & Wein, D. (1995). Spatiotemporal continuity, smoothness of motion and object identity in in- fancy. *British Journal of Developmental Psychology, 13,* 113–142.

Spelke, E. S. (1990). Principles of object perception. *Cognitive Science, 14,* 29-56.

Strawson, P.F. (1959). *Individuals: An Essay in Descriptive Metaphysics*. London, UK: Methuen & Co. Ltd.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology 18*(6), 643–662.

Thelen, E., & Smith, L. (1994). *A Dynamic Systems Approach to the Development of Cognition and Action*. Cambridge, MA: MIT Press.

Thelen, E. (1995). Time-scale dynamics in the development of an embodied cognition. In R. Port and T. van Gelder (Ed.), *Mind In Motion*. Cambridge, MA: MIT Press.

Thelen, E., Schoner, G., Scheier, C., & Smith, L. B. (2001). The Dynamics of Embodiment: A Field Theory of Infant Perservative Reaching. *Behavioral and Brain Sciences, 24,* 1-86.

Thompson-Schill, S. L. (2003). Neuroimaging studies of semantic memory: inferring "how" from "where". *Neuropsychologia, 41,* 280-292.

Tomasello, M. (2009). *Why We Cooperate*. Cambridge, MA: MIT Press.

Tversky, A. (1969). The intransitivity of preferences. *Psychological Review, 76,* 31-48.

Tversky, A. (1977). Features of similarity. *Psychological Review, 84,* 327–352.

Tversky, A., & Kahneman, D. (1981). The Framing of decisions and the psychology of choice. *Science, 211*(4481)*,* 453-458.

Van Berkum, J. J. A., Van Den Brink, D., Tesink, C., Kos, M., & Hagoort, P. (2008). The neural integration of speaker and message. *J. Cogn. Neurosci.*, *20*, 580–591.

Van Dantzig, S., Pecher, D., Zeelenberg, R., & Barsalou, L. W. (2008). Perceptual processing affects conceptual processing. *Cognitive Science, 32,* 579-590.

Van Overwalle, F. (2009). Social cognition and the brain: a meta-analysis. *Human Brain Mapping, 30*(3), 829-858.

Varela, F., Thompson, E., & Rosch, E. (1991). *The Embodied Mind*. Cambridge, MA: MIT Press.

Velichkovsky, B. M. (1999). From levels of processing to stratification of cognition: Converging evidence from three domains of research. In B. H. Challis & B. M. Velichkovsky (Eds.), *Stratification in cognition and consciousness* (pp. 203–235). Amsterdam, Netherlands: John Benjamins Publishing Company.

Velichkovsky, B.M., Rothert, A., Kopf, M., Dornhoefer, S.M. & Joos, M. (2002). Towards an express diagnostics for level of processing and hazard perception. *Transportation Research*, *5*(2), 145-156.

Wasserman, R. (2015). "Material Constitution", *The Stanford Encyclopedia of Philosophy* (Spring 2015 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/spr2015/entries/material-constitution/>.

Weiss, S. & Mueller, H.M. (2003). The contribution of EEG coherence to the investigation of language. *Brain & Language, 85,* 325-343.

Wiggins, D. (1997). Sortal concepts: A reply to Xu. *Mind & Language, 12,* 413– 421.

Wiggins, D. (2001). *Sameness and Substance (Renewed)*. Cambridge, MA: Cambridge University Press.

Williams, L. E. & Bargh, J. A. (2008). Experiencing physical warmth promotes interpersonal warmth. *Science, 322,* 606-607.

Wu, L. L, & Barsalou, L. W. (2009). Perceptual simulation in conceptual combination: Evidence from property generation. *Acta Psychologica, 132,* 173-189.

Willems, R. M., Ozyurek, A., & Hagoort, P. (2007). When language meets action: The neural integration of gesture and speech. *Cereb. Cortex*, *17*, 2322-2333.

Willems, R. M., Ozyurek, A., & Hagoort, P. (2008). Seeing and hearing meaning: Event-related potential and functional magnetic resonance Imaging evidence of word versus picture integration into a sentence context. *J. Cogn. Neurosci.*, *20*, 1235–1249.

Wilson-Mendenhall, C. D., Barrett, L. F., Simmons, W. K., & Barsalou, L. W. (2011). Grounding emotion in situated conceptualization. *Neuropsychologia, 49*, 1105-1127.

