COMPARISON OF COGNITIVE MODELING AND USER PERFORMANCE ANALYSIS FOR TOUCH SCREEN MOBILE INTERFACE DESIGN

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ABSTRACT

COMPARISON OF COGNITIVE MODELING AND USER PERFORMANCE ANALYSIS FOR TOUCH SCREEN MOBILE INTERFACE DESIGN

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The main aim of this thesis is to analyze and comparatively evaluate the usability of touch screen mobile applications through cognitive modeling and end-user usability testing. The study investigates the accuracy of the estimated results cognitive model produces for touch screen mobile phone interfaces.

CogTool application was used as the cognitive modeling method. Turkcell Cüzdan application, which is suitable for the implementation of both methods, was chosen as the mobile application. Based on the feedback given by the developer of the application, 8 tasks were determined, considering the most widely used actions and critical operations on the application. 10 people who had not used the application before were selected and user tests were conducted in a usability laboratory. Since CogTool gives skilled users' performance prediction, the test was performed twice. CogTool predictions were compared with the second test results. The results obtained from CogTool were analyzed step by step, and tasks were compared on the basis of step time and total task completion time. This study reveals that CogTool gives approximate estimations with actual user performance on touch screen mobile phone application interfaces. However, if there are special cases in the tasks such that users are very accustomed to the steps or decision-making is involved in the tasks, the "Think Operation" in CogTool should be changed appropriately or it should be deleted. In addition, this study shows that performing cognitive modeling method requires one third of the time needed for conducting end user tests. Furthermore, the results reveal that CogTool can be used for measuring some factors which affect user satisfaction level.

Keywords: Mobile usability, Cognitive Modeling, CogTool, User Testing, GOMS

ÖZ

BİLİŞSEL MODELLEME VE KULLANICI PERFORMANS TESTİ YÖNTEMLERİNİN DOKUNMATİK MOBİL ARAYÜZ TASARIMINDA KARŞILAŞTIRILMASI

OCAK, Nihan
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Ocak 2014, 99 Sayfa

Bu tez çalışmasının temel amacı, dokunmatik ekranlı mobil uygulamaların kullanılabilirliğini bilişsel modelleme ve son kullanıcı kullanılabilirlik testi metotlarıyla analiz ederek karşılaştırmalı olarak değerlendirmektir. Çalışma, bilişsel modelleme yönteminin dokunmatik mobil cihazlarda verdiği tahmini sonuçlarının doğruluğunu araştırmaktadır.

Çalışmada, bilişsel modelleme yöntemi için CogTool uygulaması kullanılmıştır. Mobil uygulama olarak her iki yöntemin uygulanması için uygun olan Turkcell Cüzdan uygulaması seçilmiştir. Uygulama geliştiricileri ile görüşülerek en çok kullanılan ve kritik olduğu düşünülen 8 görev belirlenmiştir. Uygulamayı daha önce kullanmamış 10 kullanıcı seçilerek kullanılabilirlik laboratuvarında kullanıcılarla test gerçekleştirilmiştir. CogTool deneyimli kullanıcı performans tahmin sonuçları verdiği için çalışma iki aşamalı olarak gerçekleştirilmiştir. Kullanıcılar ilk önce görevleri gerçekleştirerek uygulama üzerinde deneyim sahibi olmuştur. Kullanıcılarla yapılan ikinci testin sonuçları CogTool sonuçları ile karşılaştırılmıştır. CogTool sonuçları adım adım analiz edilerek, görevler adım bazında ve toplam süre bazında karşılaştırılmıştır. Bu çalışmanın sonuçlarına göre, CogTool dokunmatik mobil telefon uygulama arayüzlerinde kullanıcı performanslarına yakın tahmin sonuçları vermektedir. Ancak, CogTool kullanılırken kullanıcıların sayfa üzerinde yapmaya çok alışık oldukları işlemler veya seçim yapmasını gerektiren seçenekler olduğu durumlarda “Think Operation” süresi işleme uygun olarak değiştirilmeli veya silinmelidir. Ayrıca, çalışma CogTool’u uygulamanın kullanıcı testi yöntemini gerçekleştirmenin üçte biri zaman gerektirdiğini göstermiştir. Bunun yanında, çalışma sonuçları CogTool’un kullanıcı memnuniyetini etkileyen bazı faktörlerin ölçülmesi için kullanılabileceğini göstermiştir.

Keywords: Mobil kullanılabilirlik, Bilişsel Modelleme, CogTool, Kullanılabilirlik testi

To the memories of my grandmother

&

My Parents and Brothers

who believed me and offered me unconditional love throughout my life

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

HCI: Human Computer Interaction

ISO: International Standards Organization

METU: Middle East Technical University

QUIS: Questionnaire for User Interaction Satisfaction

MHP: Model Human Processor

GOMS: Goals, Operators, Methods, and Selection Rules

ACT-R: Adaptive Control of Thought—Rational

KLM: Keystroke-Level Model

UI: User Interface

IOS: iPhone Operating system

3G: Third Generation

ELAN: EUDICO Linguistic Annotator

CHAPTER I

INTRODUCTION

The first chapter serves as an introductory chapter for the study, thereby the purpose and the significance of the present study are described in detail. Moreover, the chapter concludes by presenting the research questions and the definition of the terms used within the scope of this thesis.

1.1 INTRODUCTION

The increasing use of mobile devices has brought about significant changes and trends in the fields of Human Computer Interaction (HCI) and Communications. With the help of mobile devices, users have the opportunity to access information independent of time and place. According to the Smartphone Adoption report published by Deloitte (2012), smartphone sales will have remarkably increased by the end of 2013 due to the increasing amount of data and the convenience provided by smartphones that facilitate daily life. Also, smartphones are estimated to take over computers as the most preferred devices. Moreover, according to the research report created by iSuppli (2009), touch screen technology also grows every year with the development of new technical devices with corresponding human-computer interface. Touch screens are used in many kinds of devices but are more popular by means of smartphones.

The increase in the use of smartphones has led to the rise of the number of mobile applications and mobile application developers, meaning that the demands for such applications increased as a result of the increased interaction between users and mobile applications. For this interaction to be effective and efficient, mobile usability studies are of utmost importance. Conceivably, interacting with small screens and accessing information on such screens on the move is much more difficult than desktop application (Nielsen, 2011). Therefore, it is imperative for companies developing mobile applications to learn about mobile usability and take it into account when developing mobile applications.

There is a wide range of usability methods to evaluate the usability of the products. These usability methods differ from each other in terms of application, results obtained, time and cost required etc. (Nielsen, 2008). The most commonly used methods to evaluate usability of the human computer-interface are end user usability tests, heuristic evaluation and survey methods. Cognitive modeling is another method that is used to evaluate usability and it that predicts user performance through a generalized representation (John, 2012). However, it is not a widely used method for evaluating usability of user interface of touch screen mobile phones.

There are several cognitive modeling methods used to evaluate usability by estimating how long it takes to execute tasks on an interface. The most commonly used methods are Model Human Processor (MHP), Keystroke-Level Model (KLM), and Goals, Operators, Methods and Selection Rules (GOMS). CogTool, developed by researchers in the Human Computer Interaction Institute at Carnegie Mellon University, is a modeling tool which uses KLM modeling to predict the approximate mean time to execute a task on an interface. In this thesis study, CogTool was used as a cognitive modeling method and the accuracy of the predictions for touch screen mobile phones was investigated by comparing actual users' performance.

1.2 PURPOSE OF THE STUDY

The purpose of the study is threefold;

1. to investigate the differences between results obtained from the cognitive modeling tool and user tests,
2. to explore the effectiveness of cognitive modeling tools in a performance aspect of usability testing on touch screen mobile application,
3. to explore the optimum usability method that is suitable for guiding the development of touch screen mobile applications.

1.3 SIGNIFICANCE OF THE STUDY

The rapid development in the usage of mobile phones and rigorous competition in the market make it necessary to evaluate user performance and usability in the early stages of the development of application interfaces so as to prevent potential problems in the interaction between users and interfaces (Li, Liu, Liu, Wang, Li & Rau, 2010). Cognitive modeling is an appropriate method to evaluate usability in the early steps of the development process due to its validity and reliability. John, Prevas, Salvucci, and Koedinger (2004) stated that CogTool's predictions are within about 10% of empirical data. However, this has not been widely validated for the touch screen mobile applications.

In addition, comparison of cognitive model predictions with actual users' observed data is the most frequently used way to investigate the accuracy of cognitive modeling. In this study, two usability methods have been used to evaluate the touch screen mobile application interface; cognitive modeling and end user performance test.

The findings of this study will be important for both developers and end users. Firstly, the findings will be helpful for mobile application developers in deciding which method they should choose to evaluate the usability of mobile applications. Also, the findings of this study will aid in improving mobile interfaces in terms of effectiveness and efficiency. Moreover, since the research into the use of cognitive modeling method to evaluate the usability of the applications for new generation smartphones is scarce, the findings will contribute to the field of Human Computer Interaction.

1.4 RESEARCH QUESTIONS

This study is guided by the following research questions:

1. Does cognitive modeling method yield similar results to those of user tests in the usability evaluation of touch screen mobile applications?

2. To what extent is cognitive modeling method suitable to evaluate the performance aspect of usability on touch screen mobile applications?

3. What is the optimum usability method that can guide the development of touch screen mobile applications?

1.5 DEFINITIONS OF TERMS

Cognitive modeling: A computer science area which produce a computational model to simulate or predict how people perform tasks and solve problems, based on cognitive psychology principles.

CogTool: According to John (2010) CogTool is a general purpose user interface prototyping tool. Differently from other tools, it automatically evaluates interface with a predictive human performance model.

Touch screen: It is an electronic visual display that the user can interact with it by touching the screen with fingers. In some touch screen displays, objects such as a stylus or specially pen can be used for interaction.

CHAPTER II

LITERATURE REVIEW

Usability is defined in the ISO 9241-11 Usability Guide, which is a section of the ISO 9241 “Ergonomics of Human System Interaction” as the degree of usage satisfaction for the effective and efficient use of a product by certain users toward certain goals in particular environments (ISO 9241-11, 1998). In order to evaluate usability, the effectiveness of a product is measured by the user’s proper use for certain aims and reaching the wholeness. On the other hand, efficiency is evaluated by the measurement of resources spent in reaching proper usage and wholeness.

For evaluating the usability of products, there is a wide range of usability methods, varying from end user usability tests to desirability studies used to measure aesthetic appeal (Nielsen, 2008). End user usability tests, heuristic evaluations and survey methods are the most commonly used ones to evaluate the usability of interfaces. Cognitive modeling is another method that predicts user performance through a generalized representation (John, 2012). Nonetheless, this method is not very commonly used.

In this chapter, some of the usability evaluation methods relevant to this study are discussed in detail. Moreover, mobile usability is elaborated in this chapter.

2.1 METHODS USED IN USABILITY FIELDS

2.1.1 User Tests

Usability testing with end users is described as a technique to collect data from authentic users by observing them while using the product to perform representative tasks (Rubin, 1994). In a usability test the participants must be real users which are members of the population who currently use or who will use the product (Dumas & Redis, 1993). Furthermore, the participants must perform real tasks during tests. According to Dumas and Redis (1993), usability studies can vary according to how and where they are conducted but there are some characteristics that are common to all usability studies. In all usability studies, the person who conducts the study observes the participants and record what they do and say. Also, since the primary goal of usability studies is to improve the usability of products, observers analyze the data collected during the tests in order to diagnose usability problems, and then they make recommendations to fix those problems for the purpose of improving the usability of products.

According to Nielsen (2012), of all the various usability testing methods, user based usability testing method is the most basic and useful one since, with the help of this method, it is possible to directly collect data from real users about how they use the system. However, it is not so easy to conduct usability test with end users. To perform a usability test, there are several steps that should be followed, which are planning the test, defining test tasks, recruiting test users, conducting tests with users, analyzing the results, and writing the report. Conducting usability studies by following these steps takes about 39 hours, as suggested by Nielsen (1998). This time estimation may increase depending on the time spent on identifying and recruiting appropriate test users. When time and cost are limited, end user test method is not a suitable method. This is also true if the product has many usability problems in its early stages of development. In this case, different usability testing methods should be used because it is unnecessary to bring participants to identify apparent usability problems (Rubin, 1994).

As for test settings, end user usability tests may be conducted in a usability laboratory or in the field. In usability laboratories, users try to accomplish the given tasks on the interface being tested and usability specialists observe what users do while doing tasks and note the steps and behaviors of users. In user tests, users are asked to think out aloud while performing the assigned tasks and their comments are recorded. Usability laboratories may include cameras to record users' behaviors and one-way mirror to hide observers during tests. As Nielsen (2005) states, in spite of artificial situation of usability laboratories, since users are strongly engaged in the tasks and get into the scenario quickly as if they perform the tasks at their home, or in their office, etc., the end user tests conducted in usability laboratory can reveal realistic findings. Nevertheless, field studies, in which users are tested in their home, office with their own computer or phone etc., are one of the most valuable usability methods because observers collect information from users in their natural habitats. However, field studies are much more expensive than laboratory studies (Nielsen, 2005).

Another aspect of the end user usability test method is the number of users who will be tested. According to Nielsen (2012), 5 users are enough to find out most of the usability problems. As Nielsen (2012) states, the results of the comparison of 83 case studies show that the number of the usability problems found does not change significantly by testing more users. However, there is an opposing view about whether 5 users are sufficient in a usability test. Spool and Schroeder (2001) argue that only 35% of usability problems are found with 5 users. They found new, severe usability problems in 13^{th} and 15^{th} user's section and if the study had been finished after 5 users some severe problems would have been missed. According to Çağıltay (2011), the number of the users in usability study is a disputable issue. To obtain meaningful results from the tests, it is more important to specify the appropriate users, appropriate tasks and appropriate study design than specifying the number of the users.

2.1.2 Heuristic Evaluation

In heuristic evaluation, interfaces are reviewed by usability experts according to commonly accepted heuristics, which are usability principles. In order to conduct heuristic evaluations more than one usability expert should examine the interface and judge its compliance with the heuristics (Nielsen, 1995). Since it is difficult for one expert to find all usability problems in an interface, it is possible to increase effectiveness of the method by involving multiple experts. According to Jeffries and Desurvire (1992), the number of usability problems found in a heuristic evaluation conducted by four usability experts is greater than that of any other usability test. However, with heuristic evaluation, half of the usability problems which are found in usability test are missed. Same with that, usability test missed similar number of usability problems detected with heuristics (Desurvire, Kondziela & Atwood, 1992). Moreover, different search methods reveal various types of problems which are quite different from each other.

In addition, it is possible to use heuristic evaluation method in the early lifecycle of usability engineering since it is not necessary to perform real tasks on the system during heuristic evaluation (Nielsen, 1995). According to Nielsen, for one expert, a heuristic evaluation session lasts only one or two hours for a typical interface. Nevertheless, the explorers should be experts to find significant usability problems in the interface. The more expert the explorer who analyzes the interface is, the more usability problems are found (Desurvire et al., 1992). This suggests that the cost for heuristic evaluations will also increase with an increase in the number of usability experts employed in the study.

2.1.3 Surveys

Survey is another search method used in usability studies. With the help of surveys, quantitative data about users' opinions regarding software or website being tested is collected. As Holzinger (2005) states, surveys are a good way to search end users' preferred features and to see how they use the software or website. Because data is gathered directly from the user, surveys give users' subjective preferences, satisfaction level and possible anxieties. In addition, according to Nielsen (2004) one of the most important advantages of surveys is that they enable researchers to collect data from a large number of users. Besides, survey research is usually a quick and practical method and it is cost effective in terms of conducting and analyzing data (Kirakowski, 2000). However, there are some disadvantages of the survey method. First of all, participants should be selected carefully so that they represent actual users. Otherwise, the data becomes unreliable (Nielsen, 2004). Moreover, according to Holzinger (2005), survey search method defines fewer usability problems in contrast to other usability methods. Also, survey studies should be administered to a sufficient amount of participants in order to gather significant result.

2.1.4 Cognitive Modeling

Predictive Human Performance Modeling is one of the models in human computer interaction field with the longest research history (John et al., 2004). Designing a model behaving, making mistakes and thinking like a human being would be very beneficial for testing and comparing design ideas in terms of speed and cost (John & Suzuki, 2009). The first model to satisfy these goals was Model Human Processor (MHP), developed by Card, Moran and Newell in 1983. The MHP model is comprised of three interacting systems: perceptual, motor and cognitive. According to Crystal and Ellington (2004), the MHP model assumes that brain is able to make several information processing operations like comparing, matching and calculating. Later on, Card et al. (1983) developed an engineering model using MHP's characteristics about human performance in 1983. This model was named GOMS, which stands for Goals, Operators, Methods, and Selection Rules. In GOMS modeling technique, the user's procedural knowledge needed to accomplish tasks on a system is described. With the help of GOMS, researchers have been able to predict and collect the quantitative data about skilled users' task execution time. The KLM, which is the simplified version of GOMS, stands for Keystroke-Level Model and it uses only keystroke-level operators. Goals, methods, or selection rules are not included in the analysis of this model. In this model, task execution time is described in terms of four physical-motor operators: K (key-stroking), P (pointing), H (homing), D (drawing); together with one system response operator R(t) and one user mental operator M (John & Kieras, 1996). The number of studies concerning the prediction of skilled users' performance time has continuously increased and this has validated the use of this method in many areas of human computer interaction in time. Over one hundred research papers about GOMS and KLM have been published (John et al., 2004).

Cognitive modeling extends classical usability methods by providing insight into detailed cognitive aspects of human computer interaction. As Heinath and Urbas state (2007), it is possible to use the cognitive model method in early stages of design in contrast to empirical user testing. However, although cognitive modeling provides a variety of advantages to usability testing studies, it is not, surprisingly, such a popular tool for studies including user interface design and usability tests (John et al., 2004). The reason why the use of cognitive modeling in usability studies is rare has been ascribed to the difficulty in learning its modeling process. Therefore, the need for the tools that do not require considerable time for learning to model has arisen. For this reason, various studies have been done in order to develop tools with a new methodology to minimize the effort while developing cognitive models. Several tools with different working principles have been developed in order to make it easier to analyze user interface design in terms of usability by using the cognitive modeling method.

CogTool, developed by Carnegie Mellon University, is one of the user interface (UI) prototyping tools which produce quantitative prediction of skilled user's' execution time. The quantitative prediction data produced by CogTool is based on the extensive research in cognitive psychology. CogTool has the ability to simulate the cognitive, perceptual and motor behavior of humans while trying to complete the assigned tasks on an interface successfully. In order to develop this simulation CogTool uses ACT-R cognitive architecture which is a theory that explains how simulation and human cognition work (Anderson, Bothell, Byrne, Douglass, Lebiere & Qin, 2004). When the task is demonstrated, CogTool turns the demonstrations into ACT-R code which emulates the KLM and gives estimation for the mean of skilled users' task execution time.

2.2 MOBILE USABILITY

While the use of mobile devices increases quickly, studies have revealed that it is very difficult for users to understand information by reading from small screens of mobile devices (Nielsen, 2011). According to Nielsen (2011), it is a known fact that presenting information in a concise way is the best method for web users and this fact also applies to mobile applications. In mobile applications, even short is too long for mobile users: in mobile interfaces, very short rule should be applied.

As Nielsen (2011) asserts, mobile users are hastier than desktop users to access information. Therefore, in mobile applications/web pages, interfaces should be designed specifically for small screens and, features should be limited. Moreover, 2 years after the first report published in 2009, the number of the studies and level of consciousness in the field of mobile usability have increased. The success rate of mobile users on the tasks has increased from 59% to 62% in two years but this rate is low when compared with the rapidly increasing number of mobile users. Besides, within these two years between the two studies, the number of design principles offered to mobile application/web site developers has increased from 85 to 210 thanks to the extensive research and resources about mobile usability. This shows that there is a rapid development in the mobile usability area. However, while the evaluation process of mobile usability has improved rapidly, the performance of mobile users have not increased as expected. This shows the failure in using design suggestions and having users involved in the development process of mobile applications in order to increase usability.

2.3 METHODS USED IN MOBILE USABILITY

In order to see which methods are preferred for mobile usability studies, a literature review has been conducted. The articles which use different methods on mobile usability and are written in English have been selected. Moreover, considering that the use of mobile applications and mobile usability issues has rapidly risen, only the studies done between 2006 and 2013 years have been analyzed. After applying these filters, most related 50 articles have been selected for analysis. The methods used in the analyzed articles to evaluate mobile application interfaces are shown in the Figure 1 below.

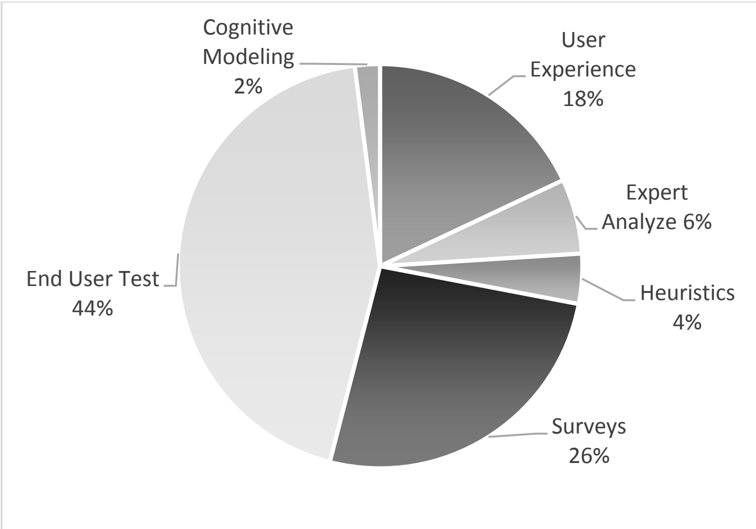


Figure 1 - Methods Used in Evaluating Mobile Usability

As it is shown in the figure, the end user usability test method was used in the 44% of the analyzed 50 studies. The end user usability test method, which is the most preferred method in order to gather realistic results, is not regarded suitable for the studies with time and cost constraints. The second mostly-used method for evaluating usability of mobile applications is surveys with the 26% rate. Surveys may provide an advantage compared to other methods in terms of speed and cost but it reveals relatively fewer usability problems. Another method used in the analyzed articles is user experience method. With this method, data are collected by observing or using specific tools to record users' behaviors when using mobile applications. Different from the end user usability test, in user experience method no tasks are assigned to users: users are supposed to use the application as they would if they were alone. In time and budget limited circumstances, user experience method is not preferred similar to the end user usability test method. Moreover, it was seen that in 6% of the analyzed 50 studies, usability expert method was used and that 4% of the mobile applications were analyzed through heuristic evaluations. Finally, it was seen from the analyzed 50 studies that cognitive modeling method was used in limited number of study, only in 2%, to evaluate usability of mobile devices.

2.4 MODELS USED IN THE COGNITIVE MODELING STUDIES

As part of this thesis, the studies that utilize cognitive modeling methods in a variety of different areas related with human computer interaction were analyzed in order to see which cognitive modeling methods are mostly preferred to be used. When searching, the studies done between 2006-2013 in English are selected. After applying the abovementioned filters, the most related 50 studies were selected by reviewing the abstracts of the articles. The models used in the analyzed articles are shown below in the Figure 2.

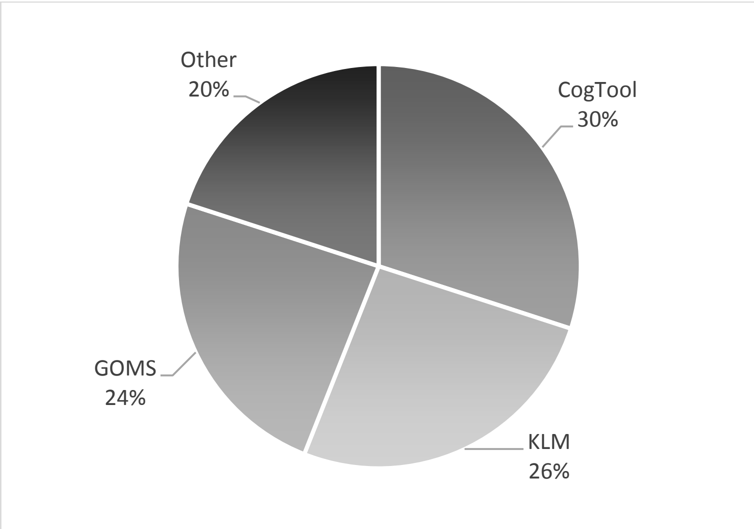


Figure 2 - Models Used in the Cognitive Modeling Studies

As it is shown in the figure, CogTool was used in 30% of the cognitive modeling studies. The ease of use of CogTool on application interfaces increases its utilization rate. The second and third most commonly used models, which are "Keystroke - Level Model" (KLM) and "Goals, Operators, Methods, and Selection rules" (GOMS) models, have proved their validity by being used for the large number of tasks on desktop computers studies. Therefore, these two cognitive modeling methods continue to be used extensively in the modeling studies.

The 13 out of 50 studies were conducted using mobile devices but only in two studies touch screen mobile devices were used. Most of the studies were focusing on extending the cognitive modeling for mobile devices. One study investigated the accuracy of CogTool results by comparing observed user performance results on middle sized touch screen devices similarly with this study (Abdulin, 2011).

2.5 DISCUSSION OF THE LITERATURE REVIEW

Mobile phones have become an indispensable part of our daily lives and the use of mobile applications has been increasing day by day. Therefore, developing efficient, effective and user friendly mobile interfaces is important for the mobile users who would like to reach information quickly and with the minimum number of errors. Furthermore, it is seen that the number of usability studies in the field of mobile application interfaces and the value of these studies are increasing every day. In addition, studies using cognitive modeling method have proved the accuracy of this method’s estimates for performance on interfaces. However, it is also seen that cognitive modeling method is not a commonly used method when evaluating the usability of touch screen mobile applications. Since there are not so many studies that evaluate mobile application usability using the cognitive modeling method, there is a need for revealing if the result of the cognitive modeling method is accurate on touch screen mobile applications.

In this study, the performance results obtained through cognitive modeling method on applications running on touch screen mobile devices were compared with the performance results of actual users. By investigating the similarities between two performance data obtained from different usability methods, the accuracy of the result of cognitive modelling method on mobile application interfaces was questioned. Interpretation of the data obtained from this study will reveal if cognitive modeling is suitable for use in the usability evaluation of touch screen mobile applications.

CHAPTER III

METHODOLOGY

This chapter provides an in-depth overview of the research design used in the present study, the procedures of data collection and analysis as well as information about the participants and the tasks they were assigned.

3.1 STUDY SETTING

In cooperation with Turkcell, which is the leading mobile phone operator in Turkey, Turkcell Cüzdan application was selected as the mobile application to be analyzed in terms of usability with two different usability testing methods, namely cognitive modeling and end user performance tests. The criterion for the selection of the mobile application was that it should be suitable for prototyping and user testing. This application was installed on a smartphone with iOS operating system and during the study there have not been any changes to the operating system, applications or the smartphone per se.

In order to identify the tasks to be used in the study, a task analysis was conducted by the researcher to find out the mostly-used features and the critical operations that could be performed with the mobile application. At the end of the task analysis, 8 tasks were generated and these selected tasks were practiced by the researcher. The researcher's performance in these tasks; that is, completion time and number of steps, were recorded to be used for analysis.

Later on, 10 participants from the target audience of the application were recruited to participate in end user tests. The participants were able to use a smartphone and they had not used the designated application, Turkcell Cüzdan, before. Prior to conducting the end user tests with the participants, a pilot study with 3 different participants was conducted so as to eliminate and fix probable study failures and to clarify and edit the tasks that might be misunderstood by the participants.

Since CogTool gives an estimate for the performance of skilled users, who are supposed to have used the application at least once, this study was carried out in two stages to compensate for the participants' lack of experience in using the designated mobile application. In their first encounter with the application, the participants were asked to perform the 8 specified tasks and then they were informed of their performance; that is, whether they performed the tasks correctly or not. If they had not completed a task correctly, the participants were asked to explore the application in order to find the desired information while performing the task. On average, users were given a 10-minute period to explore the application. In their second encounter with the application, the same participants, who were experienced with the application at that time, were asked to complete the same 8 tasks again. Thus, two different results were obtained for each participants: one as a novice user in the first stage and one as an experienced user in the second stage.

End user performance tests were conducted in the Human Computer Interaction Research and Application Laboratory at Middle East Technical University (METU). The lab consists of a control room and a test room separated from each other by a one-way mirror. During the tests, the steps which the participants followed to complete each task on the mobile application were recorded with the help of two moving camcorders. During the tests, the participants were free to use the smartphone however they like: whether on the table (Figure 3) or in their hands (Figure 4). All of the tests with the participants were conducted by the researcher. The participants performed the tasks presented to them by the researcher one by one in the test room, while the researcher observed the participants' behaviors in the control room.

Figure 1 - Using Phone on the Table

Figure 2 - Using Phone in Users' Hand

As it is seen in the Figure 5, thanks to the design of the laboratory, the participants could not see the researcher while the researcher had the ability to observe the participants and the interface of the mobile phone. The researcher presented the tasks verbally via a microphone one by one to the participants and asked them to complete the stated tasks. The tasks were given to all participants in the same order. Turkcell 3G connection was used during the tests.

Figure 3 - METU Human Computer Interaction Research and Application Laboratory

The end user tests, including the first and second trials and the time given to the participants in order for them to explore the application, took about 30 minutes in total for each participant. The first test in which the participants used the application for the first time took about 10 minutes and the second test in which the participants were already familiar with the application took about 5 minutes. At the end of the study, the participants were asked to fill out the Questionnaire for User Interaction Satisfaction (QUIS) in order to measure their satisfaction level with the application.

In the second stage of the study, the Turkcell Cüzdan application was evaluated in terms of usability with cognitive modeling method by using CogTool program. The CogTool was used as a cognitive modeling program in this study since it is fast and easy to construct a user interfaces with CogTool and the results can be interpreted easily by researchers who have not any background about psychology. For this purpose, the screenshots of the application were taken and each screen of the interface for each step to be followed while performing the tasks was installed to CogTool. Afterwards, widgets such as button, text, menu, etc. were defined on the screens loaded for each interface as a background in the Frame window of CogTool (Figure 6).

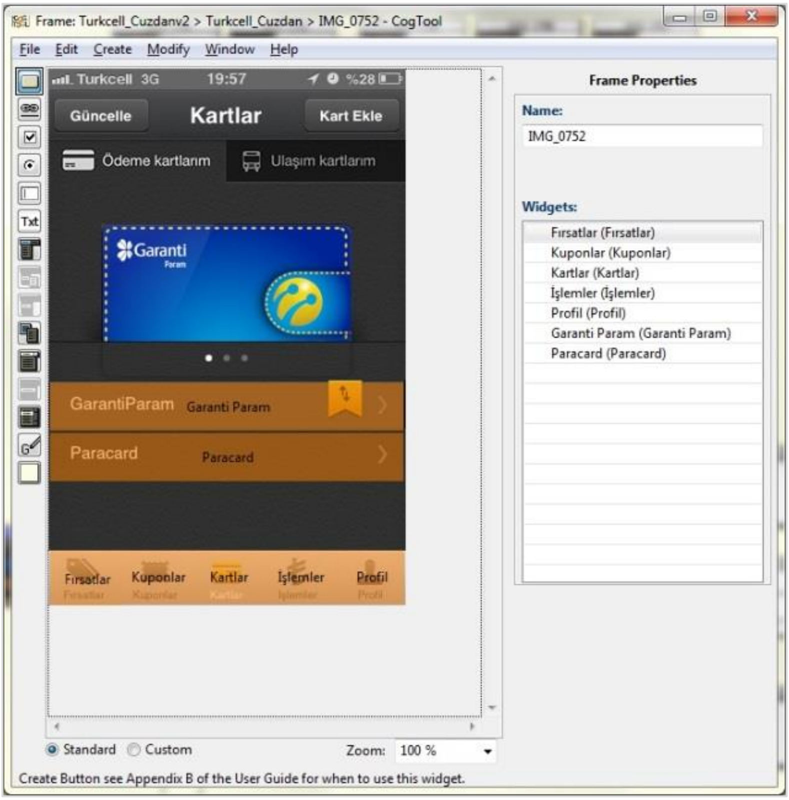


Figure 4 - CogTool Frame Window

Using the widgets available in CogTool, the prototype of each screen of the application used to execute the tasks was created. The widgets were placed on the prototype in such a way that they are consistent with the real design of the application and that the prototype looks like the real application. Then, transactions were defined for the components, taking into consideration their actions and the changes they make on the page when activated in the Design window of CogTool. For instance, which interface will be opened when pressing a button was defined (Figure 7). By creating transactions between prototypes, the steps required to complete a task were simulated as they were in the real application. Moreover, the system response time for the activation of each component was computed from the actual application and entered to CogTool.

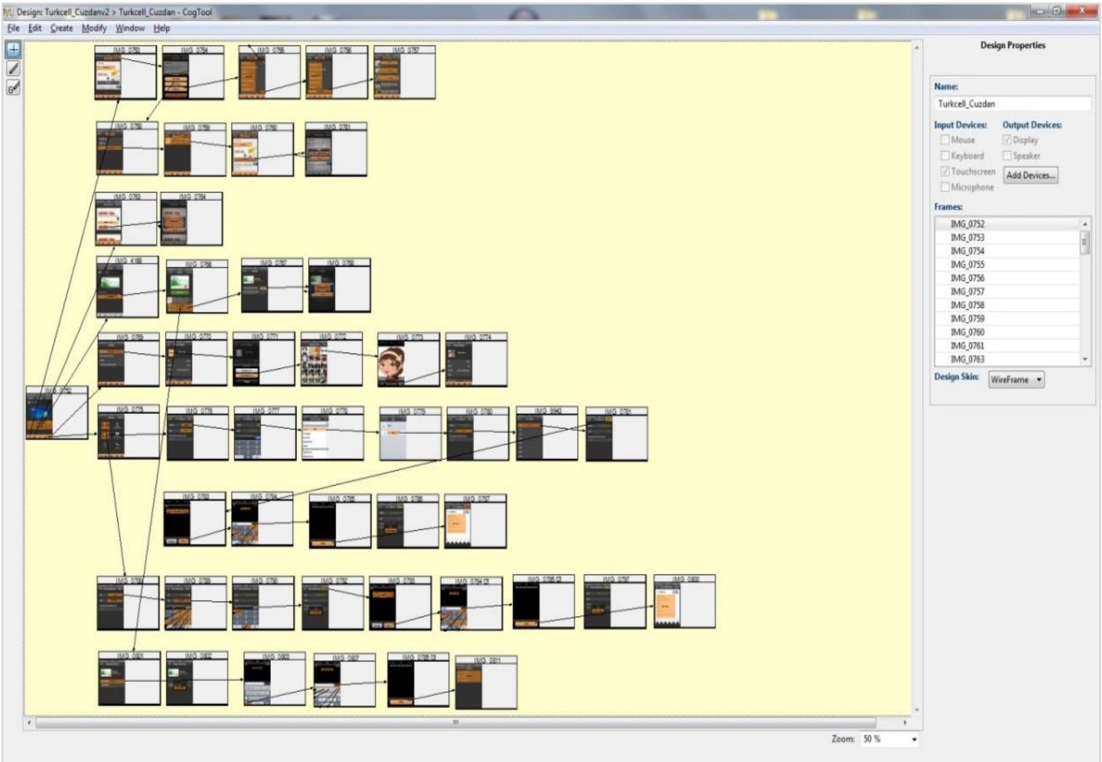


Figure 5 - CogTool Design Window

After each interface was designed and its transaction was defined, 8 tasks were demonstrated through the prototyped screens. After the demonstration, CogTool estimated the completion time for each task. For tasks in which users took certain actions without thinking, the ‘Think’ operations between steps were altered or removed in the demonstration on the Script window of CogTool (Figure 8).

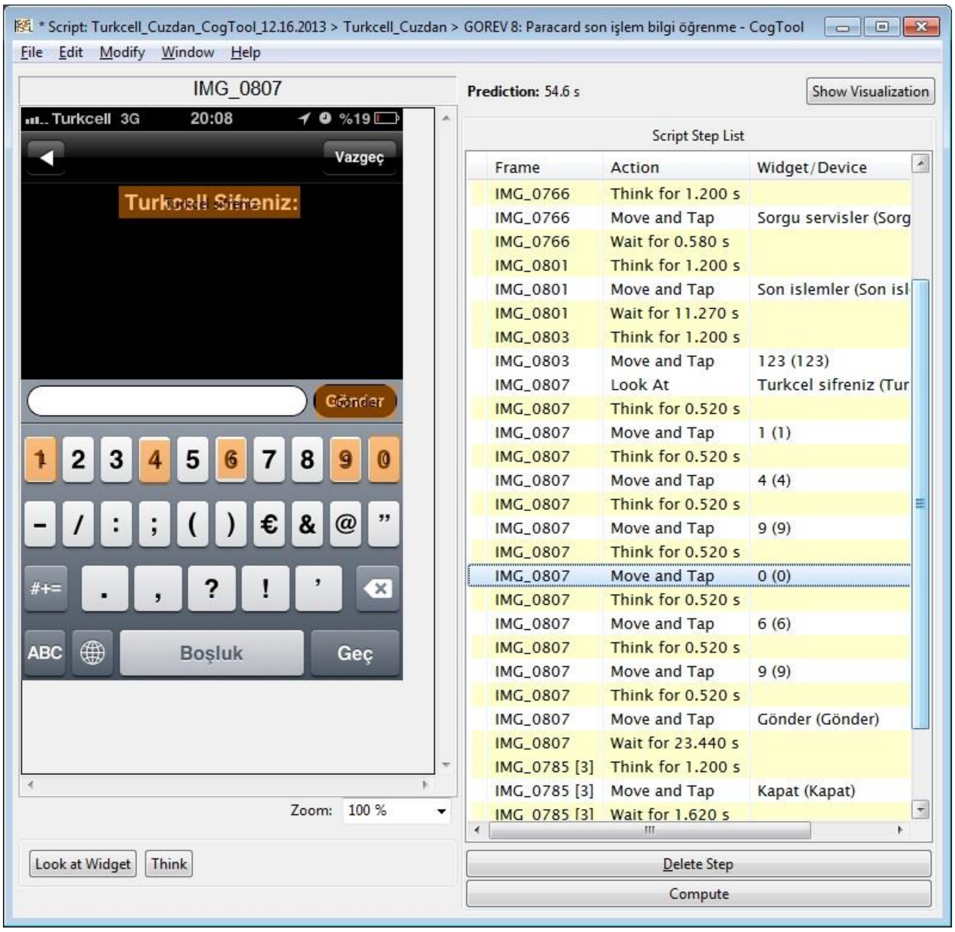


Figure 6 - CogTool Demonstration Script Window

As it was pointed out before, CogTool gives predicted task completion times for each task in seconds after the demonstration of each task (Figure 9). In addition, on the Visualization window of CogTool, the time of each separate step can be analyzed. From this page, time required to perform each step was calculated in terms of cognition, eye movement preparation-execution, vision encoding and motor behaviors.

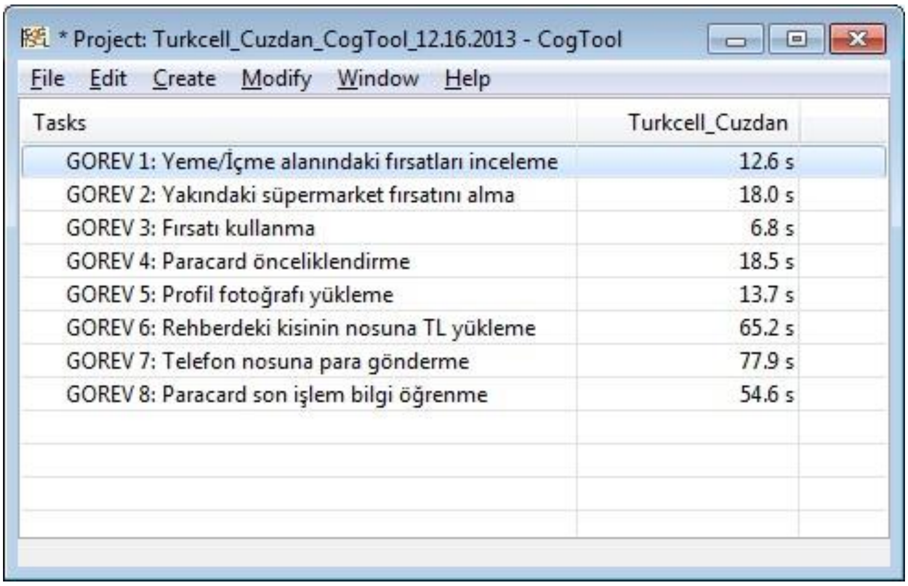


Figure 7 - CogTool Project Window

The following timeline illustrates the processes completed throughout the study (Figure 10).

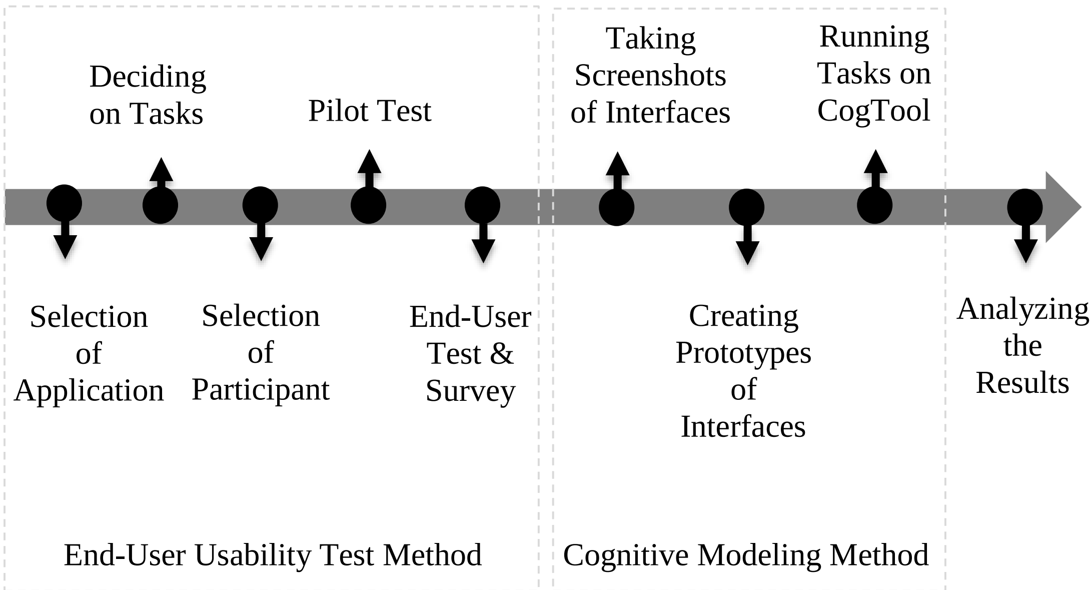


Figure 8 - Timeline of the Methodology

3.2 DATA COLLECTION

For data collection, two different methods were employed. In the first method, the end user usability testing, the participants were asked to complete the designated tasks one by one on the mobile application selected for the study. The participants performed the same tasks twice, but the results acquired from the first test were evaluated separately as the participants used the application for the first time.

The results obtained from the first tests and the think-aloud process in which the participants spoke out their opinions about the application while performing the tasks are presented separately in Chapter IV under Results. The usability issues with the selected mobile application were detected based on these results. The results of the second tests, which were conducted after the participants were exposed to the application and became familiar with it, were scrutinized step by step. The results of the stepwise performance and overall performance durations were analyzed as a timeframe in CogTool so that the results from the two methods could be compared.

In the second method, the cognitive modeling method, the graphical interface components and actions of mobile application interfaces were modeled as they were in the real application by using CogTool. Each task was executed on CogTool. . The estimated performance results obtained from CogTool were analyzed step by step and total time for each task was recorded.

Apart from end user performance tests and CogTool modeling, the QUIS (Questionnaire for User Interaction Satisfaction) questionnaire, consisting of 39 questions in 4 main sections, was administered to the participants in order to collect data about their opinions and satisfaction level with the selected mobile application. The four main parts of the questionnaire are as follows: general user responses, appearance of Turkcell Cüzdan application, terms used in Turkcell Cüzdan application and learning the use of the Turkcell Cüzdan application.

3.3 DATA ANALYSIS

In order to analyze the videos recorded during the end user performance tests, ELAN (EUDICO Linguistic Annotator) video analysis program was used (Figure 11). When analyzing the video records, the time right after the researcher read the task and before the participants' first interaction with the smartphone was taken ass the first step time. The time spent by the participants on each step of each task was calculated in this fashion. The total time for each task was calculated by subtracting the time when the participants began the task from the time at which the participants stated that they completed the task. The times were recorded in mm:ss.SS (minute:second.split second) format.

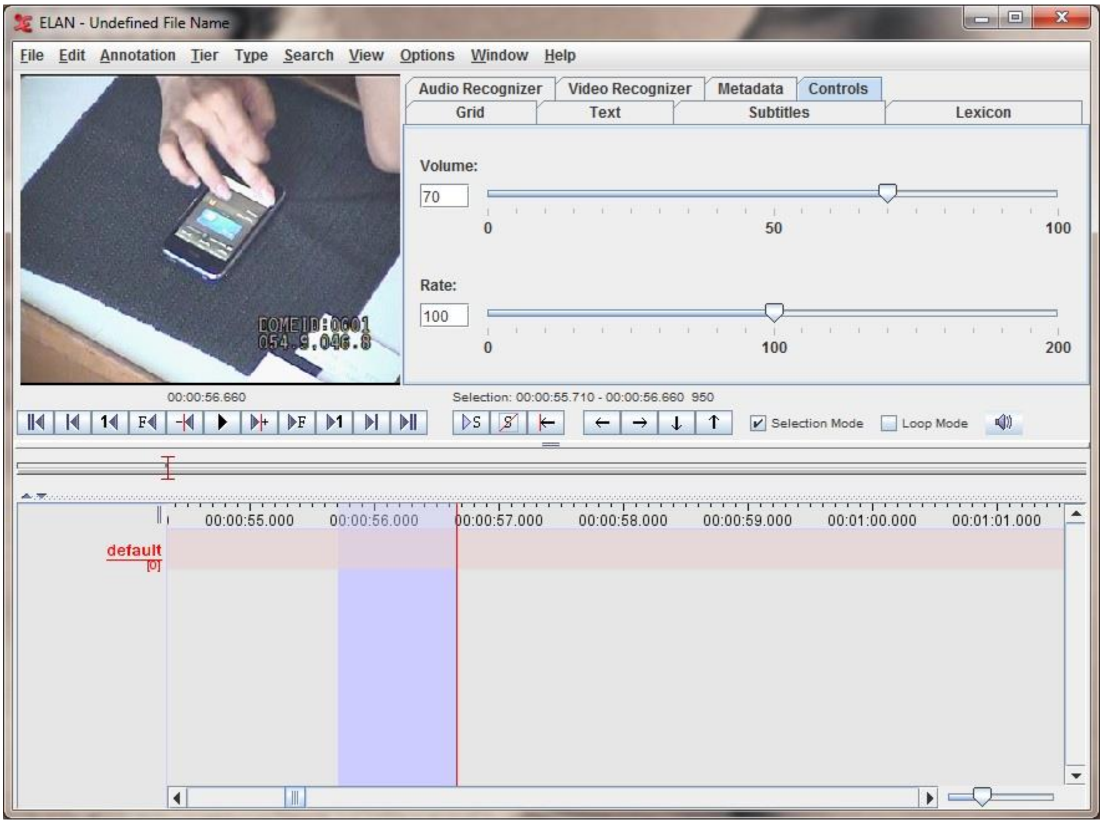


Figure 9 - ELAN Video Analysis Program

At the end of its computations, CogTool application gives an estimated completion time for each task. In this study, the steps of each task were also examined individually under the "Visualization" menu of CogTool. In addition to giving the total estimated time to complete a task, CogTool also gives the opportunity to analyze the cognitive, sensory and motor behavior of users while performing a task. It is possible to see the start and finish time of the users' eye movements, thinking duration and moving their hand to an appropriate point for each step from the visualization page of CogTool (Figure 12).

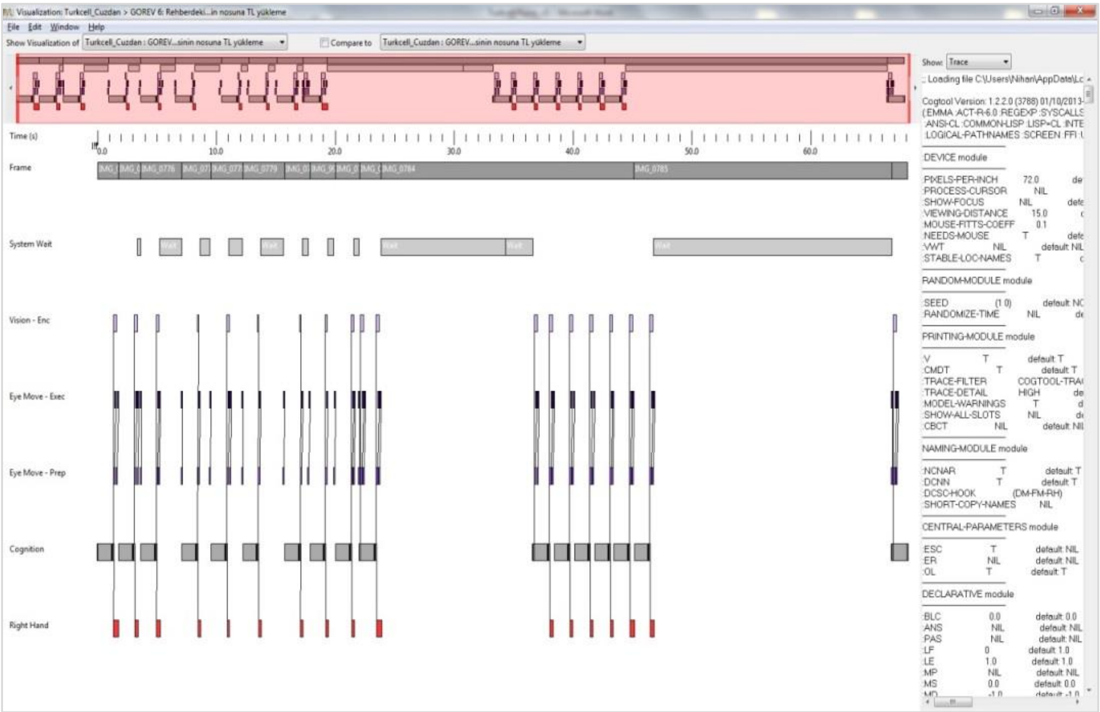


Figure 10 - CogTool Visualization Window

Furthermore, in visualization menu, the step can be analyzed in more detail by examining each step of the task with respect to such titles as the system response time, recognition of related graphical interface components, positioning eye to the corresponding point and moving hand (Figure 13).