Wilson-Mendenhall, C. D., Simmons, W. K., Martin, A., & Barsalou, L. W. (2013). Contextual processing of abstract concepts reveals neural representations of non-linguistic semantic content. *Journal of Cognitive Neuroscience, 25,* 920-935.

Wittgenstein, L. (1958). *Philosophical Investigations*, (2nd edition), G.E.M. Anscombe and R. Rhees (eds.), trans. by G.E.M. Anscombe, Oxford: Basil Blackwell.

Xu, F. (2007). Sortal concepts, object individuation, and language. *Trends in Cognitive Sciences 11*(9), 400-406.

Xu, J., Kemeny, S., Park, G., Frattali, C., & Braun, A. (2005). Language in context: Emergent features of word, sentence, and narrative comprehension. *Neuroimage*, *25*, 1002–1015.

Xu, F. (1997). From Lot's wife to a pillar of salt: Evidence that physical object is a sortal concept. *Mind & Language, 12,* 365–392.

Xu, F. (2002). The role of language in acquiring object kind concepts in infancy. *Cognition, 85,* 223–250.

Xu, F. (2003). The development of object individuation in infancy. In Hayne, H., & Fagen, J. (Eds.), *Progress in infancy research* (Vol. 3, pp.159–192). Mahwah, NJ: Erlbaum.

Xu, F. (2005). Categories, kinds, and object individuation in infancy. In L. Gershkoff-Stowe & D. Rakison (Eds.), *Building object categories in developmental time* (pp. 63-89). Mahwah, NJ: Erlbaum.

Xu, F., & Baker, A. (2005). Object individuation in 10-month-old infants using a simplified manual search method. *Journal of Cognition and Development, 6,* 307-323.

Xu, F., & Carey, S. (1996). Infants' metaphysics: The case of numerical identity. *Cognitive Psychology, 30,* 111-153.

Xu, F., Carey, S., & Quint, N. (2004). The emergence of kind-based object individuation in infancy. *Cognitive Psychology, 49,* 155-190.

Yablo, S. (1993). Paradox without self-reference. *Analysis, 53,* 251–252.

Yeh, W., & Barsalou, L.W. (2006). The situated nature of concepts. *American Journal of Psychology, 119,* 349-384.

Yuan, J. J. (2007), Are we sensitive to valence differences in emotionally negative stimuli? Electrophysiological evidence from an ERP study. *Neuropsychologia, 45*(12)*,* 2764-2771.

Zempleni, M. Z., Renken, R., Hoeks, J. C., Hoogduin, J. M., & Stowe, L. A. (2007). Semantic ambiguity processing in sentence context: Evidence from event-related fMRI. *Neuroimage*, *34*, 1270–1279.

Zhong, Chen-Bo & Leonardelli, G. J. (2008). Cold and Lonely. Does social exclusion literally feel cold? *Psychological Science, 19*(9), 838-842.

APPENDICES

APPENDIX A- THE CONCEPTUAL TENDENCY TEST

Kavramsal Eğilim Testi

1. Bir organı değiştirilen bir insan operasyon öncesiyle karşılaştırıldığında aynıdır/farklıdır.
2. Yeni doğan tek yumurta ikizleri aynıdır/farklıdır.
3. Yapay ortamda üretilen aynı genetik özelliklere sahip iki karaciğer aynıdır/farklıdır.
4. Aynı koşullar altındaki iki su molekülü aynıdır/farklıdır.
5. Bir kişi doğumundan ölümüne kadar aynıdır/farklıdır.
6. Bir kağıt parçası 3 kere üst üste katlandığında aynıdır/farklıdır.
7. Pedalları çıkartılmış bir bisiklet pedalları olan haline göre aynıdır/farklıdır.
8. Bütün parçaları sökülmüş bir araba (bütün parçaları bir arada) sökülmeden önceki haliyle karşılaştırıldığında aynıdır/farklıdır.
9. Aynı davranışlara ve kalıtsal özelliklere sahip iki kuş aynıdır/farklıdır.
10. Molekülleri tam olarak korunmuş bir cansız nesne 1000 sene sonra da aynıdır/farklıdır.
11. Kırılarak parçalara ayrılmış bir cam bardağın parçaları ilk halinden hiçbir fark olmayacak şekilde bir araya getirilirse aynıdır/farklıdır.
12. Suyun farklı fiziksel durumları (katı, sıvı, gaz) aynı kimyasal formüle sahip olduğu için aynıdır/farklıdır.
13. Hafıza özelliklerini kaybetmiş bir insana aynı işlevleri yerine getirecek, eski hafızasına ulaşabilecek bir çip takıldığında bu kişi eski haliyle karşılaştırıldığında aynıdır/farklıdır.
14. Aynı yapay zeka yazılımına sahip iki robot aynı ortamlarda aynı şekilde davranıyorlarsa ikisi aynıdır/farklıdır.
15. Aynı davranışsal eğilimlere ve fiziksel özelliklere sahip bir yapay zeka biyonik robotu ve bir kedi aynıdır/farklıdır.
16. Tamamen moleküllerine ayrıldıktan sonra hiçbir fiziksel değişime uğramaksınız bir araya getirilen bir kuş önceki durumuyla karşılaştırıldığında aynıdır/farklıdır.
17. İşlev gösteren bir robotun tamamen sökülerek ve sonrasında eski haline getirilmesi durumu için robot ilk durumuyla karşılaştırıldığında aynıdır/farklıdır.
18. Normal bacakla aynı işlevleri yerine getiren bir protez bacak takılarak olimpiyatlarda yarışmak isteyen biri aynıdır/farklıdır.
19. Biyonik olarak tasarlanmış bir kol üçüncü kol olarak birine takılırsa, bu kişi öncesiyle karşılaştırıldığında aynıdır/farklıdır.
20. Kalbi değiştirilen bir insan önceki durumuyla karşılaştırıldığında aynıdır/farklıdır.
21. Hafızasında bir sorun olan robotun hafıza çipi değiştirilip hafıza sorunu giderilirse bu robot öncesiyle karşılaştırıldığında aynıdır/farklıdır.
22. Motoru değiştirilen bir araba öncesiyle karşılaştırıldığında aynıdır/farklıdır.
23. Yüz transplantasyonu gerçekleştiren bir insan öncesiyle karşılaştırıldığında aynıdır/farklıdır.
24. Zaman geçmesiyle rengi değişip kahverengiye dönen bir muz ilk haliyle karşılaştırıldığında aynıdır/farklıdır.

APPENDIX B- INFORMED CONSENT FORM

Gönüllü Katılım Formu

Bu çalışma, Enformatik Enstitüsü doktora adaylarından Tuna Çakar tarafından doktora tezi çerçevesinde yürütülen akademik bir çalışmadır. Çalışmanın amacı, kişilerin kavramsal ve muhakemeye yönelik süreçlerini daha iyi anlayabilmek ve hangi faktörlerden etkilendiğini açıklamaya çalışmaktır. Çalışma süresince sunulacak soruların doğru veya yanlış cevaplanması değil sadece kişisel eğilimleri yansıtması açısından önemlidir. Deney boyunca göz izleme ölçüm yöntemi kullanılarak veri alınacaktır. Göz izleme yönteminin sağlık açısından hiçbir zararı yoktur. Çalışma yaklaşık 25 dakika sürecektir.

Çalışmaya katılım tamamı ile gönüllülük temelindedir. Ankette, sizden kimlik belirleyici hiçbir bilgi istenmemektedir. Cevaplarınız tamamıyla gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir; elde edilecek bilgiler bilimsel yayınlar ve sunumlar için kullanılacaktır.

Verilecek bulmacalar, kişisel rahatsızlık verecek sorular içermemektedir. Ancak, katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz deneyi yarıda bırakıp çıkma hakkına sahipsiniz. Böyle bir durumda deneyin yürütücüsüne, deneyi tamamlamayacağınızı söylemeniz yeterli olacaktır. Deney sonunda, bu çalışmayla ilgili sorularınız cevaplandırılacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için Tuna Çakar'a (Tel: 0530 922 55 05, E-posta: cakar.tuna@gmail.com) ulaşabilirsiniz.