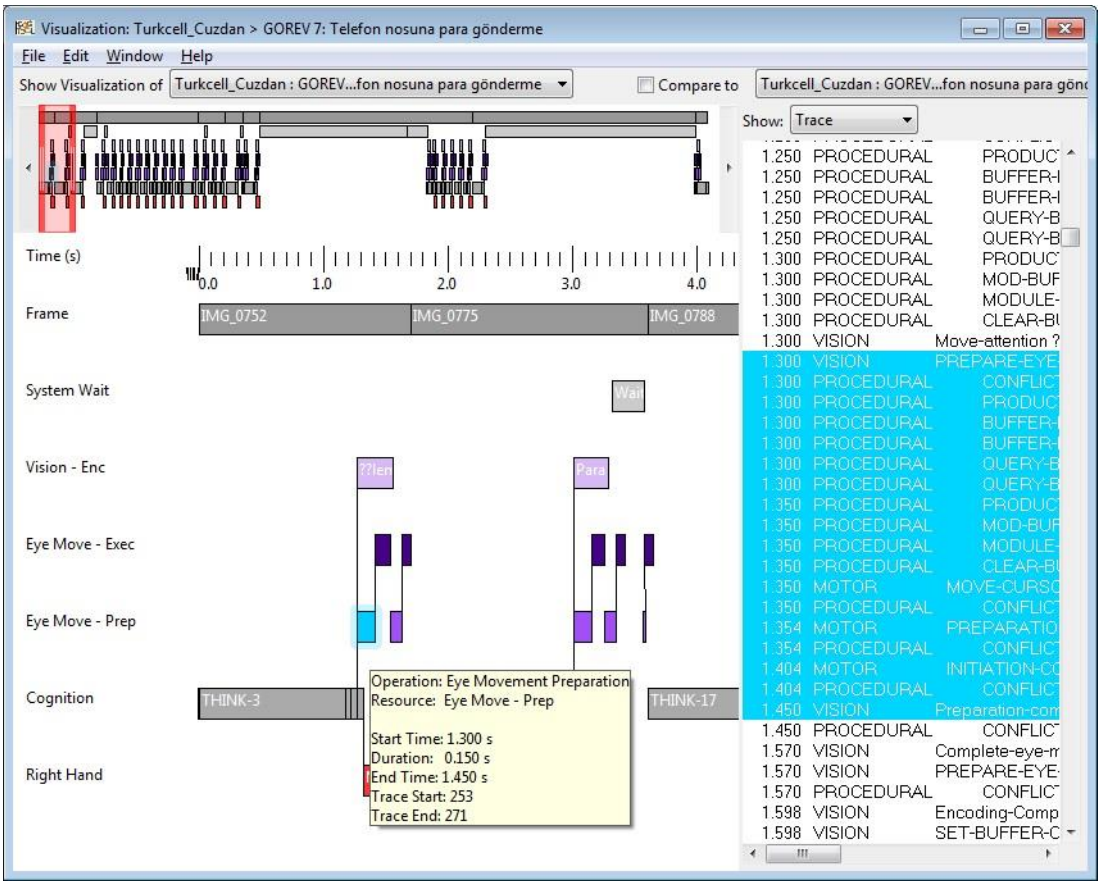


Figure 11 - Detailed Analysis in Visualization Window

In this study, all the steps for each task were analyzed and the CogTool's estimated time was calculated on the basis of the steps. Some graphical interface components used on touch screen mobile phones have not been defined on CogTool since its usage on touch screen mobile phones has not spread enough yet. For example, swiping gestures that came into our life with touch screen devices are still in development in CogTool. Therefore, CogTool gives slightly higher scores for swipe gestures than it actually is.

In addition, in CogTool, the keyboard input is thought as a separate input device for desktop applications and thus the motor and cognitive behaviors are calculated in accordance with keyboard inputs. However, in touch screen input type, there is not any separate selection for keyboard input. For this reason, the numbers on the on-screen keyboard are defined as normal buttons while designing the prototypes of interfaces in CogTool. During the end user tests, it was noticed that the participants performed the steps requiring input from keyboard faster while using on-screen keyboard than the other steps requiring the use of normal buttons. Therefore, defining the numbers on the on-screen keyboard as a button produces higher estimated performance time than it actually is. After the completion of all tests, the duration of the steps in which participants used on-screen keyboard was calculated for each participant and the average value was obtained. Based on this result, the approximate value obtained from actual tests was entered into the thinking time on CogTool manually by the researcher in the steps including the use of on-screen keyboard for such input operations as entering phone number or password.

3.4 PARTICIPANTS

When selecting the participants for the study, the aim was to create a homogenous group of people who had not used the mobile application, Turkcell Cüzdan, before, were adept at using a smartphone and were experience with iOS operating system. 10 participants, including 5 women and 5 men were recruited for the study from the target audience of the application. The target audience of the application includes the people who use iPhone for a while and make financial transaction by using their smartphones. The participants who recruited for this study were graduates of the Faculty of Engineering and had their Master’s degree.

In order to see whether the technical knowledge of the participants affected the results of the study, the pilot study was done with 3 participants before the actual tests. It was observed that the ability to use the iOS operating system and touch screen smartphone devices have an impact on the results but technical knowledge did not seem to have such an effect.

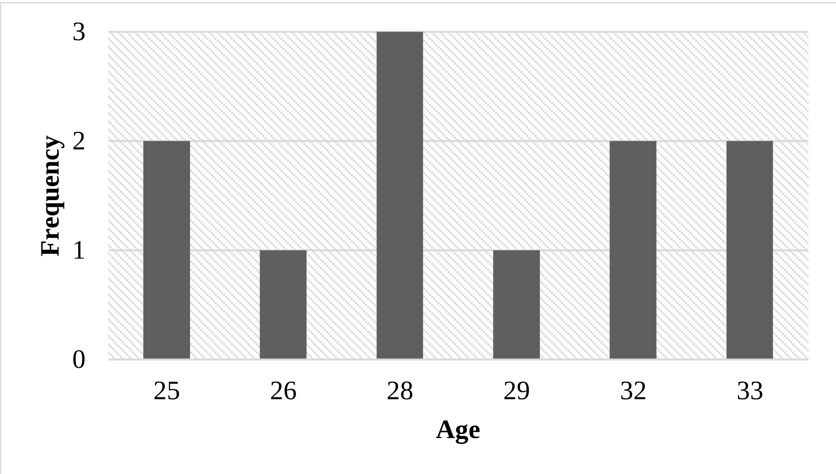


Figure 12 - Age Distribution of Participants

The average age of 10 participants, aged between 25 and 33, is 28.6 (Figure 14). Participants stated that they had used a smartphone for 2 years in average. 90% of the participants reported that they connect to the Internet with mobile devices every day. The demographics of the participants, including gender, age, education and the mobile phone experience, are given below in the Table 1.

Table 1 - Participants' Information

Part. No	Gender	Age	Education	Experience (year)
P01	Male	29	Electrical Engineering	1
P02	Female	28	Computer Engineering	2
P03	Female	28	Computer Engineering	4
P04	Female	25	Computer Engineering	2
P05	Male	32	Electrical Engineering	1
P06	Male	33	Computer Engineering	3
P07	Male	25	Electrical Engineering	2
P08	Female	28	Computer Engineering	2
P09	Male	26	Computer Engineering	2
P10	Female	32	Computer Engineering	1

3.5 TASKS

When specifying the tasks, the most commonly used features on the mobile application and critical operations that could be accomplished using the application were taken into consideration. Initially, the tasks were determined. The researcher contacted the mobile application development team responsible for Turkcell Cüzdan in order to collect information about the important tasks such as those frequently used and their relevance to critical functions. Furthermore, the developer provided insight into the tasks in which they suspected that users might experience some difficulties.

Next, task-based scenarios were formulated as they simulate real-world contexts to which the participants can easily relate and thus they are more likely to behave in a natural way. Since the tasks had only one way of being completed, the task-based scenarios specifically stated what the participants were supposed to do. However, the scenarios did not include any information on how the participants could complete the tasks. The tasks were ordered in a way that they reflect the logical flow of certain tasks. For instance, the task in which the participants were asked to buy a promotion preceded the task in which the participants were asked to use that promotion. In the tasks including financial transitions, participants spent real money and they were informed before test.

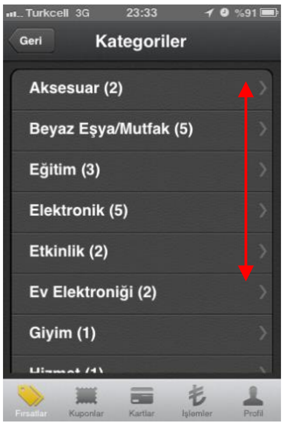
Finally, the specified tasks were analyzed by the researcher by performing the tasks, and the number of steps and the completion time for a typical user were defined. Moreover, tasks sets were tested in a pilot test with 3 other participants to ensure that they were understandable and the orders of the tasks were meaningful. As a result of the pilot tests, the tasks sets were improved and prepared for use in end user tests.

The finalized 8 tasks are given below with the help of the images taken by application interface as well as the explanation of the steps in each task. What actions participants were supposed to do was marked in red. In addition, the number of steps and the expected completion time were calculated by the researcher and are presented below.

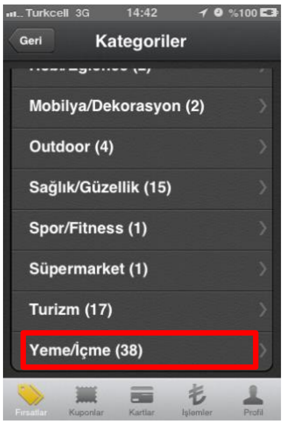
- Task 1: You will go to a store for shopping something to eat in your house. Before going shopping, please view the promotions in the eating/drinking field by using the Turkcell Cüzdan application.
  - Number of Steps to Complete: 6 Steps
  - Completion Time by a Typical User: 13 sec

1- Selecting "Promotions" menu
2- Pressing "Options" button

3- Selecting "Categories" option



4- Swiping "Categories" list



5- Selecting "Eating / Drinking" option

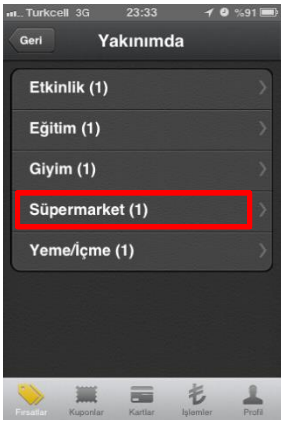
6- Viewing promotions

Figure 13 - Steps of the Task1

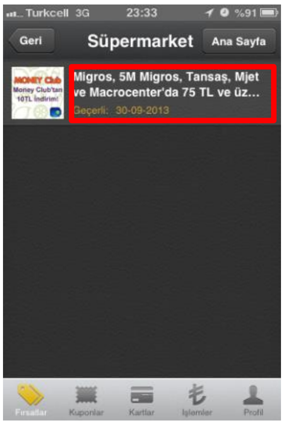
- Task 2: You have seen from the application that there are lots of promotions but you would like to know more about those which are available in the supermarket close to your home. Please check the application to see if there is any promotion in the supermarket nearby. If there is, please buy it.
    - Number of Steps to Complete: 7 Steps
    - Completion Time by a Typical User: 16 sec

1- Selecting “Promotions” menu
2- Pressing “Options” button

3- Selecting “Nearby” option



4- Selecting “Supermarket” option



5- Selecting related promotion

6- Pressing “Buy Now” button

7- Pressing “Ok” button

Figure 14 - Steps of the Task2

- Task 3: You have done your shopping and you are waiting for payment. Please use the promotion you have bought in your supermarket shopping.
    - Number of Steps to Complete: 3 Steps
    - Completion Time by a Typical User: 6 sec

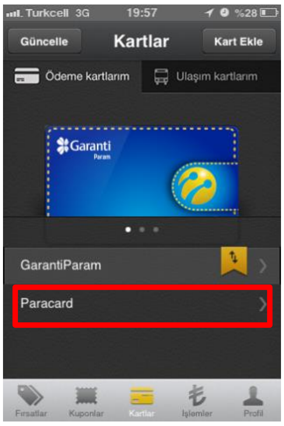
1- Selecting “Coupon” menu

2- Pressing “Use Now” button

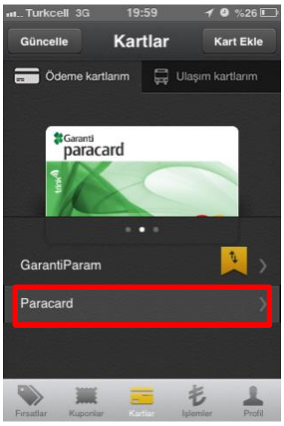
3- Pressing “Ok” button

Figure 15 - Steps of the Task3

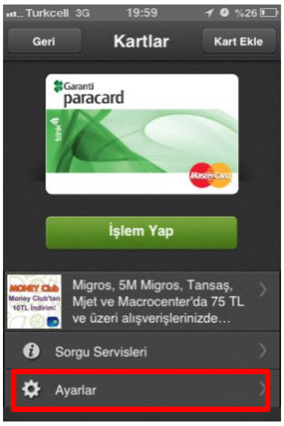
- Task 4: You have used all of your money in your GarantiParam card but you still have money in your Paracard. In order to use your Paracard in your shopping, you know that you should first prioritize it. Please prioritize your Paracard so that it could be used primarily among your all cards.
    - Number of Steps to Complete: 5 Steps
    - Completion Time by a Typical User: 18 sec



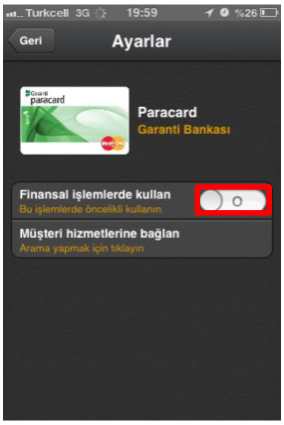
1- Selecting the “Paracard”



2- Pressing on Paracard



3- Pressing “Setting” button

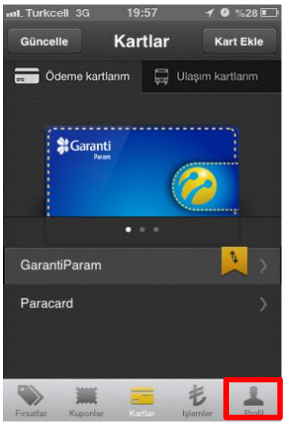


4- Pressing “Prioritize” button

5- Pressing “Ok” button

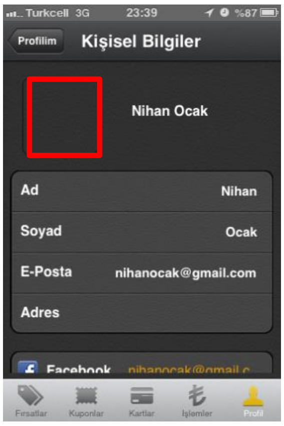
Figure 16 - Steps of the Task4

- Task 5: You want to personalize the Turkcell Cüzdan application by creating your profile. So, please add an existing photo to the application.
  - Number of Steps to Complete: 6 Steps
  - Completion Time by a Typical User: 15 sec

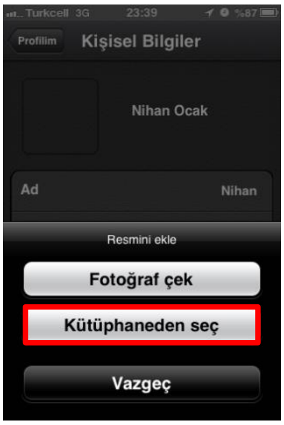


1- Selecting the “Profile” menu

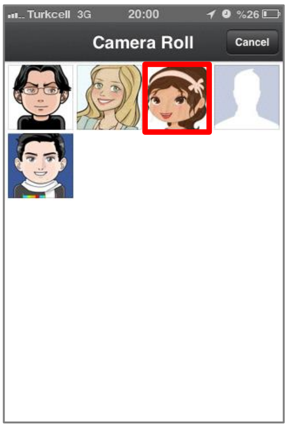
2- Pressing “Personal Information” button



3- Selecting the area of photo



4- Pressing “Select from a Library” button

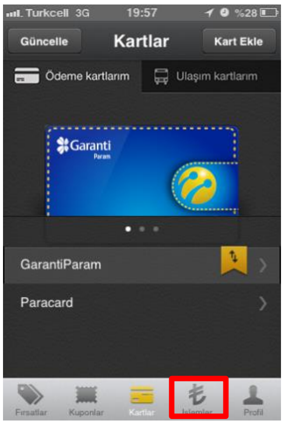


5- Selecting the photo

5- Pressing “Select” button

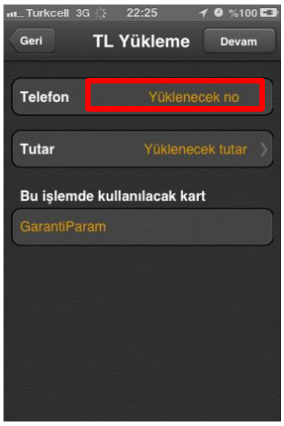
Figure 17 - Steps of the Task5

- Task 6: Your mother told you that she had run out of credit in her phone and that she could not call anyone. Please add 10 TL credits to your mother’s phone.
  - Number of steps to Complete: 14 Steps
  - Completion Time by a Typical User: 65 sec



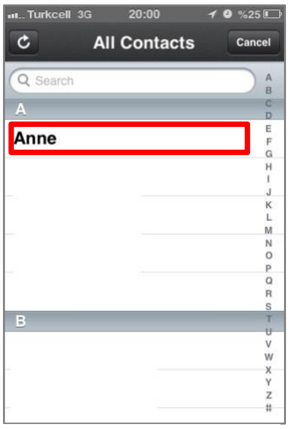
1- Selecting the “Operations” menu

2- Pressing the “Add Credits” icon

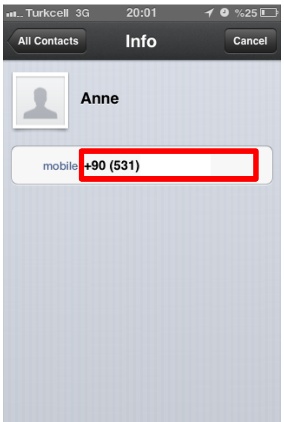


3- Pressing the phone number field

4- Pressing the "+" icon



5- Selecting the contact



6- Selecting the number of contact

7- Selecting the amount field

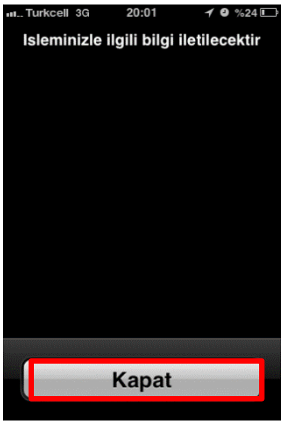
8- Choosing the amount to be added

9- Pressing the "Continue" button

10- Pressing the "Accept" button

11- Entering the card password

12- Pressing the "Send" button

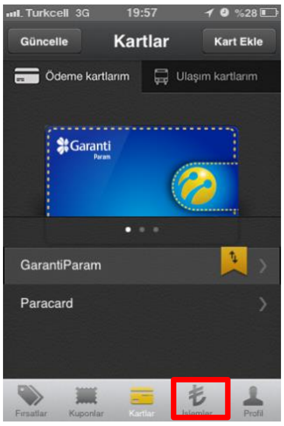


13- Pressing the "Close" button

14- Reading the explanation

Figure 18 - Steps of the Task6

- Task 7: Your friend is in an urgent need of money. Please send 10 TL to your friend's phone number.
    - Number of Steps to Complete: 13 Steps
    - Completion Time by a Typical User: 75 sec



1- Selecting the "Operations" menu

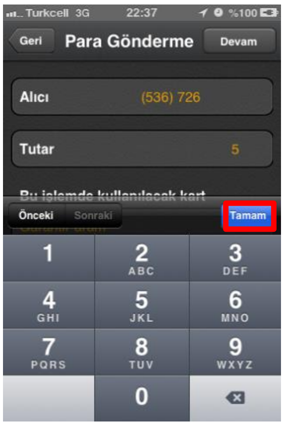
2- Pressing the "Send Money" icon

3- Pressing the receiver field

4- Entering the phone number

5- Selecting the “Amount” field

6- Entering the amount to be sent



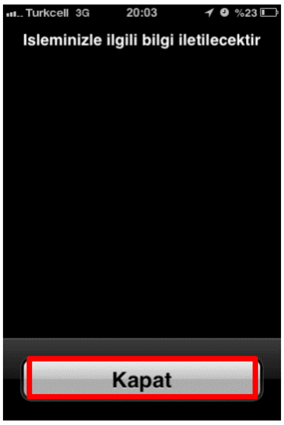
7- Pressing the “OK” button

8- Pressing the “Continue” button

9- Pressing the “Accept” button

10- Entering the card password

11- Pressing the “Send” button

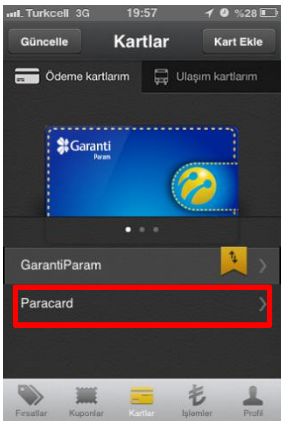


12- Pressing the “Close” button

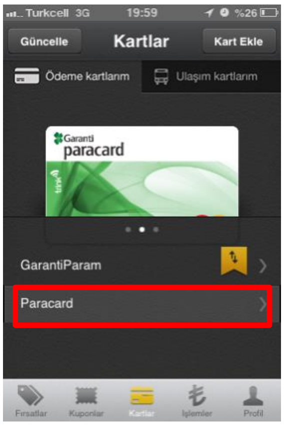
13- Reading the explanation

Figure 19 - Steps of the Task7

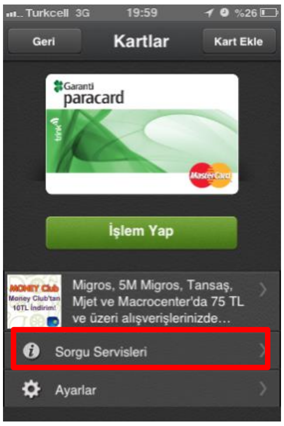
- Task 8: You got confused which card you used for which action. So please check the last actions of Paracard.
  - Number of Steps to Complete: 9 Steps
  - Completion Time by a Typical User: 56 sec



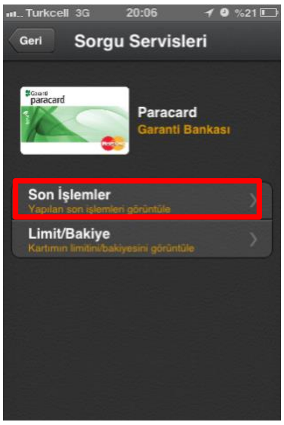
1- Selecting the “Paracard”



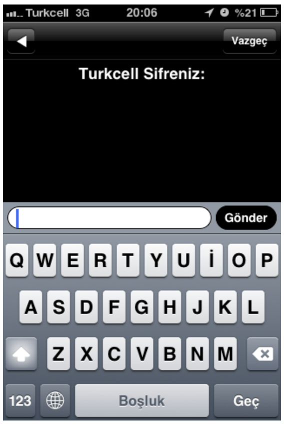
2- Pressing on the Paracard



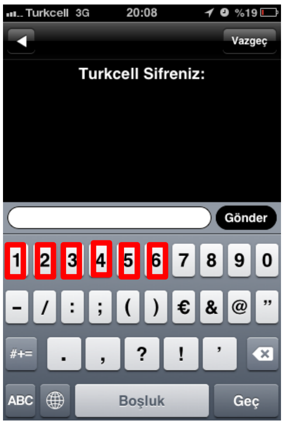
3- Selecting the “Query Services” button



4- Pressing the "Last Actions" button

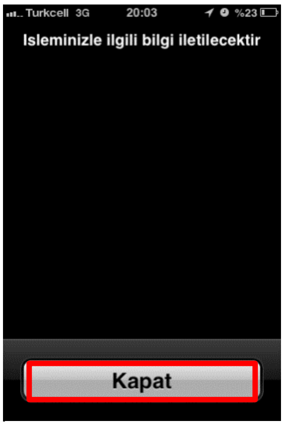


5- The opening of on-screen keyboard



6- Entering Turkcell password

7- Pressing the "Send" button



8- Pressing the "Close" button

9- Reading the last actions

Figure 20 - Steps of the Task8

CHAPTER IV

RESULTS

All results obtained from this thesis study are presented under this chapter. The results are interpreted under two main headings. The results obtained through CogTool and skilled user usability tests are presented under “The Comparison of Skilled User Usability Test and CogTool Results” heading. The results of the questionnaire administered to the participants after the tests were presented under the “User Satisfaction Survey” heading.