Bu çalışmaya tamamen gönüllü olarak katılıyorum ve istediğim zaman yarıda kesip çıkabileceğimi biliyorum. Verdiğim bilgilerin bilimsel amaçlı yayımlarda kullanılmasını kabul ediyorum. (Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

Ad-Soyad Tarih İmza

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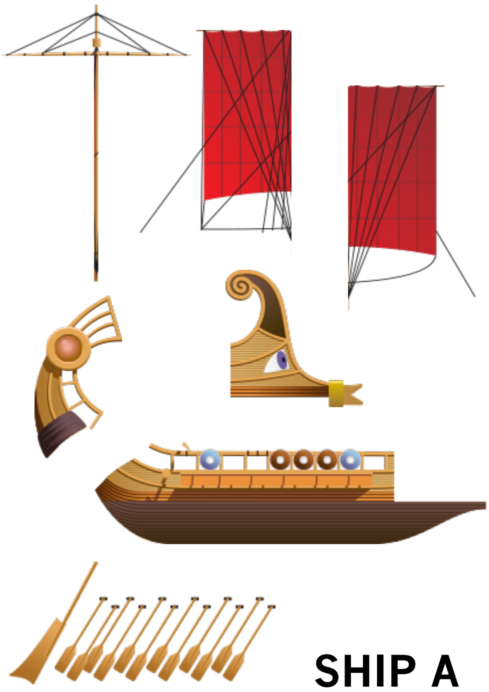
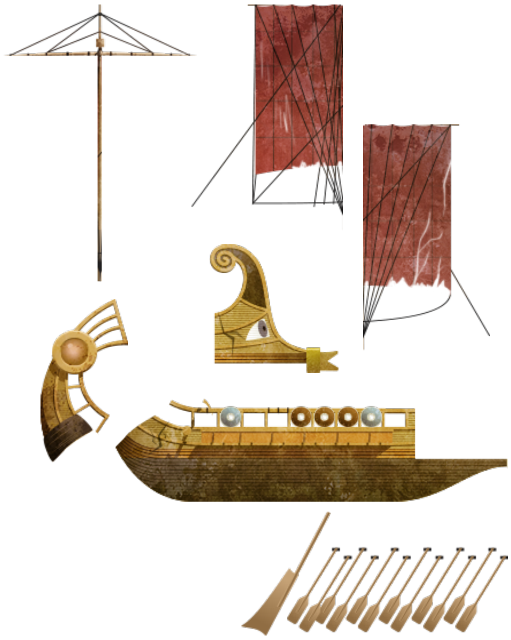
APPENDIX C- VISUAL IMAGES FOR SHIP A AND SHIP B



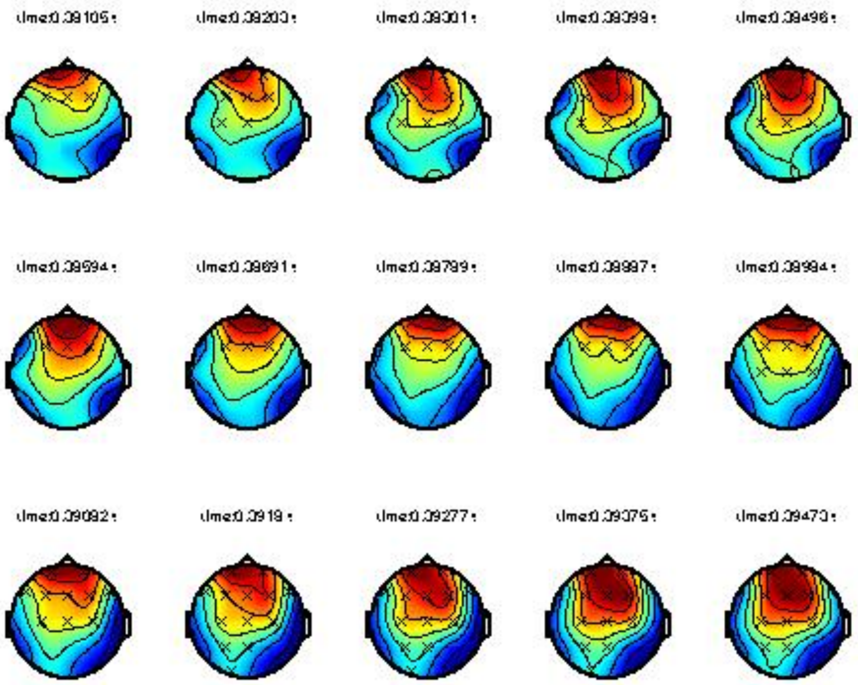
SHIP A

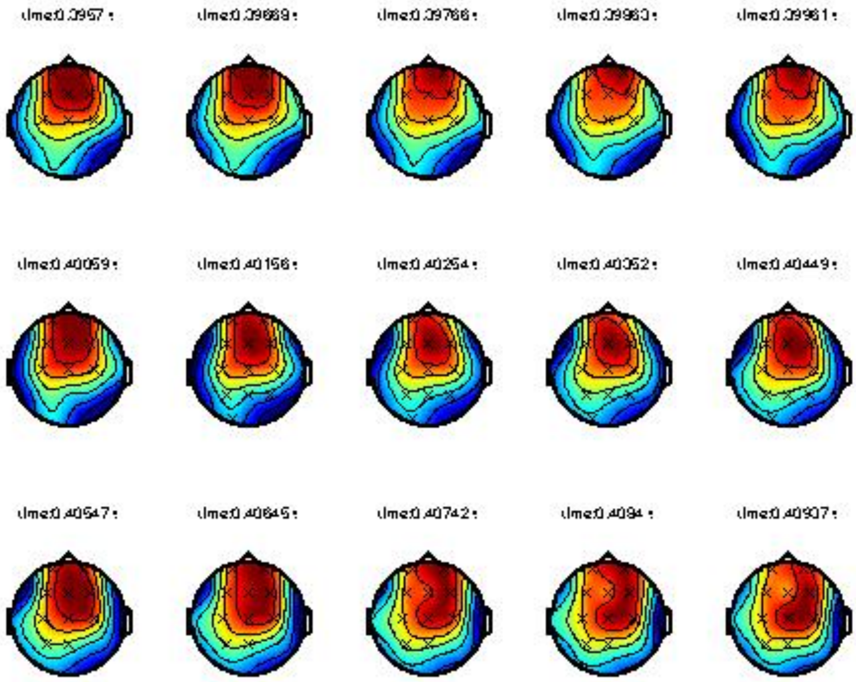


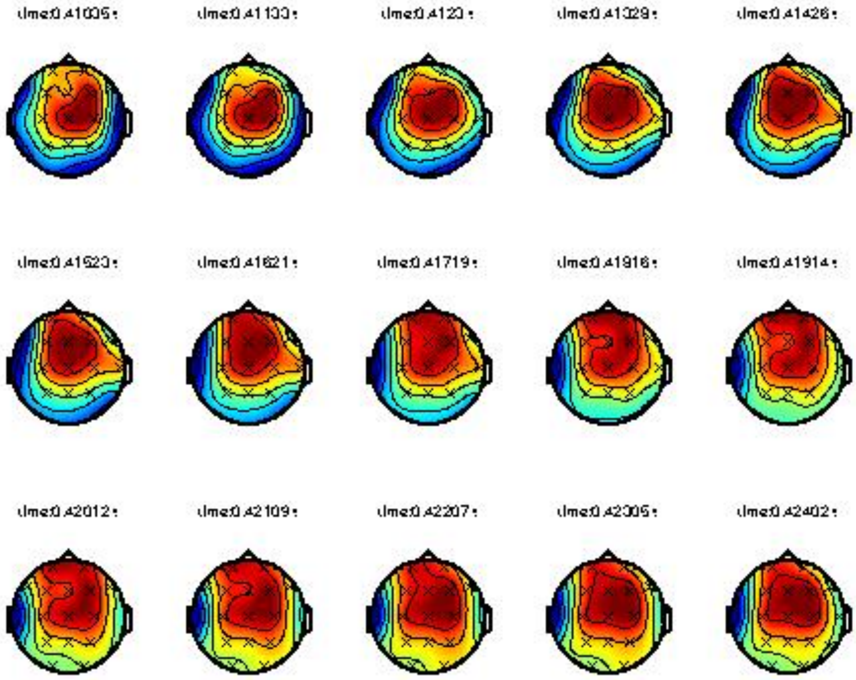
SHIP B

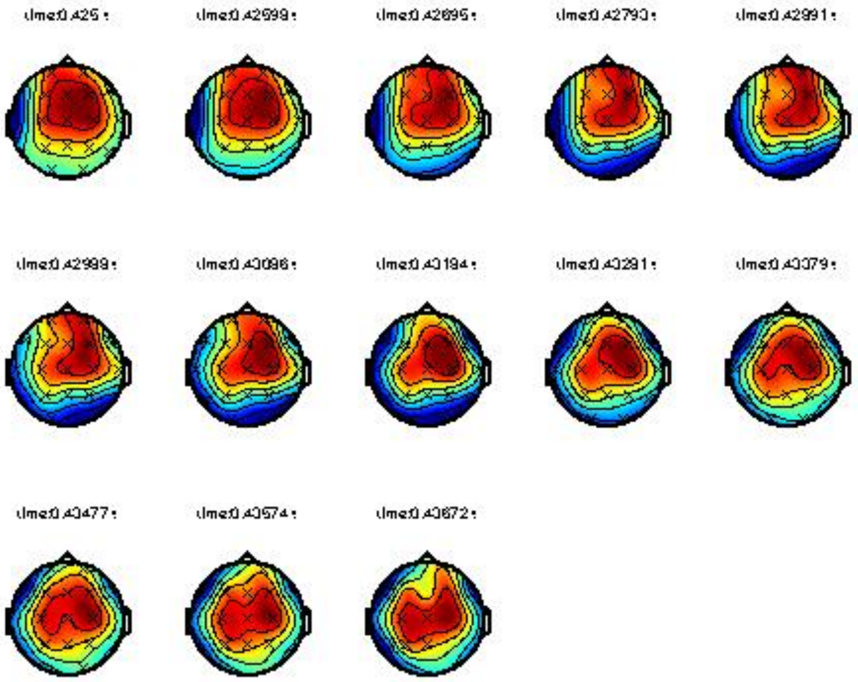
APPENDIX D- THE TOPOGRAPHICAL MAPS FOR AYNIDIR-FARKLIDIR

This appendix holds the topographical maps for the comparison between *aynıdır* and *farklıdır* condition. The topographical maps are presented within the temporal dimension. The channels marked with a cross are the ones having statistically significant difference for *aynıdır* and *farklıdır* conditions. Time flows from left to right. As can be seen from the figures, the potential difference rises with the frontal channels which is supportive for the semantic/conceptual unification issue. However, the semantic violation and world-knowledge violation cases result with a potential difference emerging in the parietal and central channels. It is also important to highlight that the time zone for this significant potential difference starts from 390 milliseconds and lasts until 436 milliseconds. This is exactly the critical time zone for the N400 signal which is in line with the scientific findings in the literature.









APPENDIX E- RESULTS OF THE RELIABILITY ANALYSES

```
R E L I A B I L I T Y   A N A L Y S I S - S C A L E   (S T R I C T)


                       Analysis of Variance

Source  of  Variation    Sum  of  Sq.       DF    Mean  Square       F
Prob.

Between People          143,4211        18      7,9678
Within People           868,8077       475      1,8291
  Between Measures      174,2287        25      6,9691          4,5151
  Residual              694,5789       450      1,5435