2.1 THE COMPARISON OF SKILLED USER USABILITY TEST AND COGTOOL RESULTS

After the analysis, it was seen that the performance result of the skilled users on usability tests and estimated performance results obtained from CogTool had approximate values. Analysis results showed that for 8 tasks performed on mobile application CogTool produced +/- 5 seconds close values to the actual values obtained from skilled user usability tests. This result confirms that CogTool, which is easy to use in terms of cost and time, is a suitable method to evaluate the usability of mobile application interfaces and to use in the early stages of the application development process. Due to the fact that CogTool can be used to model prototypes when the actual application interfaces have not been designed yet, and that it gives close results to actual performance values, it provides a fast and practical method to evaluate the usability of different design ideas and prototypes during the development stage.

When the tasks are analyzed one by one on the basis of steps, it can be seen that the results obtained from real users and CogTool differ more greatly than the results of the total time of a task. One of the possible causes of this difference is that it is not possible to calculate the thinking time of users through observations during the skilled user usability tests. For that reason, while making comparisons between these two different methods’ results, using the total task completion times gives more accurate results.

CogTool application is still under development for touch screen interface devices. Therefore, the results for the swiping and on-screen keyboard are not satisfactory yet.

When the graphical interface components and transactions for swiping and on-screen keyboard are added, +/- 5 seconds difference is expected to reduce. It is seen from the tasks such as Task 3 and Task 4 that did not include these two actions, the deviation value between two different methods' results is under 1 second. In the tables below, the results of CogTool for each steps of the tasks, the performance results of skilled users obtained from usability tests and the comparisons of these two performance results are given in the "minutes:seconds.split second" format. The differences between the results were calculated by subtracting the real user performance data from CogTool results.

As it is seen from the tables, the CogTool gives generally higher scores for performance data than the actual users' data. The (+) / (-) signs show the values of the results. If the result is negative (-) this means that the real users performed the step or the task in a longer time than CogTool's estimated value. In the tables, the time for each separate step in the tasks is given and the total values of these steps are given under the "Total Time of Steps" row. Also, the total time spent in performing a task is given under the "Total Time of Task" row. The total time values were calculated by extracting the starting time of a task from its completion time.

2.1.1 TASK 1- Viewing promotions in the eating/drinking field

Table 1 - CogTool and User Performance Results of the Task1

Step No	Step Description	COGTOOL Time (mm:ss.SS)	USER Time (mm:ss.SS)	DIFFERENCES Time (mm:ss.SS)
Step 1	Selecting "Promotions" menu	00:01.73	00:01.38	+ 00:00.34
Step 2	Pressing "Options" button	00:01.83	00:01.80	+ 00:00.03
Step 3	Selecting "Categories" option	00:01.77	00:01.00	+ 00:00.77
Step 4	Swiping "Categories" list	00:03.62	00:01.18	+ 00:02.45
Step 5	Selecting "Eating/Drinking" option	00:01.60	00:00.62	+ 00:00.98
Step 6	Viewing of promotions	00:01.63	00:01.91	- 00:00.28
	Total Time of Steps	**00:12.18**	**00:07.89**	**+ 00:04.29**
	Total Time of Task	**00:12.61**	**00:11.93**	**+ 00:00.68**

As it is seen from the Table 2, the largest difference between different methods' results is in the 4th step which includes swiping action. In order to formulate this move in CogTool, the button-up and button-down actions were used. The use of these two actions was offered in the forum page of CogTool by Bonnie E. John, who is one of the creators of CogTool. However, as it is stated in the forum thread, this method does not fully correspond to the performance data of actual behaviors.

When the steps in CogTool and the skilled user usability tests are analyzed, another reason for the difference between the results obtained from the two methods is seen. The users' grip of the phone and the phone's display size affect the position of the user's finger. Since the iPhone 3GS was used in the tests, the participants began the tests when their finger was near the home key which located on the bottom of the phone. The location of the finger directly affects the performance time of the steps and tasks. After swiping the category list, the next selection, which is “Eating/Drinking” option, falls right under the finger of the users because the users flick the screen up and locate their finger to the previous position. Therefore, the performance data of the step 5 is very low when compared to CogTool’s data on that step because CogTool calculates the performance data by moving the finger from button-up to Eating/Drinking option, which requires longer movement duration than it actually takes.

2.1.2 TASK 2- Buying promotion of nearby supermarket

Table 2 - CogTool and User Performance Results of the Task2

Step No	Step Description	COGTOOL Time (mm:ss.SS)	USER Time (mm:ss.SS)	DIFFERENCES Time (mm:ss.SS)
Step 1	Selecting “Promotion” menu	00:01.73	00:01.56	+ 00:00.17
Step 2	Pressing “Options” button	00:01.83	00:01.11	+ 00:00.73
Step 3	Selecting “Nearby” option	00:01.72	00:00.93	+ 00:00.79
Step 4	Selecting “Supermarket” option	00:01.56	00:00.95	+ 00:00.61
Step 5	Selecting related promotion	00:01.55	00:01.17	+ 00:00.38
Step 6	Pressing “Buy Now” button	00:01.70	00:01.30	+ 00:00.40
Step 7	Pressing “Ok” button	00:01.65	00:01.19	+ 00:00.46
	Total Time of Steps	**00:11.74**	**00:08.20**	**+ 00:03.54**
	Total Time of Task	**00:17.97**	**00:15.53**	**+ 00:02.44**

In the second task, the time differences between the performance results of two methods are under 1 second for all steps. All difference values are positive; that is, the CogTool’s results are higher than those obtained from actual end users. These small differences are related to thinking time and finger movement actions. If there is a limited number of selections shown to users and the users are waiting for one of them, then the time of the think actions can be reduced. In the step 3 and step 4, the users select the related option quicker than they are estimated to select according to CogTool results. When CogTool results are analyzed, it is seen that the time of finger movement is reduced depending on the location of the buttons, but the time of the think action is the same for all steps. However, CogTool offers the ability to change the think time of the steps. Therefore, the think time can be changed with respect to the interface design.

2.1.3 TASK 3- Using the promotion

Table 3 - CogTool and User Performance Results of the Task3

Step No	Step Description	COGTOOL Time (mm:ss.SS)	USER Time (mm:ss.SS)	DIFFERENCES Time (mm:ss.SS)
Step 1	Selecting “Coupon” menu	00:01.78	00:01.70	+ 00:00.08
Step 2	Pressing “Use Now” button	00:01.70	00:01.76	- 00:00.06
Step 3	Pressing “Ok” button	00:01.65	00:01.74	- 00:00.09
	Total Time of Steps	**00:05.13**	**00:05.73**	**- 00:00.23**
	Total Time of Task	**00:06.81**	**00:07.07**	**- 00:00.26**

Task 3 is the task having the smallest difference between the scores of two methods. The system response time is quite low in this task and the design of the interfaces is so simple that there is no distraction on the interface. Users see the coupon on the screen and touch the "Use it" button after realizing that it is the correct coupon. The results of the CogTool are quite close to the actual data in each step. The reason why users’ performance is higher in the steps of this task when compared to other tasks may be that users need to read a brief explanation shown on coupon and confirmation window.

2.1.4 TASK 4- Prioritization of Paracard

Table 4 - CogTool and User Performance Results of the Task4

Step No	Step Description	COGTOOL Time (mm:ss.SS)	USER Time (mm:ss.SS)	DIFFERENCES Time (mm:ss.SS)
Step 1	Selecting the “Paracard”	00:01.76	00:02.34	- 00:00.58
Step 2	Pressing on the Paracard	00:01.55	00:01.44	+ 00:00.11
Step 3	Pressing “Setting” button	00:01.61	00:01.43	+ 00:00.18
Step 4	Pressing “Prioritize” button	00:01.75	00:01.02	+ 00:00.70
Step 5	Pressing “Ok” button	00:01.67	00:00.98	+ 00:00.70
	Total Time of Steps	**00:08.35**	**00:07.21**	**+ 00:01.13**
	Total Time of Task	**00:18.45**	**00:17.89**	**+ 00:00.56**

In this task, different from the others, the first step’s performance time is higher in actual users’ test results than CogTool’s estimates. The usability test conducted with users showed that the participants were confused in the first two steps of this task. The task required the participants to perform the same action twice but the participants waited to see the result after the first step. Although the users did this task for a second time, they were again confused, which led to an increase in the performance data. This difference between two methods' results shows that if there are certain logical usability problems in the interface, the CogTool will not discover those problems based on the estimates. However, in situations like this, CogTool can be used to compare different interface designs, and consequently, to eliminate unnecessary steps the users are made to go through.

In addition, if the confirmation page includes only a brief confirmation message, users can perform the confirmation action very quickly. In some actions like entering password or closing confirmation window by confirming, users do not think before performing the action because they automatize this action by doing it before over and over again. Therefore, in the step 5, the CogTool result can be reduced by decreasing the think time.

2.1.5 TASK 5- Adding a Profile Photo

Table 5 - CogTool and User Performance Results of the Task5

Step No	Step Description	COGTOOL Time (mm:ss.SS)	USER Time (mm:ss.SS)	DIFFERENCES Time (mm:ss.SS)
Step 1	Selecting the "Profile" menu	00:01.78	00:01.03	+ 00:00.74
Step 2	Pressing "Personal Information" button	00:01.76	00:01.21	+ 00:00.54
Step 3	Selecting the area of photo	00:01.55	00:00.83	+ 00:00.72
Step 4	Pressing "Select from a Library" button	00:01.72	00:00.97	+ 00:00.75
Step 5	Selecting the photo	00:01.65	00:01.02	+ 00:00.63
Step 6	Pressing "Select" button	00:01.81	00:00.81	+ 00:01.00
	Total Time of Steps	**00:10.27**	**00:05.88**	**+ 00:04.39**
	Total Time of Task	**00:13.74**	**00:11.64**	**+ 00:02.10**

Adding a photo to the user's profile page is different from other tasks in the way the task is complete. In order to add a photo to an application in iPhone, users need to follow a certain path and this is generally the same for all applications. Therefore, the participants were familiar with and skilled for this task. This type of actions which users do by rote should be analyzed carefully and the think time should be changed in CogTool appropriately. The difference between two methods' results may be high because of the discrepancy in the think time resulting from users' tendency to do certain actions by rote.

2.1.6 TASK 6- Adding units to a contact's account

Table 6 - CogTool and User Performance Results of the Task6

Step No	Step Description	COGTOOL Time (mm:ss.SS)	USER Time (mm:ss.SS)	DIFFERENCES Time (mm:ss.SS)
Step 1	Selecting the "Operations" menu	00:01.77	00:01.66	+ 00:00.11
Step 2	Pressing the "Add Units" icon	00:01.62	00:02.13	- 00:00.51
Step 3	Pressing the phone number field	00:01.67	00:01.16	+ 00:00.51
Step 4	Pressing the "+" icon	00:01.58	00:01.56	+ 00:00.02
Step 5	Selecting the contact	00:01.55	00:01.37	+ 00:00.18
Step 6	Selecting the number of contact	00:01.55	00:00.86	+ 00:00.69
Step 7	Selecting the amount field	00:01.55	00:00.98	+ 00:00.57
Step 8	Choosing the amount to be added	00:01.55	00:00.59	+ 00:00.96
Step 9	Pressing the "Continue" button	00:01.60	00:01.56	+ 00:00.04
Step 10	Pressing the "Accept" button	00:01.88	00:01.45	+ 00:00.43
Step 11	Entering the card password	00:04.06	00:04.27	- 00:00.21
Step 12	Pressing the "Send" button	00:01.38	00:00.83	+ 00:00.55
Step 13	Pressing the "Close" button	00:01.67	00:00.49	+ 00:01.18
Step 14	Reading the explanation	00:01.30	00:01.85	- 00:00.55
	Total Time of Steps	**00:24.73**	**00:20.76**	**+ 00:03.97**
	Total Time of Task	**01.05.23**	**01:04.57**	**+ 00:00.66**

Although the Task 6 consists of 14 steps, the difference between the results of two methods is quite low. CogTool uses the location of finger when calculating movement duration of the finger between two points. It calculates the differences between two locations of finger in two steps. However, in calculation of the think time, CogTool does not take into account the complexity of the interface; it just gives the average think time for the actions. In steps 6-7-8, the graphical interface components are placed quite close to each other. As a result, CogTool gives lower performance results for these steps. Think time is another factor to consider for these steps. When performing the step 6, users are faster to act because there is not any component in the interface to select. This issue is prevalent for all the steps. Hence, if there are a limited number of components in the screen, the results estimated through CogTool can be approximated to those of the actual tests with users by decreasing the think time in CogTool.

In addition, the step 2 has a reverse situation. In this step, the users determine which action is the correct one and select it among five other actions. In the steps including decision making process the think time increases for actual users. Consequently, the think time of these steps should be increased in CogTool, as well.

The other result obtained from comparisons is pertaining to the system wait time. In Task 6, the system waits for approximately 20 seconds before step 13 and this gives users some time to think about the next action and place their finger to the appropriate location. Since users already know the next screen they are waiting for is the information page, they get ready to press “Close” button. For this reason, the difference between the performance results for this step is quite high. In order to decrease the difference between two methods in this type of steps performed right after system wait is over, the think time should be deleted.

2.1.7 TASK 7- Sending money to the phone number

Table 7 - CogTool and User Performance Results of the Task7

Step No	Step Description	COGTOOL Time (mm:ss.SS)	USER Time (mm:ss.SS)	DIFFERENCES Time (mm:ss.SS)
Step 1	Selecting the “Operations” menu	00:01.78	00:01.37	+ 00:00.41
Step 2	Pressing the “Send Money” icon	00:01.67	00:01.37	+ 00:00.30
Step 3	Pressing the receiver field	00:01.55	00:01.11	+ 00:00.44
Step 4	Entering the phone number	00:09.95	00:08.54	+ 00:01.41
Step 5	Selecting the “Amount” field	00:01.72	00:00.67	+ 00:01.05
Step 6	Entering the amount to be sent	00:02.11	00:01.41	+ 00:00.70
Step 7	Pressing the “OK” button	00:01.06	00:00.63	+ 00:00.43
Step 8	Pressing the “Continue” button	00:01.78	00:01.08	+ 00:00.70
Step 9	Pressing the “Accept” button	00:01.45	00:01.29	+ 00:00.16
Step 10	Entering the card password	00:04.06	00:04.07	- 00:00.01
Step 11	Pressing the “Send” button	00:01.04	00:00.54	+ 00:00.50
Step 12	Pressing the “Close” button	00:01.67	00:00.43	+ 00:01.24
Step 13	Reading the explanation	00:01.30	00:01.71	- 00:00.41
	Total Time of Steps	**00:31.14**	**00:24.23**	**+ 00:06.91**
	Total Time of Task	**01:17.93**	**01:12.78**	**+ 00:05.15**

Task 7 has the largest difference between CogTool’s and actual user’s performance time. According to the Table 8, the highest scores in the steps 4-12. While modeling these steps including number input through on-screen keyword on CogTool, the question was asked to one of the creators of CogTool, Bonnie E. John. Based on her feedback, a button widget was placed on each key. However, the problem in entering number is that users see the number they will enter next from the paper given to them by the researcher and thus they do not need to think before acting. Therefore, in some cases like this think operation should be deleted or changed, as pointed out by Bonnie E. John. Especially in entering password step the think operation should be deleted since users are quite skilled at entering their password. The reason for the large difference in step 12 is the same as step 13 in Task 6. The difference values are higher in the steps following the system wait.

2.1.8 TASK 8- Checking the last actions of Paracard

Table 8 - CogTool and User Performance Results of the Task8

Step No	Step Description	COGTOOL Time (mm:ss.SS)	USER Time (mm:ss.SS)	DIFFERENCES Time (mm:ss.SS)
Step 1	Selecting the “Paracard”	00:01.76	00:01.44	+ 00:00.32
Step 2	Pressing on the Paracard	00:01.55	00:01.34	+ 00:00.21
Step 3	Selecting the “Query Services” button	00:01.55	00:01.35	+ 00:00.20
Step 4	Pressing the “Last Actions” button	00:01.68	00:01.03	+ 00:00.65
Step 5	The opening of on-screen keyboard	00:01.72	00:02.69	- 00:00.97
Step 6	Entering Turkcell password	00:06.06	00:06.23	- 00:00.17
Step 7	Pressing the “Send” button	00:00.89	00:00.83	+ 00:00.06
Step 8	Pressing the “Close” button	00:01.67	00:00.44	+ 00:01.23
Step 9	Reading the last actions	00:01.30	00:03.92	- 00:02.62
	Total Time of Steps	**00:18.18**	**00:19.27**	**- 00:01.09**
	Total Time of Task	**00:54.58**	**00:59.58**	**- 00:05.00**

This task is different from others in that the difference between the total times of the results of two methods is high but negative. This negative difference arose from steps 5-9. The reason why users performed the step 5 in such a long time is that they looked at the password given to them in paper during this step and they tried to keep it mind. These two actions, which are looking password and opening keyboard, could not be separated from each other easily. Therefore, the time to complete step 5 is higher in actual end user tests than is it estimated by CogTool.

The biggest difference is seen in step 9. Throughout the tasks, while performing the steps including reading action, users generally have high performance time. For reading action, the “look at” operator was used but this operator itself is not sufficient for the reading action. After the “look at” operator, the think operator should be used in CogTool and appropriate think time value should be assigned in order to increase the efficiency of look at operation for reading action.

The comparison of the task completion time results obtained from two different methods, CogTool and user tests, is presented in Table 10 with the CogTool errors. The biggest errors are seen in Task5 and Task2. As it is explained above, in Task6 users are very skilled since adding a profile photo has the same steps for all applications and users do not need to wait and think between steps. In Task2, users do the steps without thinking too much because this task involves steps that are very similar to the steps involved in the Task1. Since users performed the Task1 just before the Task2, they tended to execute most of the steps by rote without thinking about their actions for a long time.

Table 9 - Comparisons of Task Completion Time Results of CogTool and User Test

	Task1	Task2	Task3	Task4	Task5	Task6	Task7	Task8
CogTool Results (sec)	12.61	17.97	6.81	18.45	13.74	65.23	77.93	54.58
User Results (sec)	11.93	15.53	7.07	17.89	11.64	64.57	72.78	59.58
Differences (sec)	+0.68	+2.44	-0.26	+0.56	+2.10	+0.66	+5.15	-5.00
CogTool error %	0.057	0.157	0.037	0.031	0.180	0.010	0.071	0.084

The task execution time results obtained from two methods are also given in the Figure 23. As it is seen from the graph, the predictions of CogTool for tasks and real users' task completion times are close to each other. Moreover, for 6 of the designated 8 tasks, CogTool predicted higher task completion time results than users' observed actual performance times. Only in Task3 and Task8, users had higher scores than CogTool's predictions.

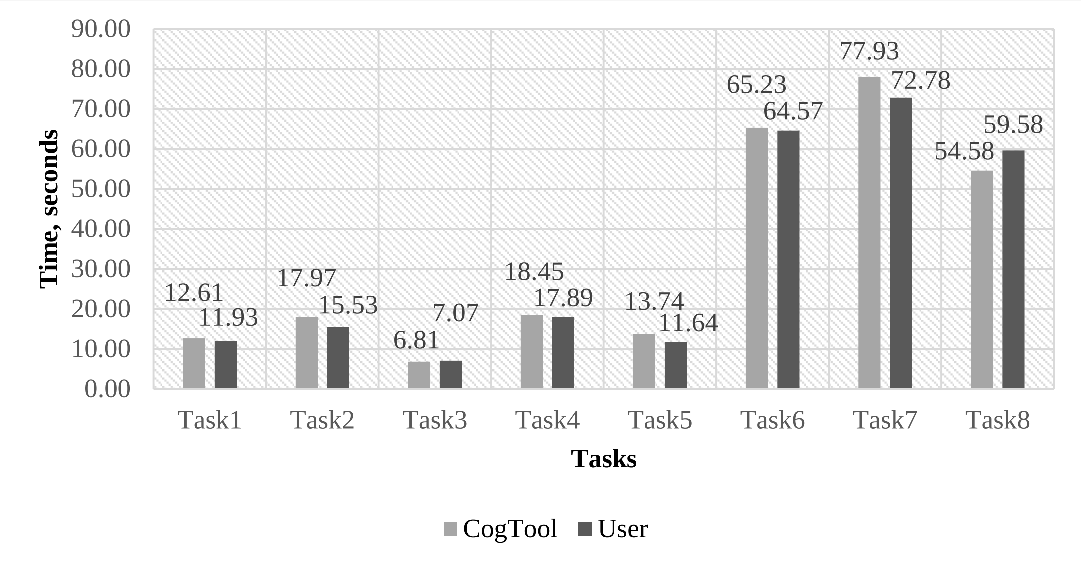


Figure 1 - The comparison of CogTool predictions and user test task completion time results

In addition to the comparisons of the results obtained from two methods, the time required to apply these different two methods were also compared. While 38 hours were spent in order to conduct and analyze end user usability tests, for the cognitive modeling method only 13.5 hours were spent. The time required to carry out these two methods is presented in detail in the following table (Table 11).

Table 10 - The Time Required for Applying Methods

End User Usability Test Method		CogTool – Cognitive Modeling Method	
	Time Spent		Time Spent
Planning the study	2	Planning the study	1
Determining the tasks	2	Determining the tasks	2
Determining the appropriate users	8	Prototyping the interfaces	3
Performing the tests	8	Running the tasks	0.5
Analyzing the results	10	Analyzing the results	4
Reporting the results	8	Reporting the results	3
Total	38	Total	13.5

As it can be seen from the Table 11, conducting usability tests with end users required almost 3 times more time than the time spent in performing cognitive modeling method. With the cognitive modeling method, the approximate value of the actual users' task completion time on application is gathered. This provides researchers with information on how much time users will spend in performing the same tasks on different interface designs. It is possible to evaluate the usability of prototypes by using CogTool in the very early stages of development even when the interface has not been designed yet. Thus, the potential usability problems that might exist in the application can be discovered and fixed at the very beginning of the application's development stage.

2.2 USER INTERACTION SATISFACTION QUESTIONNAIRE

In this section, the result of the questionnaire administered to the participants after the usability tests to find out their satisfaction level about the interface is presented and evaluated. By using CogTool, it is not possible to learn the satisfaction level of users directly - only the estimated performance data can be collected with CogTool. Yet, according to the results of CogTool, if there are tasks involving many steps and taking a long time, it may be possible to estimate that users will have a low level of satisfaction on these areas of the application.

In this study, the QUIS questionnaire (The Questionnaire for User Interaction Satisfaction) was used. The questions were altered in accordance with mobile application characteristics. The questionnaire distributed to the participants is attached to Appendix A. In the questionnaire, the participants were asked to rate the application based on the given criteria on a scale from 1 to 9. The questionnaire consists of 4 main sections and 39 questions. The sections of the questionnaire are as follows: Overall Reaction to the Application, Application Interface, Terminology and System Information, and Learning sections.

2.2.1 Overall Reaction to the Application

In this section, the participants were asked to evaluate the Turkcell Cüzdan application in a general way. When the score of the 10 participants were analyzed together, the application got 5.3 out of 9 (58.9 out of 100).

Table 11 - Result of the Overall Reaction to Application Section of the Questionnaire

Section/Questions	Average (9-scale)	Average (100-scale)
Overall Reaction to the Application	5.3	58.9

This section included 6 criteria to evaluate the users' satisfaction. The users rated their lowest satisfaction level with the application in this section of the questionnaire. When the scores are analyzed, it is seen that the users found the application dull and rigid. It is hard to deduce the users' satisfaction level in this way from the results of CogTool as these pertain to the users' opinions about the colors and the page layout of the application.

2.2.2 Application Interface

In this section, of the participants were asked to evaluate the font and size, page layout, links, images, icons and colors used in interface. The scores of this section in 9-scale and 100-scale are given in the table below.

Table 12 - Results of Application Interface Section of the Questionnaire

Section/Questions	Average (9-scale)	Average (100-scale)
Font Size	7.0	77.8
Page Layout	6.6	73.3
Transitions Between Pages	6.9	76.7
Images and Icons	7.1	78.9
Colors	6.6	73.3
Mean	6.8	75.6

In this section, the users evaluated the colors and page layout of the application with a low score of satisfaction level. In addition, the transitions between pages were given a low score by the users. By using the estimated performance results from CogTool, the satisfaction level related with transitions between pages may be estimated. The number of the steps of a task and the estimated task completion time can be used to interpret the users' satisfaction level with the transitions between pages in the application. If the number of the steps of a task and the estimated performance time are high, then it is possible to conclude that users will be dissatisfied with this aspect of the application.