    Nonadditivity        9,5921          1        9,5921        6,2875
,0125
    Balance             684,9869       449        1,5256
Total                   1012,2287      493        2,0532
     Grand Mean         2,9251


Tukey estimate of power to which observations
must be raised to achieve additivity         =      2,2738

          Not enough cases to compute Hotelling's T-Squared.


      Test for Goodness of Fit of Model Strictly Parallel

      Chi-square =         .          Degrees of Freedom =      374
      Log of determinant of unconstrained matrix =        .
      Log of determinant of constrained matrix   =        .
      Probability =    .


          Parameter Estimates

      Estimated common mean     =       2,9251
      Estimated common variance =       2,1433
                 Error variance =       1,8291
                  True variance =        ,3142
      Estimated common inter-item correlation =     ,1087

      Estimated reliability of scale   =  ,7602
      Unbiased estimate of reliability =  ,7981
```

APPENDIX F- ETHICAL APPROVAL FORM

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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27.02.2015

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Bilişsel Bilimler Bölümü

Gönderen : Prof. Dr. Canan Sümer
IAK Başkan Vekili

İlgi : Etik Onayı

Danışmanlığını yapmış olduğunuz Bilişsel Bilimler Bölümü öğrencisi Tuna Çakar'ın "Paradoks Çözümlemelerinde Kavramsal Süreçlerin Anlaşılması" isimli araştırması "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

27/02/2015

Prof.Dr. Canan Sümer
Uygulamalı Etik Araştırma Merkezi
(UEAM) Başkan Vekili
ODTÜ 06531 ANKARA

APPENDIX G- CIRRICULUM VITAE

Tuna Çakar

Date of Birth: 18.07.1981
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EDUCATION AND QUALIFICATIONS

2009-2015	Middle East Technical University – Ankara, TURKEY Informatics Institute, Cognitive Science Program *PhD Program*
2006-2009	Boğaziçi University – İstanbul, TURKEY Institute of Social Sciences, Cognitive Science M.A. Program *Master Degree*
1999-2004	Sabancı University – İstanbul, TURKEY Faculty of Engineering and Natural Sciences, Biological Sciences and Bioengineering *Bachelor Degree with Full Scholarship*

WORK EXPERIENCE

2013-2014	Co-Instructor, Neuromarketing Graduate Course (50 students each, 2 terms), İstanbul Bilgi University
2012 Spring	Instructor, Neuromarketing Undergraduate Course (50 students), Özyeğin University
2010-2011	Project Assistant, TÜBİTAK SOVAK 1001 Project, Experimental Economics Project on Gender Differences
2008-2009	Research Assistant, Psychophysics Laboratuary, Boğaziçi University
2004-2005	Project Assistant, International Competitiveness Forum, TÜSİAD

AWARDS & FINANCIAL SUPPORT

- TÜBİTAK 1507 KOBİ R&D Support (2015), Project No: 7141139
- TÜBİTAK 1501 Industrial R&D Project Support (2015), Project No: 3140565
- TÜBİTAK 1512 Entrepreneurship Support (2013), İşleyenzihin, Project No: 2130251
- TÜBİTAK 1002 Fast-track Support (2013-2014), Project No: 113E311

- Teknogirişim Sermaye Desteği (2013), Nörobilim Araştırmaları Ltd. Şti.,
- TÜBİTAK Doctorate Scholarship (2009-2014)
- Merit Scholarship, Sabancı University (1999-2004)
- 430th place in University Entrance Examination (1999)
- 9th place in European Mathematics Contest (1999)

PUBLICATIONS & PROCEEDINGS

Publications:
Cakar, T, & Girisken, Y. (2015). The role of prefrontal cortex to TV ads for predicting preferences and influence of brand image (under review).
Girisken, Y, & Cakar, T. (2015). Seçmenlerin Siyasi Parti Lider Algısının Optik Beyin Görüntüleme Sistemi ile Ölçülmesi. (under review).
Cakar, T, & Neyse, L. (2015). "Nöroiktisat" chapter in "İktisadın Davranışsal Temelleri". İmge Publishing: İstanbul.
Cakir, MP, Cakar, T, & Girisken, Y. (2015). Neural correlates of purchasing behavior in the prefrontal cortex: an optical brain imaging study. *Proceedings of the Annual Meeting of Cognitive Science Society*, July 23-25, 2015.
Ulman, YI, Cakar, T, Yildiz, G. Neuromarketing and Ethical Issues. *Science and Engineering Ethics 20* (DOI 10.1007/s11948-014-9581-5)
Cakar, T, Ulman YI. Nöpolitika ve Etik Kaygılar, Uluslararası Biyoetik Kitabı, İstanbul-Türkiye, Ekim 2012.

Proceedings:

Cakar, T, & Girisken Y. (2015). The role of prefrontal cortex to TV ads for predicting preferences and influence of brand image. NeuroPyschoEconomics Conference (pg. 46), Kopenhag-Denmark, June, 18-19, 2015.

Cakar T, & Hohenberger, A. (2015). Differences in processing between same (Aynıdır) and different (Farklıdır) judgments during an Identity Reasoning Task. 9. Dilbilim Konferansı (15-16 Nisan 2015), HÜDİT Conference Proceedings.

Cakar, T, & Hohenberger, A. (2015). Do Eye-Movements Provide Information about Decision Processes during Paradoxical Reasoning? Second International Symposium on Brain and Cognitive Science (METU, Ankara). Proceedings of ISBCS'2015.

Cakar, T, & Hohenberger, A. (2015). The Ship of Theseus: Using mathematical and computational models for predicting identity judgments. ICCM'2015 (April 9-11, 2015). Proceedings of ICCM'2105.

Ozdemir, D, Cakar, T, & Cakir, P. (2014). A case study in problem-solving via eye-tracking. First International Symposium on Brain and Cognitive Science (Boğaziçi University). Proceedings of ISBCS'2014 (April 19, 2014).