2.2.3 Terminology and System Information

Naming of the page, links and icons are evaluated in this section of the questionnaire. In addition, the evaluation of the on-screen messages for giving information about completion action or for making aware users about the error was done in this section. In addition, feedback messages and error messages raised by the application on the screen were evaluated in this section. The scores of this section in 9-scale and 100-scale are given in the table below.

Table 13 - Results of Terminology and System Information Section of the QUIS

Section/Questions	Average (9-scale)	Average (100-scale)
Terms Used	7.1	78.9
Messages that Appear on the Screen	7.2	80.0
Inform Users	6.8	75.6
Error Messages	6.4	71.1
Mean	6.9	76.7

In this section of the questionnaire, the users rated the error messages given by the application with the lowest score. They stated that error messages did not inform the users of what they should do. Therefore, the information amount was insufficient in error messages, according to the users. Moreover, the questions related with the application's informing users were rated with a low score by the users. In this subsection, there are 3 questions about connection time, predictable consequences of actions and the application's informing users. User satisfaction level about this section can also be estimated by using CogTool results. When prototyping the interactions of the application on CogTool, the system response time is also considered. If this time is high, it could be concluded that users' satisfaction level will decrease.

2.2.4 Learning

In the last section, the participants were asked to evaluate how easily they could learn to operate the application, explore the features of the system, recall and perform the tasks without wasting time. The scores of this section in 9-scale and 100-scale are given in the table below.

Table 14 - Results of Learning Section of the Questionnaire

Section/Questions	Average (9-scale)	Average (100-scale)
Learning to Operate System	7.5	83.3
Exploring the Features of the System	7.3	81.1
Recall	8.0	88.9
Performing Task	7.0	77.8
Mean	7.5	83.3

The users rated this section of the questionnaire with the highest score. This means that the users thought that learning and recalling the actions of application was easy. It may be possible to reach the same conclusion by using the results obtained from CogTool. Analyzing the steps of the tasks, the location of the graphical interface components with similar functions, the ease of learning and recalling the functions of the application can be interpreted. If similar tasks are performed in similar ways, it can be said that learning the application and recalling its functions will be easy. CogTool gives estimated performance time for each step. It can be seen from the CogTool results that similar steps, such as viewing options, include similar operations and have almost the same performance time results. This result corresponds to the result of users' satisfaction level acquired from the questionnaire.

2.3 SUMMARY OF THE RESULTS

The results of thesis study has been obtained from two different studies. In the first study CogTool and skilled user usability test results were compared with each other in terms of task completion time. In the second study, results of the questionnaire giving participants after usability test were analyzed and interpreted whether users' satisfaction level is evaluated with cognitive modeling predictions or not. The results of this thesis are summarized below.

- The biggest difference between different methods' results is in the step including swiping action.
- In some actions like entering password or closing confirmation window by confirming, users does not think before doing action because they memorize this action by doing it before number of time. Therefore, the think operation time is higher according to actual performance time.
- In the steps including decision making process the think time increases for actual users therefore think operation time of CogTool becomes insufficient.
- In the steps including reading action users have generally high performance time. For reading action the look at operator was used but this operator could not meet the reading action.
- Time spending for applying usability test was 38 hours while it was 13.5 hours for using cognitive modeling method.
- According to results of questionnaire, users found application dull and rigid. Satisfaction level of users on this way cannot be deduced with the CogTool estimation.
- Satisfaction level related with transitions between pages may be estimated by using CogTool results. It is possible to interpret that users will be dissatisfied with high task execution time, system response time and many number of steps.
- Similarities between the tasks completion ways of similar tasks may increase satisfaction level of users by making easy to learn navigation on interface.

CHAPTER V

DISCUSSION & CONCLUSION

This chapter presents the discussion of the results obtained through two different usability methods, which are end user usability tests and cognitive modeling. The conclusion of the study is also presented in this chapter. Moreover, this chapter concludes by presenting directions and recommendations for future research as well as the limitations of this study.

3.1 DISCUSSION

Mobile phones have become an indispensable part of our daily lives with the rapid developments in technology. Now, a phone is not only a device to make phone calls or send text messages to someone, but it is also a device including various applications for business transactions, entertainment, surfing the Internet etc. However, this fast rise in the number of functions introduced a design challenge for small screens. Besides, as Dumas and Redish (2004) state, people use products to be productive and they mark a product "usable" by evaluating it in terms of time required to do what they want, the number of steps to complete a task and the success they reach by doing what they think is right. Moreover, users are busy people trying to accomplish what they want with the minimum amount of effort possible. Therefore, usability is an important factor for users when they are purchasing a product. There is a growing demand for user friendly mobile phones because usability provides many benefits that companies cannot afford to ignore. For example, users need customer support and assistance less if their phone is intuitive to use and they are willing to use the variety of features and the services offered by phones. Also, with user-friendly phones, the satisfaction level of users increases (Jokela, Koivumaa, Pirkola, Salminen & Kantola, 2005). Consequently, mobile application designers need to focus on their users during the development process of an application to increase their product's usability.

As Nielsen (2008) specified, there are various methods to evaluate and improve the usability of a product. The most commonly used methods to evaluate the usability of products are user based usability tests, heuristic evaluations and survey methods. Cognitive modeling, which gives a prediction of task completion times based on specified operators, is another method used to evaluate the usability of a product. User based usability test method is the most basic and useful one among other methods since the data are collected directly from real users (Nielsen, 2012). However, conducting usability tests with end users is costly. This is also true for the heuristic evaluation method: The greater the number of experts employed to evaluate a product for its usability is, the greater the number of usability problems identified is. Nevertheless, the cost of the heuristic evaluations will also increase with the number of usability experts (Desurvire et al., 1992). Survey is a practical and quick method to gather subjective data directly from users, but it can reveal fewer usability problems when compared to other methods (Holzinger, 2005). Additionaly, Cognitive modeling method has some advantages over other techniques. For instance, it can be conducted without the implementation of interface and it does not need real users to compute task execution times. In addition, cognitive modeling method is cheaper to implement, and it can be used during the initial phases of design and development (Gokam, Devanuj, Lobo, Gore, Doke & Kimbahune, 2011).

In the literature, there is a myriad of studies investigating the usability of mobile applications with different methods. Based on the literature review conducted for this thesis study, in most of the studies, end user usability test method was used, but cognitive modeling method was not preferred to evaluate the usability of mobile applications. In addition, during the literature review, the studies using cognitive modeling methods were investigated. It was seen that 30% of the studies were done by using CogTool and 26% of were conducted with mobile phones but there is limited number of study in which cognitive modeling method is used to evaluate the usability of touch screen mobile phones. There is a study done by Abdulin (2011) in which CogTool is used to model middle-sized touch screens such as iPad and the results are compared with the actual users' results. Nonetheless, the number of the study using cognitive modeling for 3.5 inches touch screens in the literature is very limited.

The results of this study have been used to answer the following research questions:

RQ1- Does cognitive modeling method yield similar results to those of end user performance tests in the usability evaluation of touch screen mobile applications?

This study investigated the accuracy of task execution times predicted by CogTool, which is a cognitive modeling tool, by comparing them with the results obtained from actual users' performance on a touch screen smartphone. In this study, 8 goal-specified tasks were used in end user tests, and the same tasks were modeled and demonstrated in CogTool. The analysis was done on the basis of the steps. The participants' actual performance data, which are video records of the tests, were examined with ELAN video analysis program step by step. Each step of the tasks was also examined in the visualization window of CogTool. The results obtained from two methods were compared on the basis of steps and total execution time. The comparison results are shown below in the Table 16.

Table 15 - The Comparison of CogTool predictions and user test task completion time results

	Task1	Task2	Task3	Task4	Task5	Task6	Task7	Task8
CogTool Results (sec)	12.61	17.97	6.81	18.45	13.74	65.23	77.93	54.58
User Results (sec)	11.93	15.53	7.07	17.89	11.64	64.57	72.78	59.58
Differences (sec)	+0.68	+2.44	-0.26	+0.56	+2.10	+0.66	+5.15	-5.00
CogTool error %	0.057	0.157	0.037	0.031	0.180	0.010	0.071	0.084

The results of this study indicated that CogTool prediction error for mobile application interfaces on touch screens is less than 20%. As it is seen in the table, there are large differences between CogTool errors on the basis of tasks. Task2 and Task5 have the largest CogTool error value. The error values for other tasks are less than 5%. This result suggests that the tasks including steps with which users are highly experienced have the highest prediction errors. By decreasing or removing think operator from this type of tasks, the accuracy of the prediction can be increased. When CogTool think operator time in Task2 is reduced to half; that is 0.6 sec in, CogTool's prediction time decreases to 15.00 sec from 17.97 sec. and prediction error decreases to 0,034 from 0,157. The way Task2 is completed is very similar to that of the Task1, which users completed just before the Task2. Therefore they do not need to wait between actions. When the think operator is modified in the same fashion for the Task5, the prediction error decreases to 0.077 from 0.180. This result complies with the result of a study in the literature which found out that CogTool could accurately predict task execution time with less than 8% error on handheld devices (Luo, 2005).

The results of this study show that CogTool gives generally higher predictions than observed user performance data on touch screen phones. This result is in agreement with the study conducted by Abdulin (2011), using CogTool to model middle-sized touch screen devices. That study also supports that CogTool gives higher task execution time predictions on touch screen devices. In that study, the prediction error was less than 2%. However, the CogTool prediction error was found to be higher in the present study and in the other study done by Luo (2005) by using small-sized touch screen. These results indicate that CogTool's prediction's accuracy reduces with decreasing size of touch screen devices.

According to these results, the answer to the research question is positive: cognitive modeling method gives similar results with end user performance results in usability evaluation of touch screen mobile applications. However, the results show that user behaviors should be analyzed carefully and the time of the think operation in CogTool should be altered accordingly. It should be decreased or removed when the task is a task the users perform frequently and thus know very well, such as entering their password. It should be increased when the users need to compare or select among several choices.

RQ2- To what extent is cognitive modeling method suitable to evaluate the performance aspect of usability on touch screen mobile applications?

The results of this study showed that cognitive modeling method produced good estimates of skilled users' performance time on touch screen mobile devices. Earlier studies conducted by Abdulin (2011) and Luo (2005) have also similar results regarding the accuracy of cognitive modeling method on touch screen mobile devices. However, with the developments in touch screen technology, new concepts have come to our lives, such as swiping. The CogTool does not have any actions or graphical interface components to correspond to this gesture. New actions and graphical interface components should be added to cognitive modeling method to meet the requirements for new gestures introduced to our lives with the advent of touch screen devices.

In addition, the satisfaction questionnaire was administered to the participants after the usability tests and the results of this questionnaire were given by associating them with the CogTool results. The results of this study show that with the CogTool results, it is possible to measure some factors affecting satisfaction to some certain extent. The long completion time for the steps, tasks and system wait time point to a low satisfaction level with the application since users easily get bored when the time required to complete a task increases. Also, the similarities between the ways similar tasks are completed make it easier to learn the application and thus increase the satisfaction level.

These results indicate that cognitive modeling gives useful results for the usability evaluation of touch screen mobile devices. However, as John (1995) stated CogTool gives skilled users' performance prediction. Skilled users are expected to perform tasks without pausing to think what they will do; they are expected to have already mastered the specified tasks. Therefore, CogTool should be used in suitable situations. If the system is for novice users who will see application for the first time and need to search around what they will do next, then the cognitive modeling is not an appropriate method.

Furthermore, according to John (2011) cognitive modeling has been generally used to compare alternative interface design quantitatively; not to explore usability problems or make design recommendations. Nevertheless, different from other modeling methods, CogTool produces a timeline from which modeler can analyze what a user would see, think, and do to perform a task on a user interface. Therefore, the timeline produced by CogTool can be used to analyze an interface in terms of its usability.

Due to the fact that CogTool gives accurate estimates on touch screen mobile devices except some special cases such as swiping, and that it is possible to evaluate some factors affecting user satisfaction with CogTool, the answer to the research question 2 is: cognitive modeling can be used for the usability evaluation of touch screen mobile interfaces. However, the usage purpose of the interface, user profile and tasks should be appropriate to be tested with cognitive modeling.

RQ3- What is the optimum usability method that can guide the development of touch screen mobile applications?

As John et al. (2004) assert, CogTool has an advantage over end user testing method in terms of time and cost. During this study, it was observed that user testing required almost 3 times more time than performing cognitive modeling method. This result is in agreement with the study conducted by Nielsen and Phillips (1993) in which cost/benefit analyses were done for five different usability methods. The two of the methods were cognitive modeling and user testing methods. The cost results was calculated by estimating hourly cost of various types of staff such as usability specialist, research assistant etc. Nielsen and Phillips (1993) also found that user testing was 2.8 times as expensive as the cognitive modeling, which is one of the cheapest usability methods. The other study which explores the cost and benefits of predictive human performance modeling revealed that CogTool is less costly to learn and apply even for people who do not have any psychological background, which decreases the cost even more (John & Jastrzembski, 2010).

In addition, cognitive modeling is a beneficial method for early evaluation of user interface designs (Jastrzembski & Charness, 2007). It is possible to use CogTool even when only the prototypes of the interface have been designed. For this reason, developers can use CogTool before the actual implementation of the user interface only with their design ideas. A study conducted for assessing the usability of real world software development in IBM shows that the quantitative results of CogTool allow researchers to take into account the usability issues in the development process (Bellamy, John & Kogan, 2011). User testing still seems to be the best method for getting direct information from users but it is difficult to apply this method before an interface has been designed and implemented. Moreover, this study shows that cognitive modeling gives estimation of user performance with less than 8% error rate when think operation is modified according to user behavior on touch screen mobile interfaces. Also, cognitive modeling is better than user testing in terms of cost efficiency and it is possible to use CogTool before an interface has been designed and implemented. Therefore, based on these results, it can be said that cognitive modeling method is the optimum usability method to be used during the development stage of touch screen mobile interfaces.

3.2 CONCLUSION

The results of this study indicate that CogTool can be used to evaluate the usability of small-sized touch screen mobile application interfaces. CogTool prediction error value in measuring users' performance was less than 20% but, with the modification suggested in this study, this error rate was reduced to 8%. Based on these results, CogTool prediction error can be minimized by assigning appropriate time value to the think operation after the demonstration of the tasks. In addition, the results of this study reveal that CogTool's think operation time is high for the users using small-sized touch screen phones except the steps including decision-making among several choices.

Moreover, this study shows that CogTool falls short of providing tools and elements for such new concepts as swiping that were introduced to our lives with touch screen devices. In CogTool button up-down features are used for swiping but this does not fully meet the interaction requirements for the swiping action. A new implementation is required for the swiping action in CogTool. Also, if there is information or explanation users have to read to execute a specified task, the time of the think operation should be increased or reading action should be added to the CogTool. The current actions of the CogTool do not correctly reflect the reading process.

This study also shows that performing cognitive modeling on CogTool is easier than performing user testing. In order to evaluate the usability of touch screen mobile application interfaces with CogTool, in this study, 13.5 hours were spent while 38 hours were required to conduct the end user usability tests. After an hour of practice, CogTool can be used by people who do not have any experience with cognitive modeling. To be able to interpret the results of CogTool, modelers do not need to have a background in psychology. Therefore, the designers and programmers can use CogTool easily to model their user interfaces in order to see how much time is required by users to accomplish a task or to compare different design ideas. CogTool can be used in the early stages of user interface design processes since there is no need to have a fully functional interface implemented: even prototypes can be modeled and evaluated in terms of usability on CogTool.

This study also reveals that CogTool can be used to measure user satisfaction to some extent by predicting some factors affecting the level of user satisfaction. As the execution time of a task increases, users get bored, and this leads to a decrease in user satisfaction level. What is more, the similarities between the ways similar tasks are completed make it easy for users to learn how to navigate through the interface and thus increase the user satisfaction level.

3.3 CONTRIBUTION OF THE STUDY

In the past, mobile phones were used to make phone calls, send text messages, etc; however, with the advancements in mobile technology, mobile phones have morphed into smartphones with various capabilities that were once deemed impossible, making them an inseparable part of our everyday lives. Moreover, human computer interfaces are being made more and more tactile: touch screen technology is being rigorously applied to such interfaces. Therefore, there is an increasing demand for increasing the usability of such mobile interfaces and designing user-friendly interfaces in order for manufacturers to compete with others in the market as it is highly acknowledged that usability is an important factor for uses while purchasing a product. To evaluate the usability of interfaces, there are various methods, including end user testing, heuristic evaluations, survey methods and cognitive modeling. Of all these methods, cognitive modeling is regarded as the easiest one to use and it requires less resources and expertise when compared to the other methods. Hence, the accuracy of the predictions produced by cognitive modeling for the usability evaluation of touch screen mobile phone interfaces should be investigated.

This study contributes to the Human Computer Interaction literature by explaining the accuracy of the predictions of cognitive modeling on touch screen mobile devices. The findings of this study show that CogTool, as a cognitive modeling method, can be used to evaluate the usability of the interfaces of touch screen mobile devices as long as the think operator is modified appropriately. Also, the study shows how easy CogTool is to use to model mobile interfaces. These results can aid researchers and mobile application developers in deciding which methods should be used to evaluate the usability of mobile application under certain circumstances.

3.4 LIMITATION AND FURTHER RESEARCH

There are several limitations of this study. The first limitation of the study is related with the users' experience with the mobile application used in the study. CogTool gives the skilled users' task execution predictions. In order to make the participants skilled users' of the mobile application, they were asked to perform the same tasks twice with 10 minutes interval and their performance results in the second trials were used for comparisons with CogTool's results. However, this might not suffice to safely assume that the participants became skilled users of the mobile application in their second trial. Therefore, it is recommended that further studies consider training the participants before the study so that they have the opportunity to use and explore the application for a longer time.

The second limitation of this study is with regards to the setting in which user tests were conducted. The user tests were done in a usability laboratory, but the mobile nature of mobile phones gives users the ability to use their phones on the go. Thus, it is recommended that further studies conduct these user tests in the field where users have mobility.

The final limitation is related with the order of the tasks. The tasks were given to users in the order they were described in the scenarios but this brought about some negative effects: users performed similar tasks by rote or without thinking before acting. Therefore, it is recommended that future studies present the tasks to the users in mixed order to eliminate potential order effects.

Further studies can be conducted with CogTool to model two design ideas for touch screen applications and results can be compared with actual user performances. Also, eye-tracking can be used in further studies to compare the usability issues obtained from CogTool and eye tracking results.

REFERENCES

Abdulin, E. (2011, May). Using the keystroke-level model for designing user interface on middle-sized touch screens. In *Proceedings of the 2011 annual conference extended abstracts on Human Factors in Computing Systems,* (pp. 673-686). Vancouver, BC, Canada.

Adio, O. D. (2013). *Assessing the accuracy of task time prediction of an emerging human performance modeling software – Cogtool* (Unpublished master's thesis). Louisiana State University, USA.

Anderson, J. R., Bothell, D., Byrne, M. D., Douglass, S., Lebiere, C., & Qin, Y. (2004). An Integrated Theory of the Mind. *Psychological Review*, 111(4), 1036-1060. doi: 10.1037/0033-295X.111.4.1036

Bellamy, R., John, B. E., & Kogan, S. (2011, May). Deploying CogTool: Integrating quantitative usability assessment into real-world software development. In *Proceeding of the 33rd International Conference on Software Engineering*, (pp. 691-700). New York, NY, USA.

Crystal, A., & Ellington, B. (2004, August). Task analysis and human-computer interaction: approaches, techniques, and levels of analysis. In *Proceedings of the Tenth Americas Conference on Information Systems* (p. 391). New York, NY, USA.

Çağıltay, K. (2011). *İnsan Bilgisayar Etkileşimi ve Kullanılabilirlik Mühendisliği: Teoriden Pratiğe.* Ankara: ODTU Yayıncılık.

Deloitte. (2012). *The State of the Global Mobile Consumer, Connectivity is Co*re. Retrieved from http://www2.deloitte.com/content/dam/Deloitte/global/Documents/Technology-Media-Telecommunications/dttl_TMT_MobileConsumer_Final_171212.pdf

Desurvire, H., Kondziela, J., & Atwood, M. E. (1992, May). What is gained and lost when using methods other than empirical testing. In *Posters and short talks of the 1992 SIGCHI conference on Human factors in computing systems* (pp. 125-126). New York, NY, USA.

Dumas, J. S., & Redish, J. C. (1999). *A practical guide to usability testing.* Exeter UK: Intellect Books.

Heinath, M. & Urbas, L. (2007, September). Simplifying the Development of Cognitive Models using a Pattern-based Modeling. In *Proceeding of 10th IFAC/IFIP/IFORS/IEA Symposium on Analysis, Design, and Evaluation of Human-Machine Systems*. Seoul, Korea.

Holzinger, A. (2005). Usability Engineering Methods for Software Developers. *Communication of the ACM. 48*(1), 71-74.

International Organization for Standardization. (1998). *ISO 9241-11: Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs): Part 11: Guidance on Usability*.

iSuppli. (2009). *Touch-Screen Interfaces Continue to Drive Growth in Signage & Professional Markets.* Retrieved from http://www.isuppli.com/Abstract/Touch-Screen-Interfaces-Continue-to-Drive-Growth-in-Signage-and-Professional-Applications.pdf

Jastrzembski, T. S., & Charness, N. (2007). The Model Human Processor and the older adult: parameter estimation and validation within a mobile phone task. *Journal of experimental psychology: applied*, *13*(4), 224-248.

Jeffries, R., & Desurvire, H. (1992). Usability testing vs. heuristic evaluation: was there a contest?. *ACM SIGCHI Bulletin, 24*(4), 39-41.

John, B. E. (1995). Why GOMS?. *Interactions, 2*(4), 80–89.

John, B. E., & Kieras, D. E. (1996). Using GOMS for User Interface Design and Evaluation: Which Technique?. *ACM Transactions on Computer-Human Interaction, 3*(4), 287-319.

John, B. E., Prevas, K., Salvucci, D. D., & Koedinger, K. (2004, April). Predictive human performance modeling made easy. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 455-462). New York, NY, USA.

John, B. E., & Suzuki, S. (2009). Toward Cognitive Modelling for Predicting Usability. In *Proceedings of HCI International 2009* (pp. 267-276). San Diego, CA. USA.

John, B. E. (2010). CogTool: Predictive Human Performance Modeling by Demonstration. In *Proceedings of the 19th Conference on Behaviour Representation in Modeling and Simulation* (pp. 83-84). Charleston, SC, USA.

John, B. E., & Jastrzembski, T. S. (2010, August). Exploration of costs and benefits of predictive human performance modeling for design. In *Proceedings of the 10th International Conference on Cognitive Modeling* (pp. 115-120). Philadelphia, PA, USA.

John, B. E. (2011, May). Using predictive human performance models to inspire and support UI design recommendations. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 983-986). Vancouver, BC, Canada.

Jokela, T., Koivumaa, J., Pirkola, J., Salminen, P., & Kantola, N. (2006). Methods for quantitative usability requirements: a case study on the development of the user interface of a mobile phone. *Personal and Ubiquitous computing*, *10*(6), 345-355.

Kirakowski, J. (2000). Questionnaires in usability engineering. *Human Factors Research Group,* Cork, Ireland.

Li, H., Liu, Y., Liu, J., Wang, X., Li, Y., & Rau, P.P (2010, April). Extended KLM for Mobile Phone Interaction: A User Study Result. In *CHI'10 Extended Abstracts on Human Factors in Computing Systems* (pp. 3517-3522). Atlanta, Georgia, USA.

Luo, L., & John, B. E. (2005, April). Predicting task execution time on handheld devices using the keystroke-level model. In *CHI'05 extended abstracts on Human factors in computing systems* (pp. 1605-1608). Portland, OR, USA.

Nielsen, J., & Phillips, V. L. (1993, May). Estimating the relative usability of two interfaces: heuristic, formal, and empirical methods compared. In *Proceedings of the INTERACT'93 conference* (pp. 214-221). Amsterdam, Netherlands.

Nielsen, J. (2005). *Authentic Behavior in User Testing.* Retrieved from http://www.nngroup.com/articles/authentic-behavior-in-user-testing/

Nielsen, J. (2008). *When to Use Which User Experience Research Methods*. Retrieved from http://www.nngroup.com/articles/which-ux-research-methods/

Nielsen, J. (2011), Defer Secondary Content When Writing for Mobile Users, from http://www.useit.com/alertbox/mobile-content.html

Nielsen, J. (2011). *Mobile Usability Update*. Retrieved from http://www.nngroup.com/articles/mobile-usability-update/

Nielsen, J. (2011). *Mobile Content Is Twice as Difficult*. Retrieved from http://www.nngroup.com/articles/mobile-content-is-twice-as-difficult/

Nielsen, J. (2012). *Usability 101: Introduction to Usability*. Retrieved from http://www.nngroup.com/articles/usability-101-introduction-to-usability/

Nielsen, J. (2012). *How Many Test Users in a Usability Study*. Retrieved from http://www.nngroup.com/articles/how-many-test-users/

Rubin J. (1994). *Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests.* USA: John Wiley & Sons.

APPENDICES

APPENDIX A: Demographic Information Form (In Turkish)

KATILIMCI VERİLERİ

Katılımcı No:_________

Yaş: ______

Cinsiyet: Kadın: ___ Erkek ___

Eğitim: İlköğretim: __ Lise: __ Üniversite: __ Yüksek Lisans:__ Doktora:__ Diğer:_____

Öğrenim görmekte olduğunuz ya da mezun olduğunuz bölüm: ____________

Mesleğiniz:___________

Bilgisayar kullanma becerinizi nasıl tanımlıyorsunuz?

Kötü__ Ortalama__ İyi__ Çok iyi__ Diğer__________

Akıllı telefon kullanma becerinizi nasıl tanımlıyorsunuz?

Kötü__ Ortalama__ İyi__ Çok iyi__ Diğer__________

Yaklaşık ne kadar süredir akıllı telefon kullanıyorsunuz? _____

APPENDIX B: User Interaction Satisfaction Questionnaire - QUIS (In Turkish)

BÖLÜM 1 : Sistem Tecrübesi

1. Turkcell Cüzdan uygulamasını ne kadar sıklıkla kullanıyorsunuz?

Hiç kullanmadım__ Haftada bir__ Haftada birkaç kere__ Günde 1 defa__ Günde bir defadan fazla__

BÖLÜM 2 : Genel Kullanıcı Tepkileri

Turkcell Cüzdan uygulaması kullanımından edindiğiniz izlenimleri yansıtan en uygun sayıyı yuvarlak içine alınız. İlgili Değil = ID

2.1	Turkcell Cüzdan uygulaması hakkındaki genel düşünceler	berbat	muhteşem	
		1 2 3 4 5 6 7 8 9		ID
2.2		tatmin edici değil	tatmin edici	
		1 2 3 4 5 6 7 8 9		ID
2.3		sıkıcı	motive edici	
		1 2 3 4 5 6 7 8 9		ID
2.4		zor	kolay	
		1 2 3 4 5 6 7 8 9		ID
2.5		uygulama yeterince güçlü değil	uygulama yeterince güçlü	
		1 2 3 4 5 6 7 8 9		ID
2.6		katı	esnek	
		1 2 3 4 5 6 7 8 9		ID

BÖLÜM 3: Turkcell Cüzdan uygulamasının görünüşü

3.1	Ekrandaki karakterlerin okunması	zor	kolay	1 2 3 4 5 6 7 8 9	ID
3.1.1	Karakterlerin görüntüsü	bulanık	net	1 2 3 4 5 6 7 8 9	ID
3.1.2	Yazı tipi (font)	okunaksız	okunaklı	1 2 3 4 5 6 7 8 9	ID
3.2	Arayüz bileşenlerinin düzeni çok yardımcıydı	hiç bir zaman	her zaman	1 2 3 4 5 6 7 8 9	ID
3.2.1	Arayüzde görüntülenen bilgi miktarı	yetersiz	yeterli	1 2 3 4 5 6 7 8 9	ID
3.2.2	Bilginin ekranda yerleşimi	mantıksız	mantıklı	1 2 3 4 5 6 7 8 9	ID
3.3	Birbirini takip eden sayfalar	kafa karıştırıcı	düzenli	1 2 3 4 5 6 7 8 9	ID
3.3.1	Bağlantılar tıklandığında karşılaşılacak arayüz (bir sonraki ekran görüntüsü)	tahmin edilebilir değil	tahmin	1 2 3 4 5 6 7 8 9	ID
3.3.2	Birbirini takip eden arayüzlerde bir önceki arayüze dönmek	imkansız	kolay	1 2 3 4 5 6 7 8 9	ID
3.3.3	Görevlerde istenilen bilgiye ulaşmak için izlenen yol	karmaşık	basit	1 2 3 4 5 6 7 8 9	ID
3.4	Hareketsiz resimlerin ve fotoğrafların kalitesi	kötü	iyi	1 2 3 4 5 6 7 8 9	ID
3.4.1	Resimler ve fotoğraflar	belirsiz	belirgin	1 2 3 4 5 6 7 8 9	ID
3.4.2	Resim ya da fotoğrafların parlaklığı	bulanık	parlak	1 2 3 4 5 6 7 8 9	ID
3.5	Kullanılan renkler	doğal değil	doğal	1 2 3 4 5 6 7 8 9	ID
3.5.1	Var olan renklerin miktarı	yetersiz	yeterli	1 2 3 4 5 6 7 8 9	ID

Turkcell Cüzdan uygulamasının görünüşü hakkındaki görüşlerinizi lütfen aşağıdaki boş alana yazınız:

BÖLÜM 4: Turkcell Cüzdan uygulamasında kullanılan terimler

4.1 Turkcel Cüzdan uygulamasında kullanılan terimler	tutarsız	tutarlı	
	1 2 3 4 5 6 7 8 9		ID
4.1.2 Bağlantıların ve ikonların isimleri	belirsiz	açıkça anlaşıla	
	1 2 3 4 5 6 7 8 9		ID
4.1.3 Başlıklar	tutarsız	tutarlı	
	1 2 3 4 5 6 7 8 9		ID
4.2 Ekranda beliren mesajlar	tutarsız	tutarlı	
	1 2 3 4 5 6 7 8 9		ID
4.2.1 Ekranda beliren talimatların yerleri	tutarsız	tutarlı	
	1 2 3 4 5 6 7 8 9		ID
4.3 Telefon ne yaptığına dair kullanıcıyı bilgilendiriyor	hiçbir zaman	her zaman	
	1 2 3 4 5 6 7 8 9		ID
4.3.1 Bir işlemi gerçekleştirmek tahmin edilebilir bir sonuç doğuruyor	hiçbir zaman	her zaman	
	1 2 3 4 5 6 7 8 9		ID
4.3.2 Bağlantılar arasında geçen bağlanma süresi	uygun	çok uzun	
	1 2 3 4 5 6 7 8 9		ID
4.4 Hata mesajları	yardımcı nitelikte değil	yardımcı nitelikte	
	1 2 3 4 5 6 7 8 9		ID

Turkcell Cüzdan uygulamasında kullanılan terimler hakkındaki görüşlerinizi aşağıdaki boş alana yazınız:

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BÖLÜM 5: Sistem Kullanımını Öğrenme

5.1 Uygulamada gezinmeyi (navigation) öğrenmek	zor	kolay	
	1 2 3 4 5 6 7 8 9		ID
5.1.1 Başlangıç aşamasındaki öğrenme	zor	kolay	
	1 2 3 4 5 6 7 8 9		ID
5.1.2 Uygulamayı kullanmayı öğrenme zama	kısa	uzun	
	1 2 3 4 5 6 7 8 9		ID
5.2 Deneme yanılma yoluyla uygulamanın	zor	kolay	
özelliklerini keşfetmek	1 2 3 4 5 6 7 8 9		ID
5.2.1 Uygulama özelliklerinin keşfi	riskli	güvenli	
	1 2 3 4 5 6 7 8 9		ID
5.2.2 Yeni özelliklerin keşfedilmesi	zor	kolay	
	1 2 3 4 5 6 7 8 9		ID
5.3 Kullanılan fonksiyonların kullanım	zor	kolay	
şekillerini hatırlamak	1 2 3 4 5 6 7 8 9		ID
5.4 Verilen görevler doğrudan yerine	asla	her zaman	
getirilebiliyordu (oyalama olmadan)	1 2 3 4 5 6 7 8 9		ID
5.4.1 Yapılacak her iş için kat edilmesi	çok fazla	uygun sayıda	
gereken aşamaların (adım) sayısı	1 2 3 4 5 6 7 8 9		ID
5.4.2 Bir işi bitirmek için takip edilen	asla	her zaman	
adımlar mantıklı bir sırada	1 2 3 4 5 6 7 8 9		ID

Sistemin öğrenimi ile ilgili görüşlerinizi aşağıdaki boş alana yazınız:

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APPENDIX C: Gönüllü Katılım Formu (In Turkish)

Bu çalışma, ODTÜ Bilişim Sistemleri Bölümü Yüksek Lisans öğrencisi Nihan OCAK tarafından Prof. Dr. Kürşat ÇAĞILTAY danışmanlığında, ODTÜ'de yürütülen bir tez çalışmasıdır. Çalışmanın amacı, kullanılabilirlik araştırma yöntemlerinden biri olan bilişsel modelleme yönteminin mobil uygulamalar üzerinde etkinliğini gerçek kullanıcılardan gelen sonuçlarla karşılaştırarak ortaya çıkarmaktır. Çalışmaya katılım tamamen gönüllülük temelinde olmalıdır. Çalışma sırasında, sizden gerçekleştirmenizi istediğimiz görevleri mobil uygulama üzerinde uygularken el hareketleriniz ve sesiniz performans sonuçlarını çıkarmak için kayıt altına alınacaktır. Yapılacak bu son kullanıcı kullanılabilirlik testi ve sonrasında size verilecek olan memnuniyet anketinde sizden kimlik belirleyici hiçbir bilgi istenmemektedir. Ayrıca cevaplarınız tamamen gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecek olup; elde edilecek bilgiler bilimsel yayımlarda kullanılacaktır.

Son kullanıcı kullanılabilirlik testi ve test sonrası uygulanacak memnuniyet anketi genel olarak kişisel rahatsızlık verecek durum, görev ve sorular içermemektedir. Ancak, katılım sırasında ortamdan, görevlerden, sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz çalışmayı yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda çalışma sorumlusuna çalışmayı tamamlamadığınızı söylemek yeterli olacaktır. Çalışma sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz.

Çalışma hakkında daha fazla bilgi almak için Bilişim Sistemleri Bölümü öğrencisi Nihan OCAK (Bilgi İşlem Daire Başkanlığı 109 Nolu Oda (Köprü Kat), ODTÜ, 06800; Tel: 0312 210 33 57 E-posta: nihan@metu.edu.tr) ile iletişim kurabilirsiniz.

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).

İsim Soyad Tarih İmza

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APPENDIX D: Katılım Sonrası Bilgi Formu (In Turkish)

Bu çalışma Enformatik Enstitüsü Bilişim Sistemleri öğrencisi Nihan OCAK tarafından yürütülmekte olan bir tez çalışmasıdır. Bu çalışmada, mobil uygulamalar üzerinde son kullanıcı kullanılabilirlik testi ve bilişsel modelleme yöntemlerinin sonuçları karşılaştırmalı olarak sunularak bu yöntemlerin mobil uygulamalar üzerindeki etkinlikleri incelenecektir.

Son kullanıcı kullanılabilirlik testi, kullanıcılar test edilen ürünü verilen görevler doğrultusunda kullanırken gözlemlenerek veri toplanması yöntemiyle gerçekleştirilmektedir. Bu yöntemle gerçek kullanıcılardan ürünü nasıl kullandıkları ile ilgili direk bilgi almak mümkün olduğundan kullanılabilirlik araştırmalarında kullanılan en basit ve verimli metot olarak görülmektedir. Ancak, son kullanıcılarla test yapmak testi planlamak, görevleri belirlemek, uygun kullanıcıların belirlenerek ayarlanması, kullanıcılarla testin gerçekleştirilmesi, sonuçların analiz edilmesi ve raporlama gibi uzun zaman ve fazla kaynak gerektiren adımları gerektirmektedir. Çalışmada kullanılan diğer metot olan bilişsel modelleme metodu ise son kullanıcı kullanılabilirlik testlerine oranla daha az zaman ve kaynak gerektirmektedir. Bilişsel modelleme, insanların bilişsel süreçlerini anlama ve tahmin etme yaklaşımıdır. İnsan gibi düşünen, davranan, hatalar yapan bir model tasarlamak, test ve tasarım karşılaştırmaları için hız ve bütçe tasarrufu açısından önemli görülmektedir. Bilişsel modelleme yöntemini kullanarak kolay bir şekilde kullanıcı arayüzlerini analiz etmeye yarayan, farklı çalışma prensiplerine sahip birkaç araç geliştirilmiştir. Bu çalışmada kullanılan bu araçlardan biri de Carnegie Mellon Üniversitesi tarafından geliştirilen CogTool uygulamasıdır. Bu çalışmada, katılımcılarla uygulanan görevler aynı uygulama üzerinde CogTool kullanılarak da test edilecek ve mobil bir uygulama üzerinde bilişsel modelleme yönteminin etkinliği gerçek kullanıcı sonuçlarıyla karşılaştırılarak test edilecektir.

Bu çalışmadan alınacak ilk verilerin Aralık 2013 sonunda elde edilmesi amaçlanmaktadır. Elde edilen bilgiler sadece bilimsel araştırma ve yazılarda kullanılacaktır. Çalışmanın sonuçlarını öğrenmek ya da bu araştırma hakkında daha fazla bilgi almak için aşağıdaki isimlere başvurabilirsiniz. Bu araştırmaya katıldığınız için tekrar çok teşekkür ederiz.

Nihan OCAK (ODTÜ BIDB Oda: 109; Tel: 210 3357; E-posta: nihan@metu.edu.tr)

Prof. Dr. Kürşat ÇAĞILTAY (ODTÜ BOTE; Oda: 19; Tel: 210 3683; E-posta: kursat@metu.edu.tr)

APPENDIX E: Tasks (In Turkish)

Görev1: Eve yiyecek bir şeyler almak için alışverişe çıkacaksınız. Lütfen alışverişe çıkmadan önce Turkcel Cüzdan uygulamasını kullanarak yeme içme alanında fırsat olup olmadığını kontrol ediniz.

Görev2: Uygulamadan gördüğünüz üzere yeme içme alanında çok fazla fırsat var fakat siz sadece size yakın süpermarketlerde fırsat olup olmadığını öğrenmek istiyorsunuz. Lütfen yakınınızda bulunan süpermarketlerde fırsat olup olmadığını kontrol ediniz eğer uygun fırsat varsa alınız.

Görev3: Alışveriş yaptınız ve ödeme için bekliyorsunuz. Lütfen aldığınız fırsatı süpermarket alışverişinizde kullanınız.

Görev4: GarantiParam kartınızdaki paranızı bitirdiniz ancak Paracard'ınızda hala paranız var. Paracard'ınızı alışverişlerinizde öncelikli kullanmak için kart önceliklendirme yapmanız gerektiğini biliyorsunuz. Kartlarınız arasından Paracard'ınızı önceliklendiriniz.

Görev5: Turkcell Cüzdan uygulamasını kişiselleştirmek için profil oluşturmak istiyorsunuz bu nedenle var olan bir fotoğrafınızı Turkcell Cüzdan uygulamasına ekleyiniz.

Görev6: Anneniz kontörü bittiğini ve arama yapamadığını söyledi. Annenizin telefonuna 10 TL kontör yükleyiniz.

Görev7: Arkadaşınız acil paraya ihtiyacı olduğunu söyledi. Arkadaşınızın telefon numarasına 10 TL para yollayınız.

Görev8: Hangi işlem için hangi kartınızı kullandığınız konusunda kafanız karıştı. Lütfen Paracard'ınızla yapılan son işlem bilgilerini kontrol ediniz.

APPENDIX F: CogTool Predictions

TASK 1:

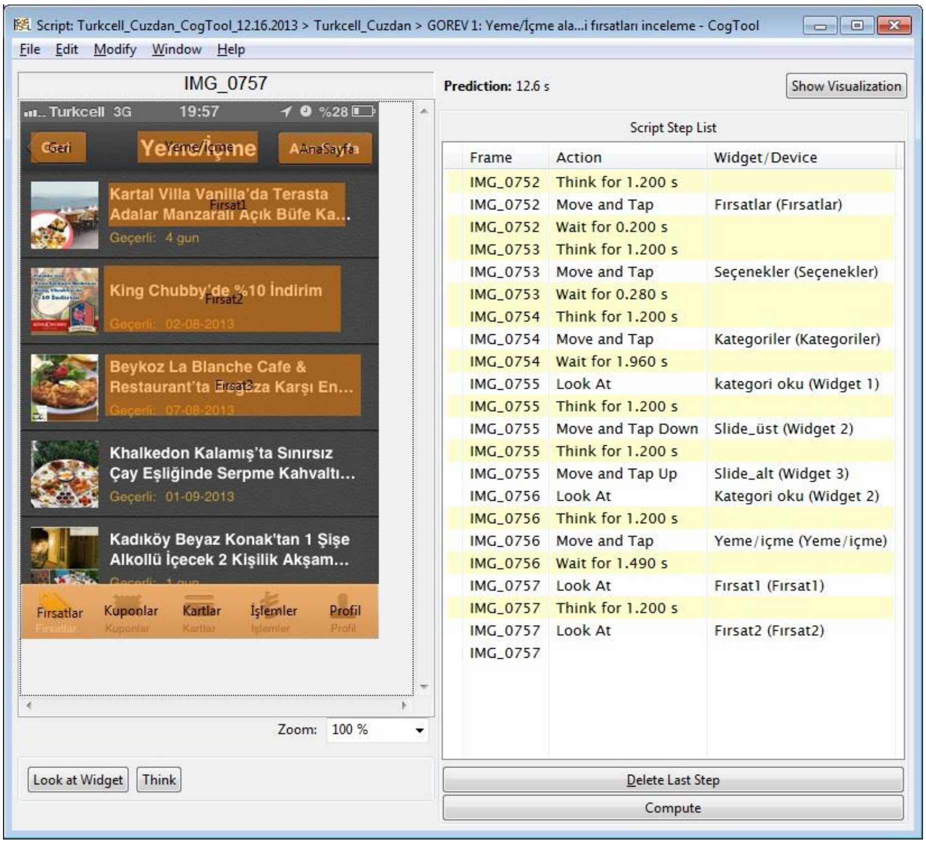

Figure F. 1 - Task1 Script Window

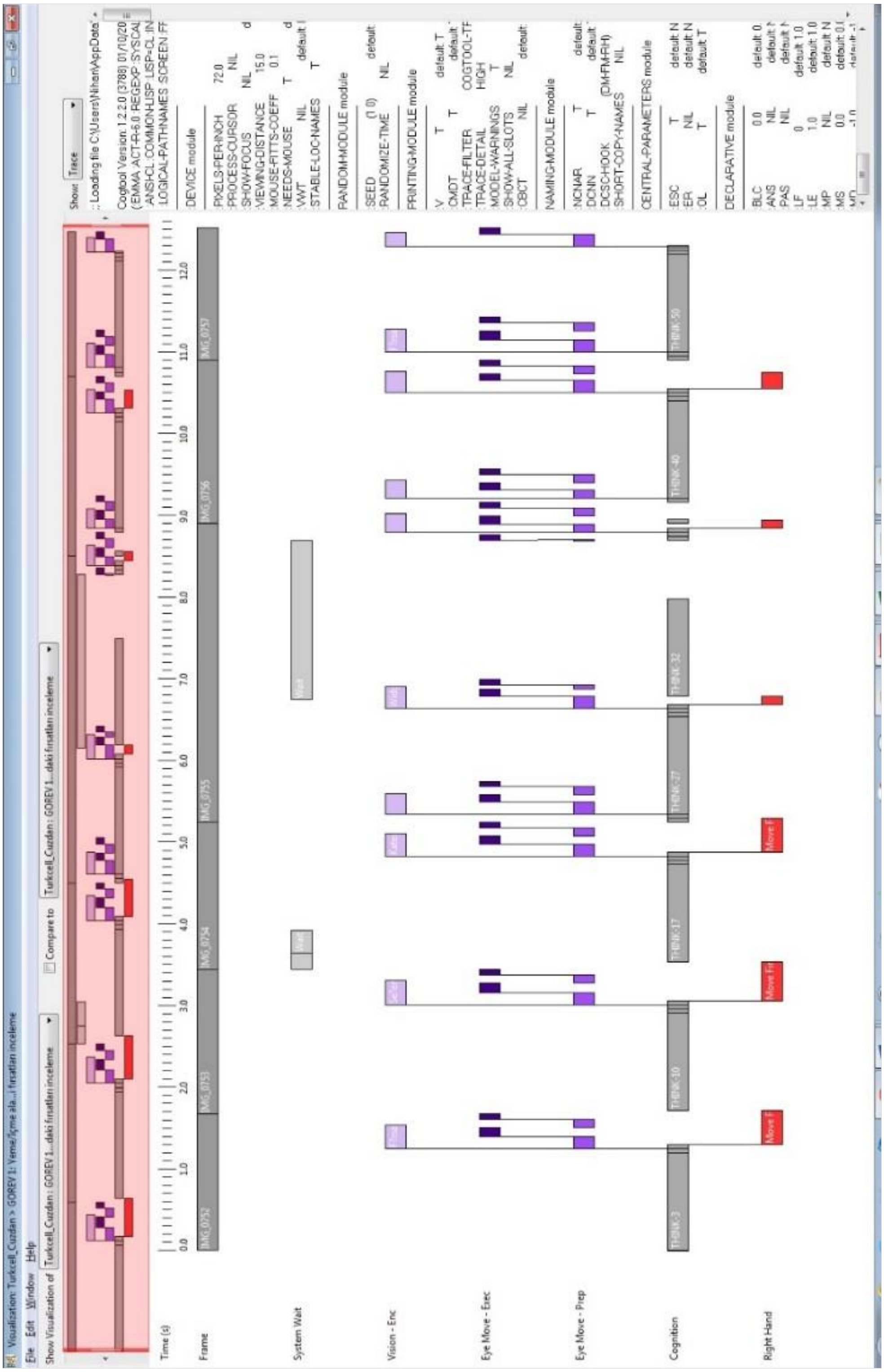

Figure F. 2 - Task1 Visualization Window

TASK 2:

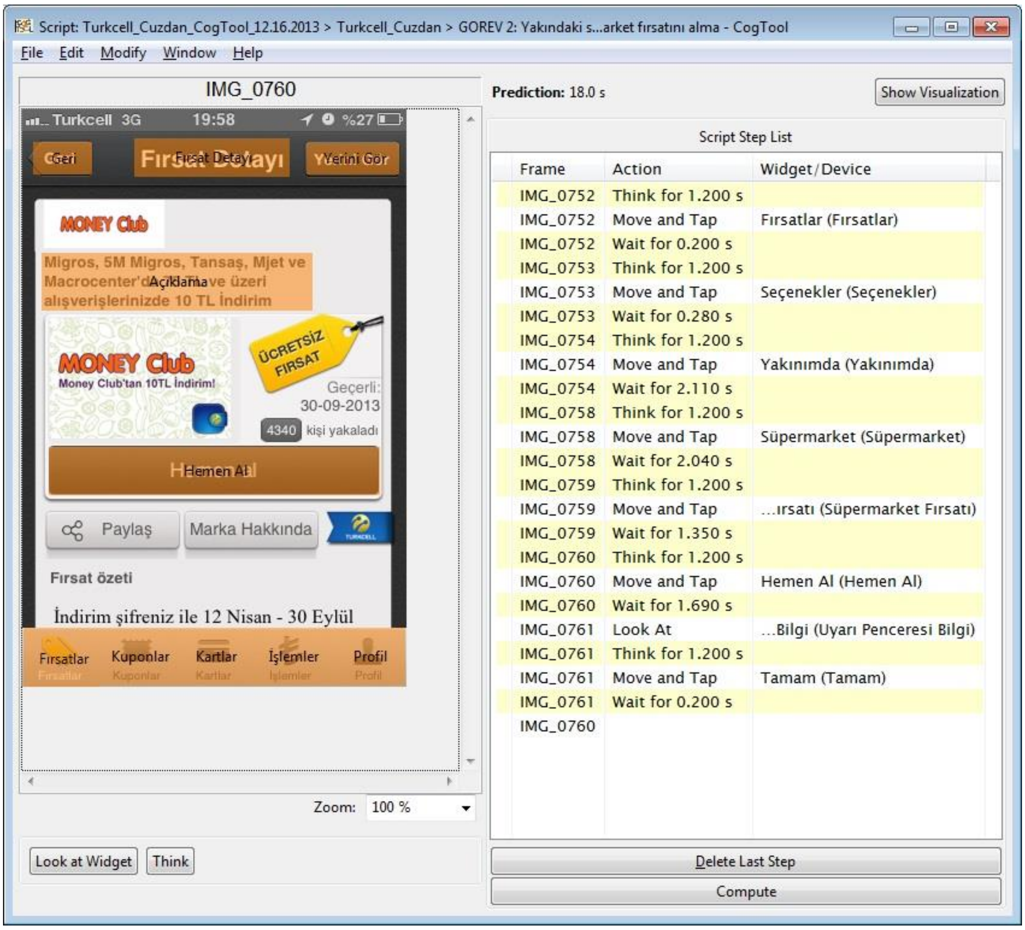

Figure F. 3 - Task2 Script Window

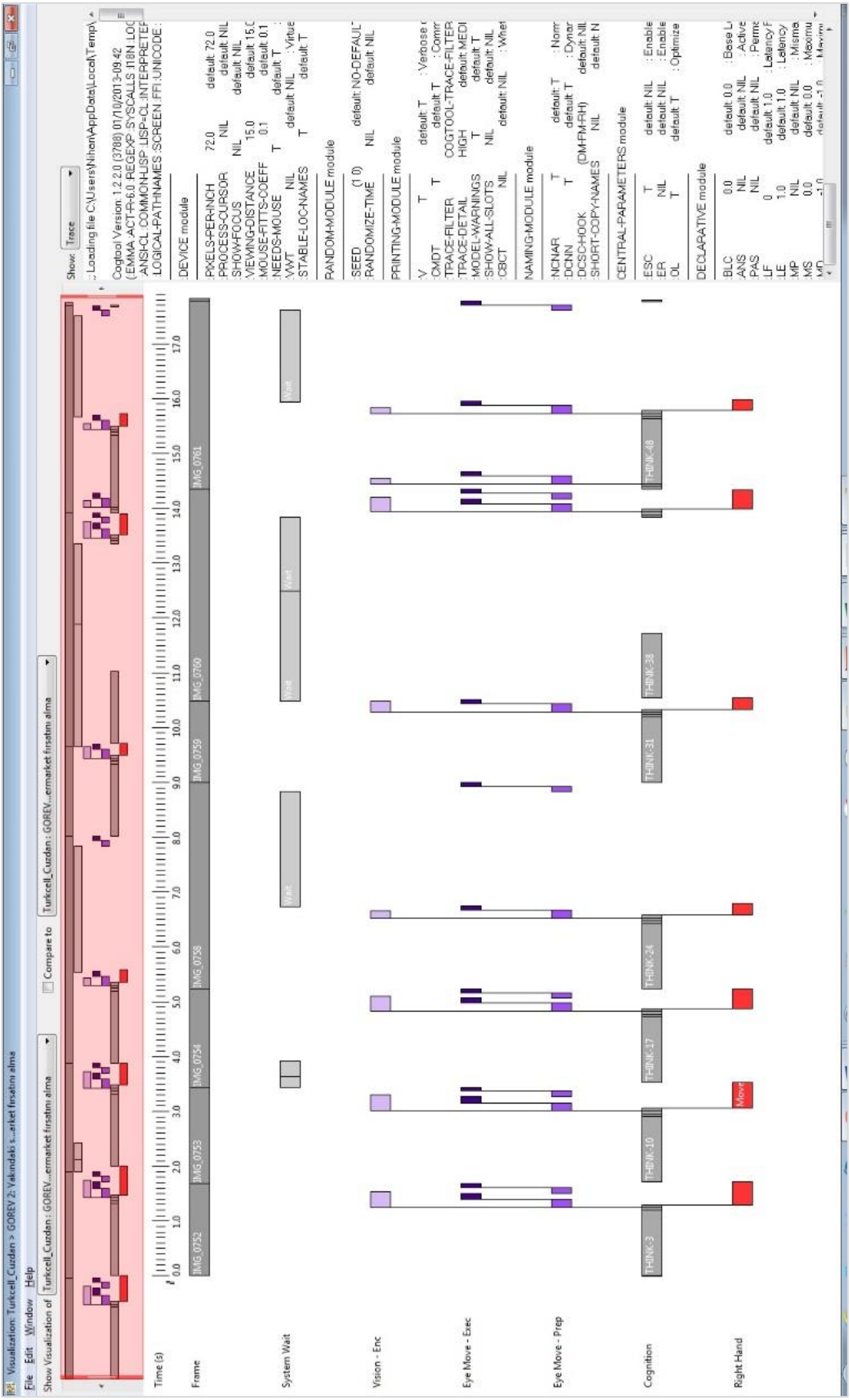

Figure F. 4 - Task2 Visualization Window

TASK 3:

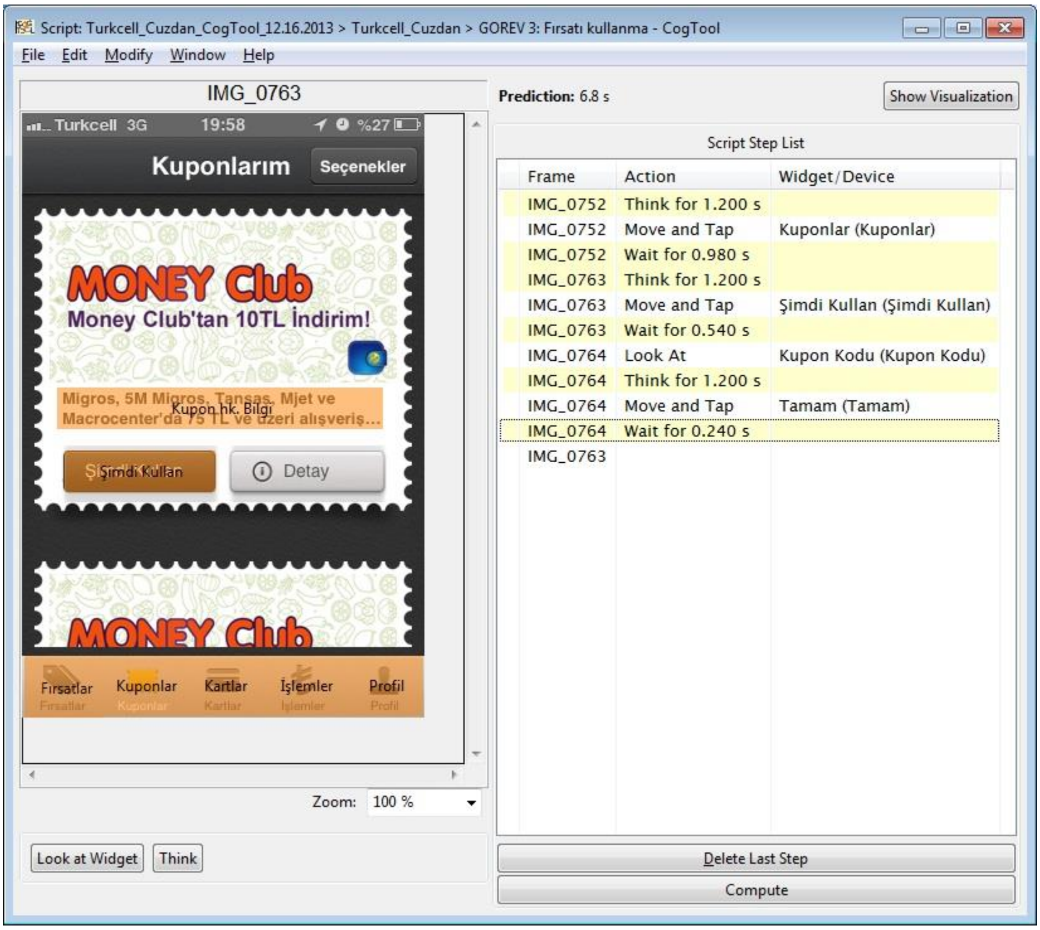

Figure F. 5 - Task3 Script Window

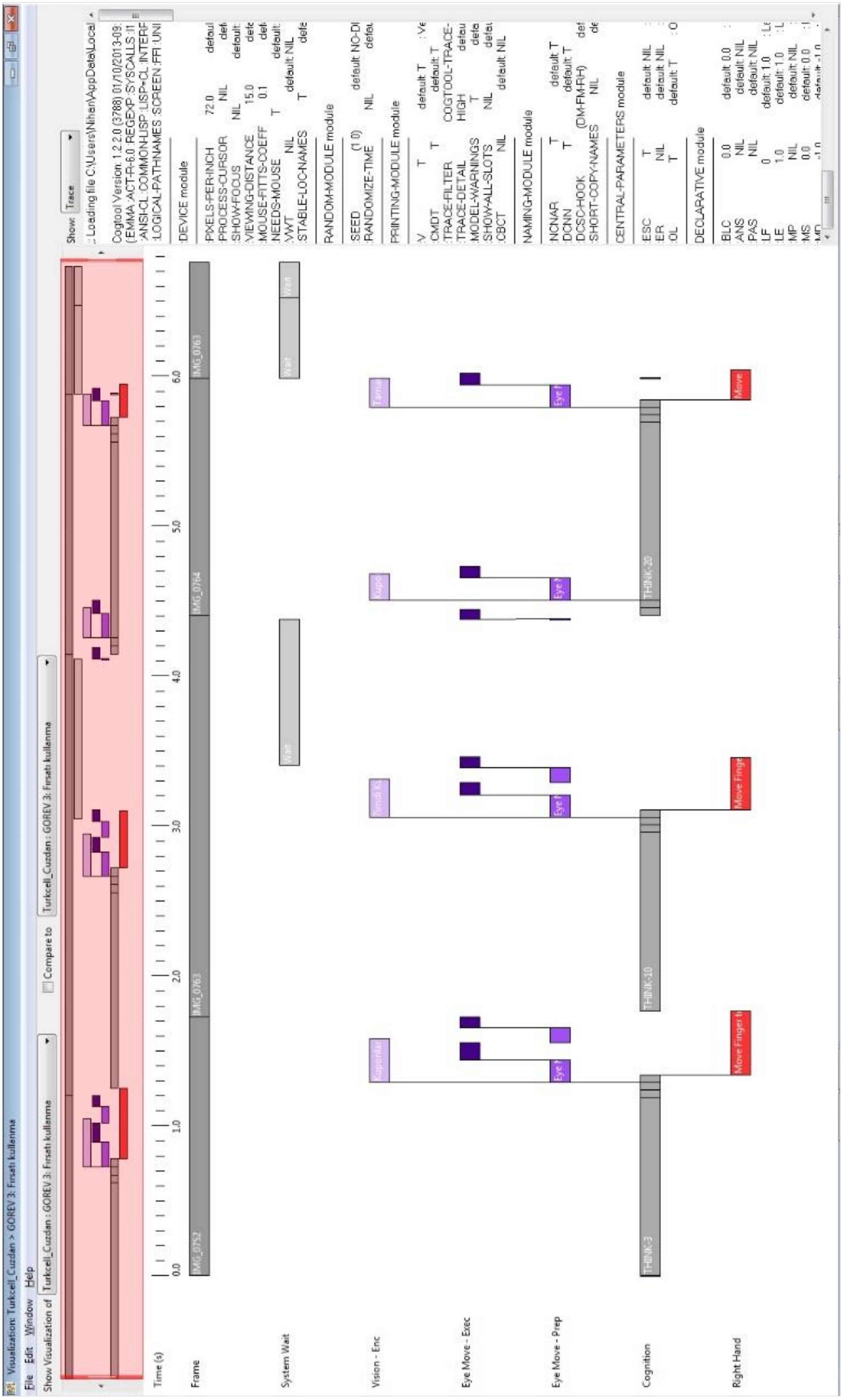

Figure F. 6 - Task3 Visualization Window

TASK 4:

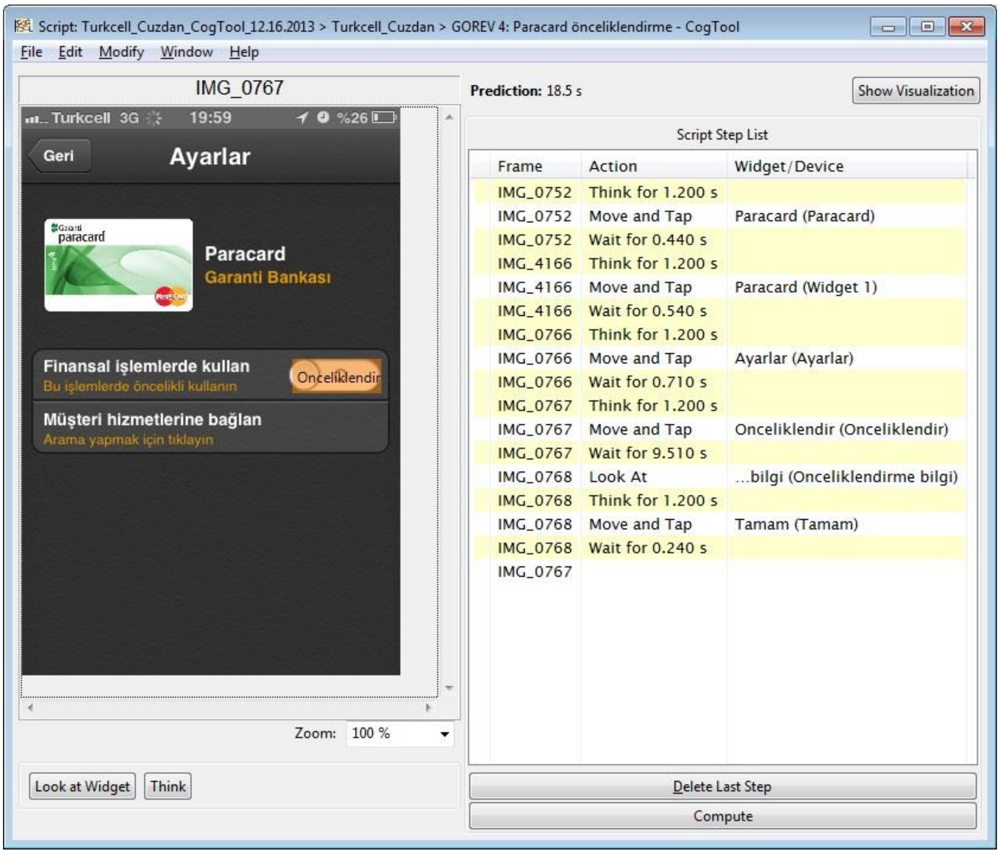

Figure F. 7 - Task4 Script Window

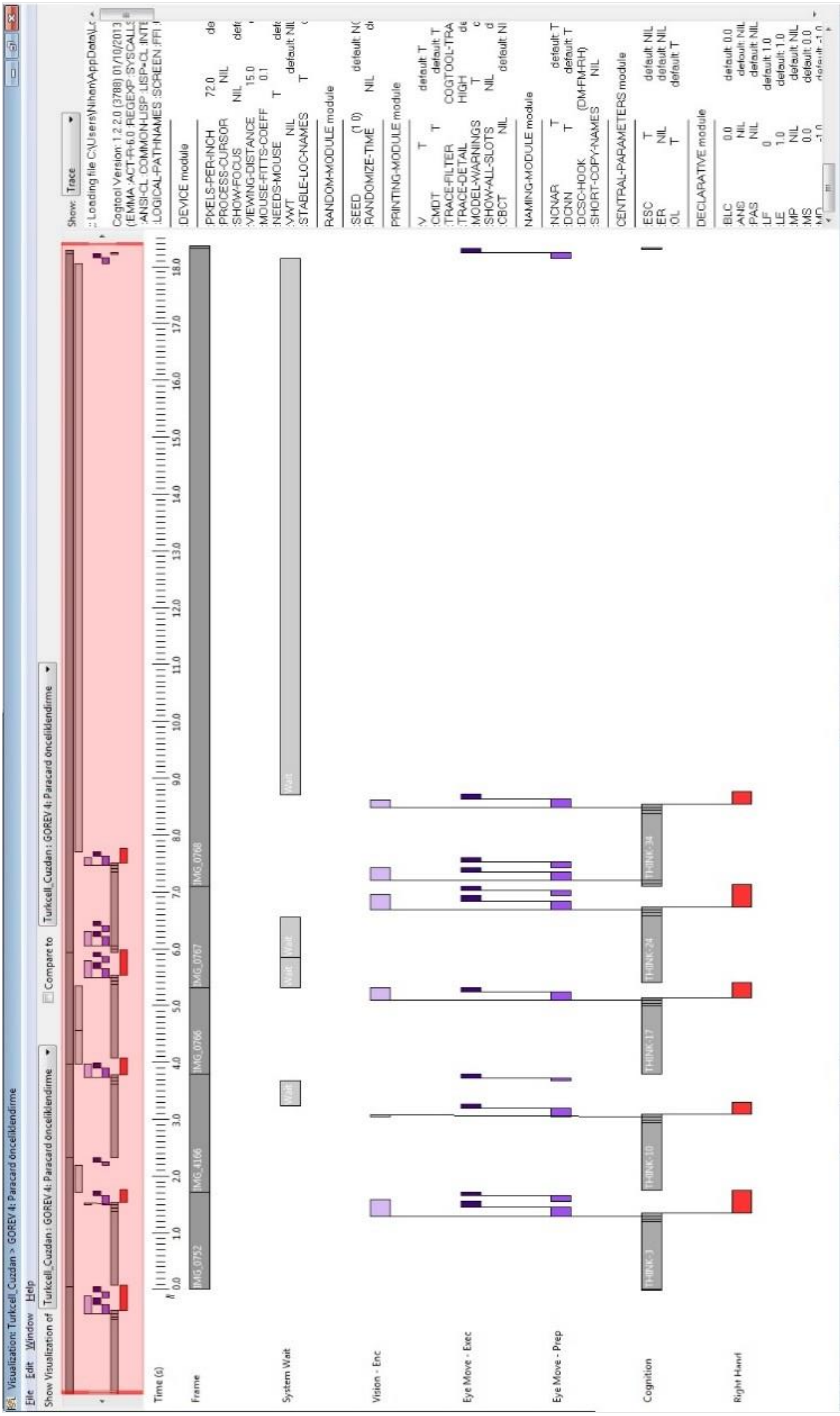

Figure F. 8 - Task4 Visualization Window

TASK 5:

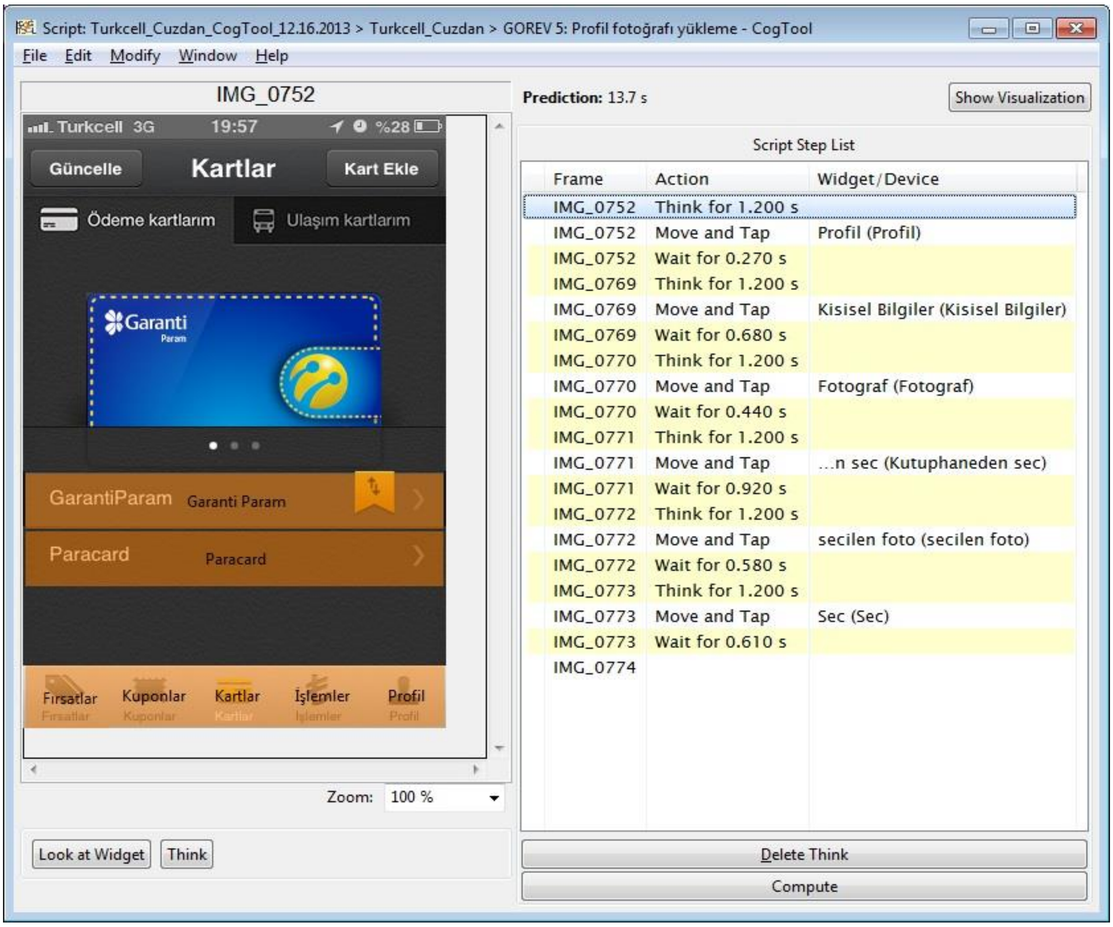

Figure F. 9 - Task5 Script Window

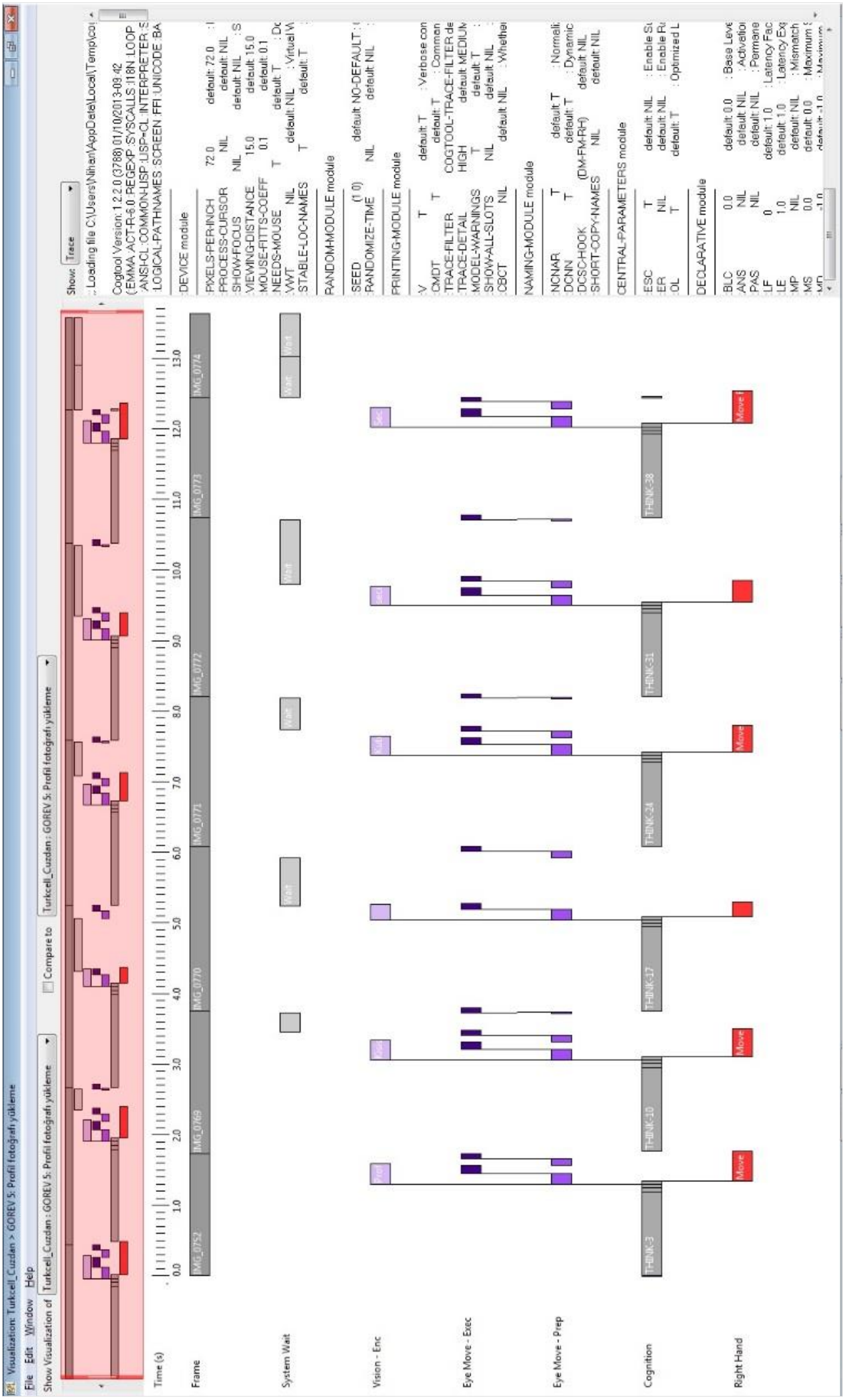

Figure F. 10 - Task5 Visualization Window

TASK 6:

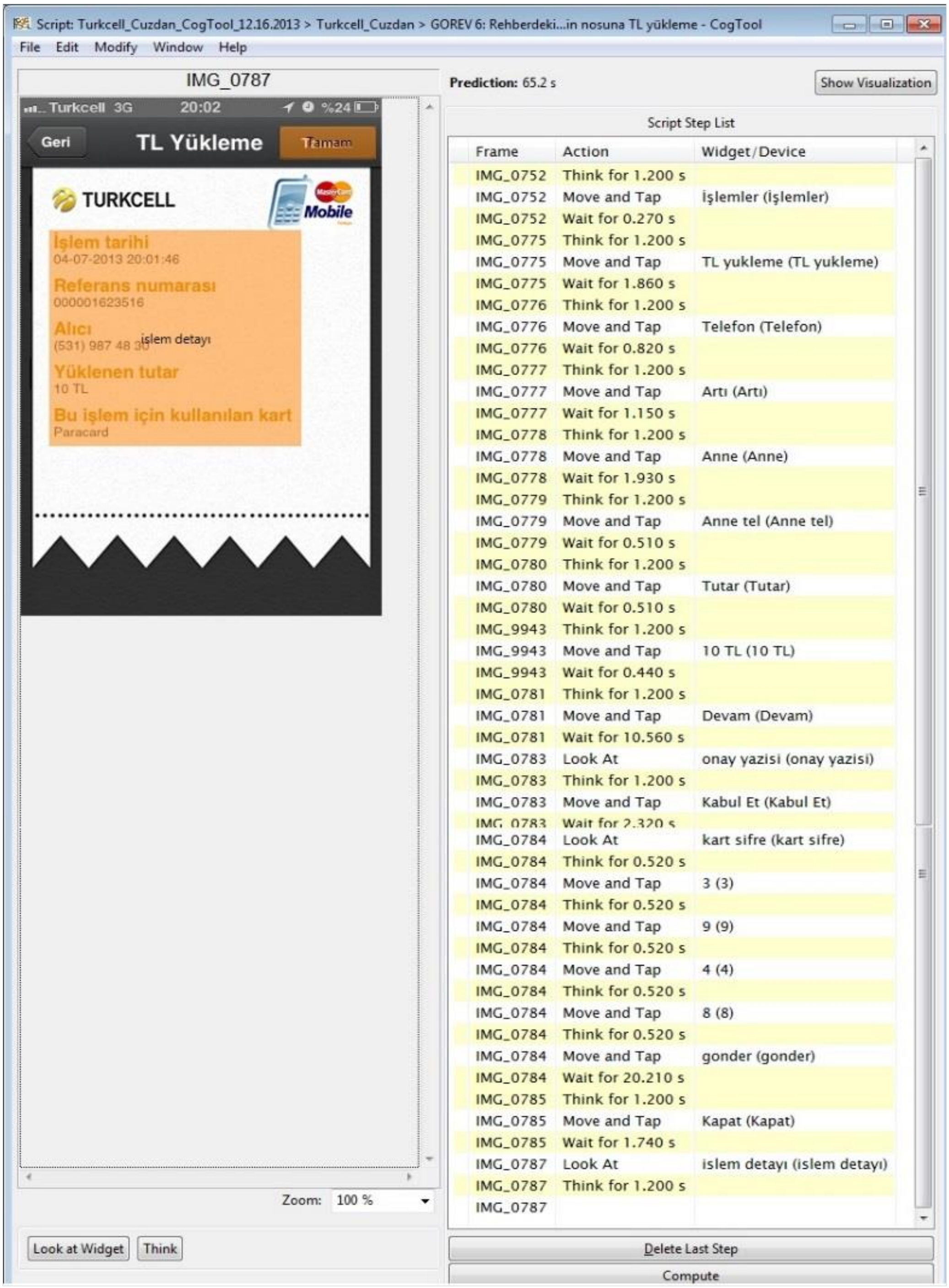

Figure F. 11 - Task6 Script Window

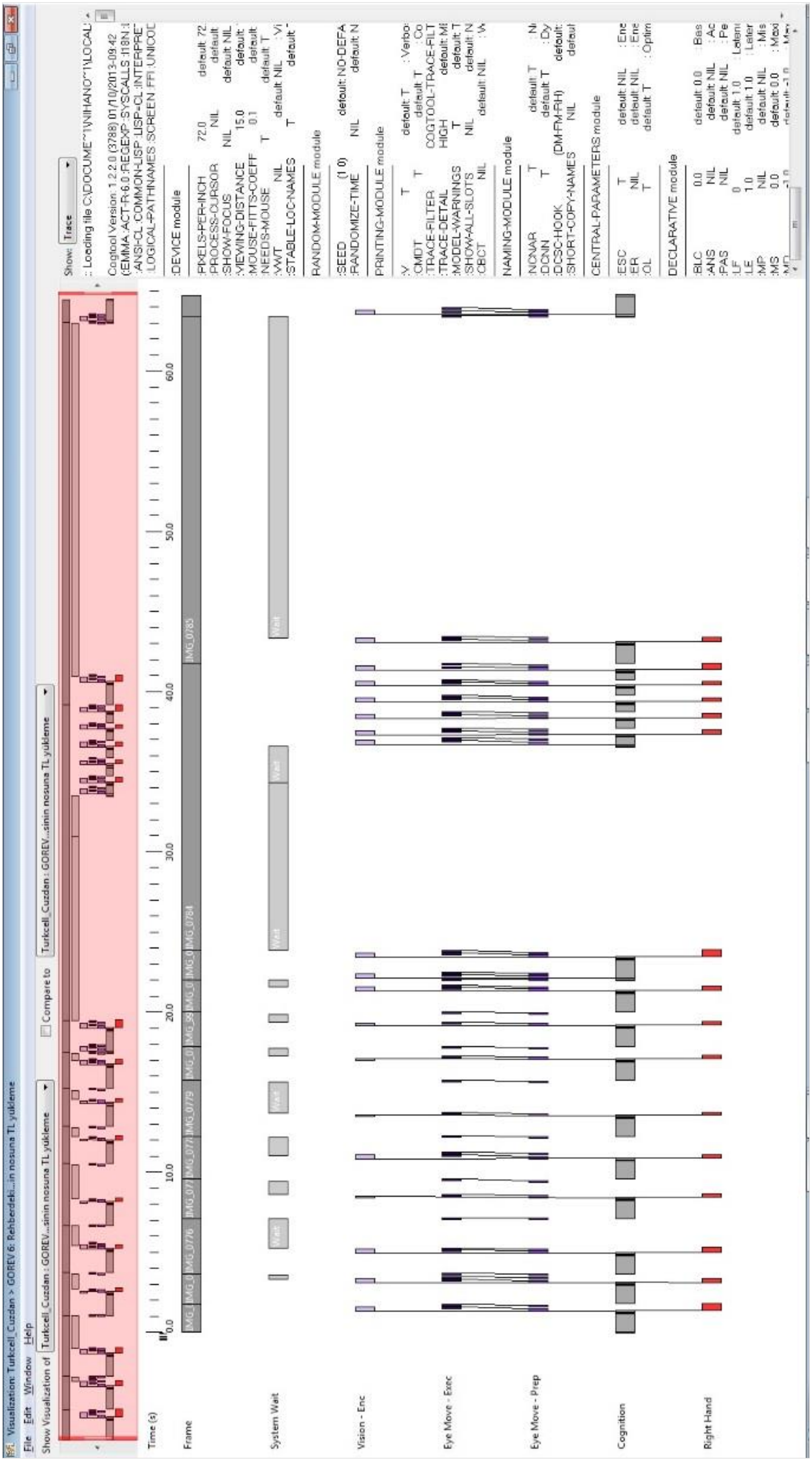

Figure F. 12 - Task6 Visualization Window

TASK 7:

Figure F. 13 - Task7 Script Window

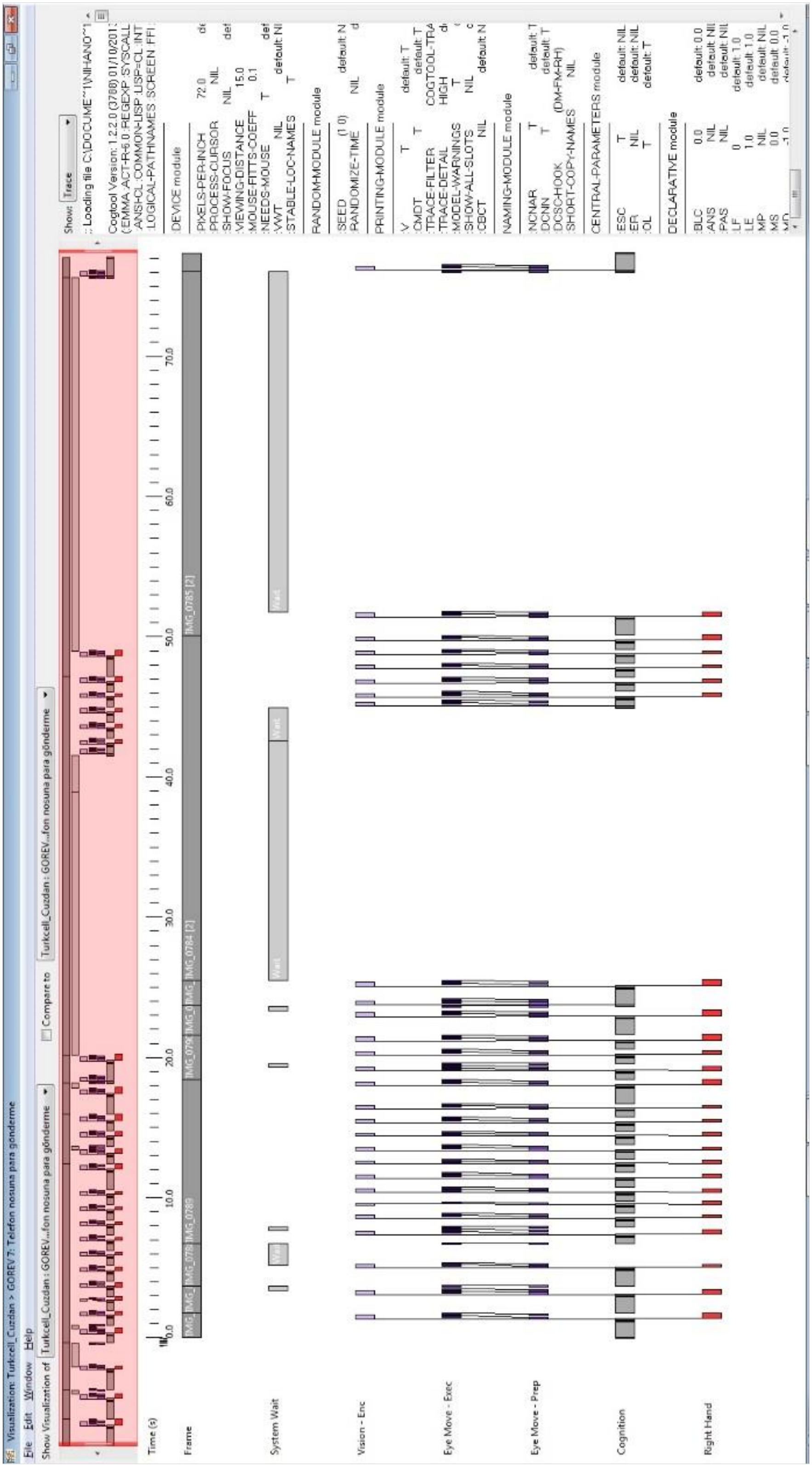

Figure F. 14 - Task7 Visualization Window

TASK 8:

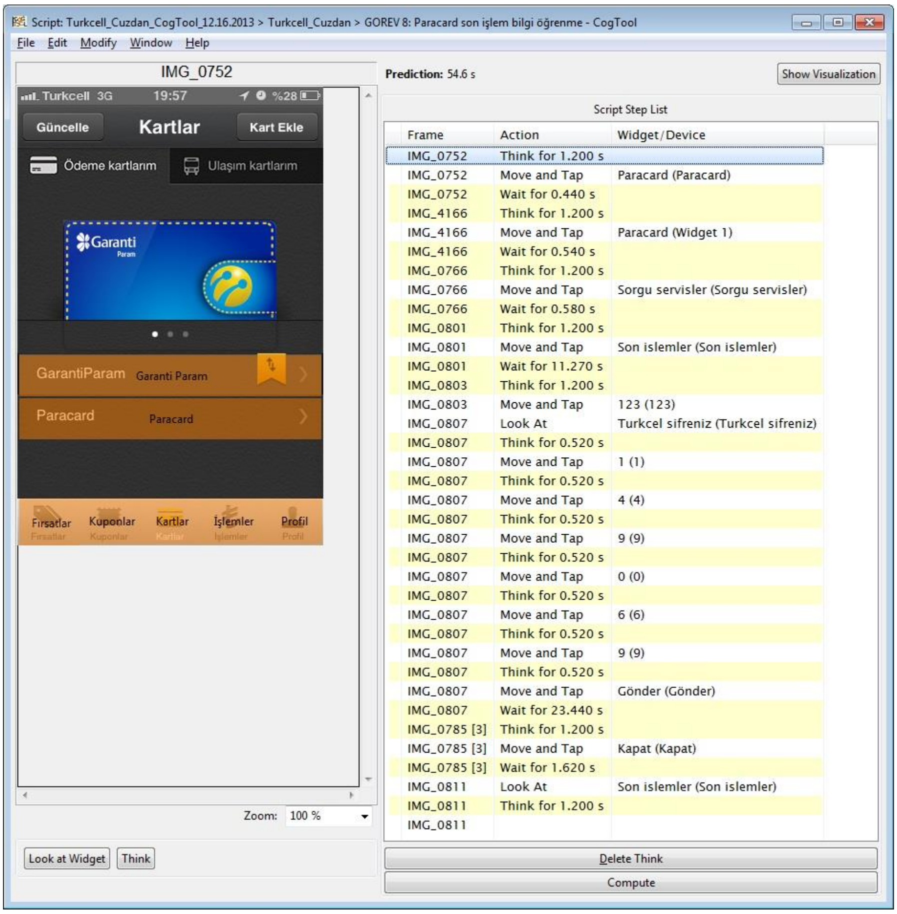

Figure F. 15 - Task8 Script Window

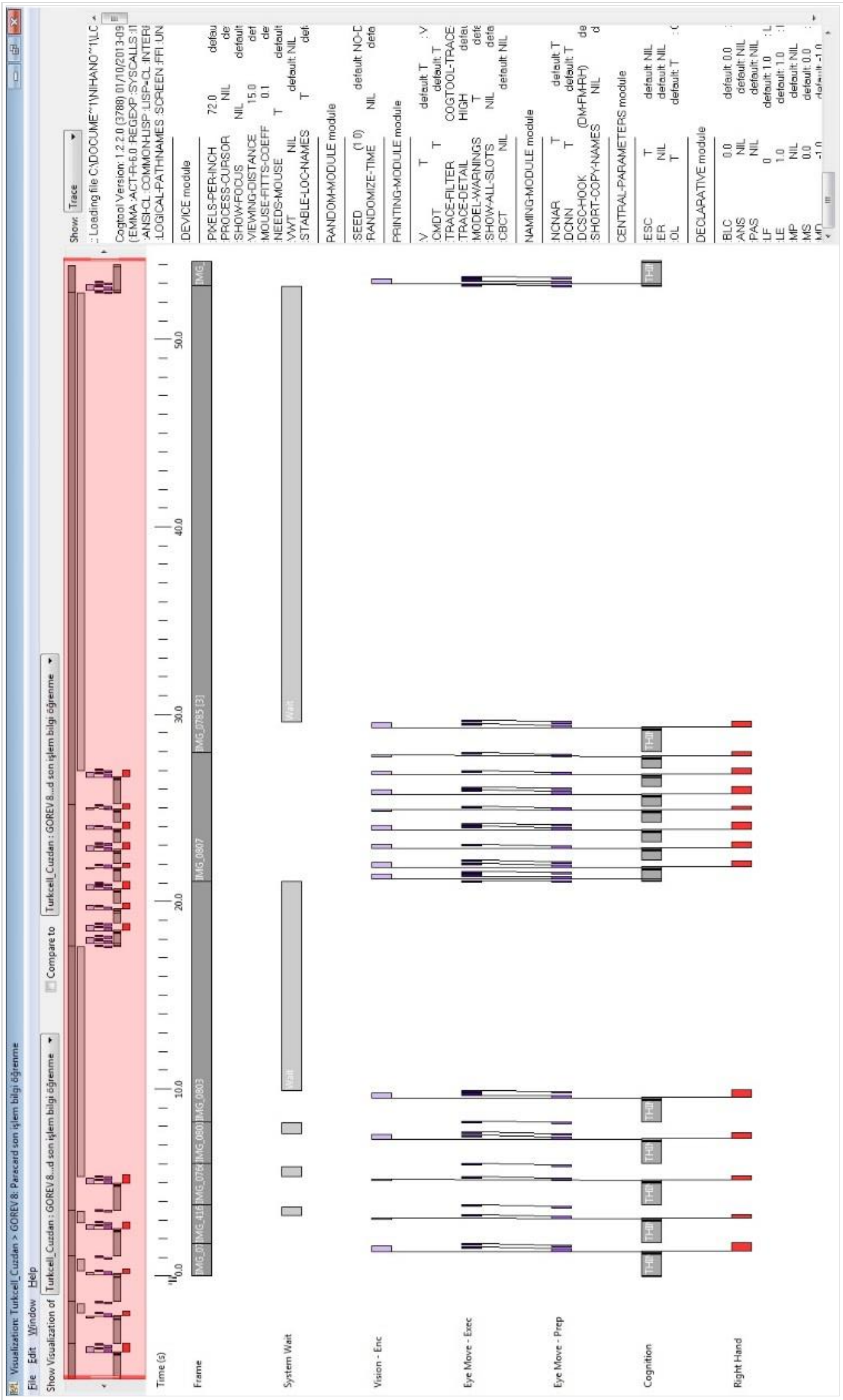

Figure F. 16 - Task8 Visualization Window

APPENDIX G: Detailed User Test Data

TASK 1:

Table G. 1 - User test results for task 1

Tasks	**Task 1**											
Users	**P 01**			**P 02**			**P 03**			**P 04**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	00:01.49	00:02.14	00:00.65	00:26.68	00:27.43	00:00.75	00:13.83	00:14.58	00:00.75	00:05.20	00:07.22	00:02.02
Step 2	00:02.41	00:03.22	00:00.81	00:27.93	00:30.78	00:02.85	00:15.12	00:16.88	00:01.76	00:07.66	00:08.75	00:01.09
Step 3	00:03.70	00:05.02	00:01.32	00:31.22	00:32.51	00:01.29	00:17.36	00:18.20	00:00.84	00:09.22	00:10.31	00:01.09
Step 4	00:06.98	00:08.98	00:02.00	00:33.46	00:35.02	00:01.56	00:20.75	00:22.48	00:01.73	00:11.19	00:12.34	00:01.15
Step 5	00:09.05	00:09.73	00:00.68	00:35.05	00:35.80	00:00.75	00:22.81	00:23.32	00:00.51	00:12.54	00:12.78	00:00.24
Step 6	00:11.46	00:12.78	00:01.32	00:37.36	00:39.02	00:01.66	00:25.29	00:27.53	00:02.24	00:15.09	00:18.00	00:02.91

Tasks	**Task 1**											
Users	**P 05**			**P 06**			**P 07**			**P 08**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	00:07.83	00:09.53	00:01.70	00:09.22	00:10.14	00:00.92	00:06.27	00:07.12	00:00.85	00:04.71	00:06.85	00:02.14
Step 2	00:09.80	00:11.46	00:01.66	00:10.37	00:12.44	00:02.07	00:07.63	00:09.15	00:01.52	00:07.12	00:08.61	00:01.49
Step 3	00:11.93	00:12.64	00:00.71	00:12.88	00:13.90	00:01.02	00:09.93	00:10.78	00:00.85	00:09.19	00:09.97	00:00.78
Step 4	00:13.42	00:14.17	00:00.75	00:14.85	00:15.71	00:00.86	00:11.90	00:13.12	00:01.22	00:10.68	00:11.73	00:01.05
Step 5	00:14.41	00:14.85	00:00.44	00:26.17	00:26.98	00:00.81	00:13.22	00:13.93	00:00.71	00:11.66	00:12.51	00:00.85
Step 6	00:17.09	00:18.24	00:01.15	00:28.51	00:30.58	00:02.07	00:15.76	00:18.41	00:02.65	00:14.24	00:16.41	00:02.17

Tasks	Task 1					
Users	P 09			P 10		
	Start	Finish	Time	Start	Finish	Time
Step 1	00:14.85	00:16.51	00:01.66	00:44.14	00:46.55	00:02.41
Step 2	00:16.85	00:20.07	00:03.22	00:46.82	00:48.34	00:01.52
Step 3	00:20.48	00:21.80	00:01.32	00:48.82	00:49.56	00:00.74
Step 4	00:22.61	00:23.26	00:00.65	00:50.34	00:51.12	00:00.78
Step 5	00:23.32	00:23.87	00:00.55	00:51.19	00:51.90	00:00.71
Step 6	00:26.14	00:26.58	00:00.44	00:54.10	00:56.61	00:02.51

TASK 2:

Table G. 2 - User test results for task 2

Tasks	Task 2											
Users	P 01			P 02			P 03			P 04		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	00:29.76	00:30.61	00:00.85	00:55.39	00:57.02	00:01.63	00:46.71	00:47.29	00:00.58	00:29.73	00:31.46	00:01.73
Step 2	00:30.85	00:31.63	00:00.78	00:57.70	00:58.31	00:00.61	00:47.70	00:48.92	00:01.22	00:31.66	00:33.02	00:01.36
Step 3	00:32.10	00:33.49	00:01.39	00:58.72	00:59.09	00:00.37	00:49.46	00:50.38	00:00.92	00:33.43	00:34.92	00:01.49
Step 4	00:35.53	00:36.44	00:00.91	00:59.63	01:00.21	00:00.58	00:53.29	00:54.38	00:01.09	00:35.66	00:36.75	00:01.09
Step 5	00:38.48	00:39.26	00:00.78	01:03.12	01:03.87	00:00.75	00:55.87	00:56.61	00:00.74	00:38.38	00:40.54	00:02.16
Step 6	00:40.58	00:41.39	00:00.81	01:04.89	01:05.87	00:00.98	00:57.87	00:58.65	00:00.78	00:42.34	00:43.09	00:00.75
Step 7	00:43.22	00:44.21	00:00.99	01:07.53	01:08.21	00:00.68	01:00.20	01:01.57	00:01.37	00:44.26	00:45.15	00:00.89

Tasks	Task 2											
Users	**P 05**			**P 06**			**P 07**			**P 08**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	00:02.00	00:03.76	00:01.76	07:57.16	07:58.72	00:01.56	00:30.41	00:31.29	00:00.88	00:36.51	00:38.75	00:02.24
Step 2	00:09.56	00:11.70	00:02.14	07:59.30	08:00.21	00:00.91	00:31.56	00:32.48	00:00.92	00:39.09	00:39.90	00:00.81
Step 3	00:12.14	00:12.98	00:00.84	08:01.89	08:03.08	00:01.19	00:32.92	00:33.80	00:00.88	00:40.34	00:41.02	00:00.68
Step 4	00:13.83	00:15.42	00:01.59	08:06.98	08:08.37	00:01.39	00:34.58	00:35.19	00:00.61	00:41.93	00:43.09	00:01.16
Step 5	00:17.76	00:18.65	00:00.89	08:09.76	08:12.43	00:02.67	00:37.22	00:38.21	00:00.99	00:45.26	00:46.24	00:00.98
Step 6	00:19.87	00:21.09	00:01.22	08:12.68	08:13.49	00:00.81	00:40.00	00:40.85	00:00.85	00:47.29	00:48.51	00:01.22
Step 7	00:22.75	00:23.87	00:01.12	08:14.18	08:15.09	00:00.91	00:42.48	00:44.44	00:01.96	00:50.41	00:51.60	00:01.19

Tasks	Task 2					
Users	**P 09**			**P 10**		
	Start	Finish	Time	Start	Finish	Time
Step 1	00:38.54	00:40.95	00:02.41	01:03.73	01:05.66	00:01.93
Step 2	00:41.26	00:42.07	00:00.81	01:05.94	01:07.43	00:01.49
Step 3	00:42.48	00:43.22	00:00.74	01:07.83	01:08.61	00:00.78
Step 4	00:44.00	00:44.51	00:00.51	01:09.36	01:09.90	00:00.54
Step 5	00:46.58	00:47.43	00:00.85	01:12.14	01:13.02	00:00.88
Step 6	00:48.31	00:49.19	00:00.88	01:13.87	01:18.61	00:04.74
Step 7	00:50.99	00:52.71	00:01.72	01:22.34	01:23.39	00:01.05

TASK 3:

Table G. 3 - User test results for task 3

Tasks	Task 3											
Users	**P 01**			**P 02**			**P 03**			**P 04**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	00:55.60	00:56.27	00:00.67	01:15.39	01:16.75	00:01.36	01:12.82	01:14.34	00:01.52	00:53.70	00:58.75	00:05.05
Step 2	00:57.29	00:59.07	00:01.78	01:17.12	01:18.21	00:01.09	01:15.12	01:16.92	00:01.80	00:59.66	01:01.97	00:02.31
Step 3	01:01.83	01:02.58	00:00.75	01:18.72	01:19.77	00:01.05	01:17.46	01:20.11	00:02.65	01:02.58	01:04.51	00:01.93

Tasks	Task 3											
Users	**P 05**			**P 06**			**P 07**			**P 08**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	00:29.56	00:31.22	00:01.66	01:07.16	01:09.53	00:02.37	00:55.29	00:56.10	00:00.81	01:01.05	01:02.55	00:01.50
Step 2	00:31.97	00:33.49	00:01.52	01:10.28	01:12.17	00:01.89	00:57.02	00:58.68	00:01.66	01:03.29	01:05.22	00:01.93
Step 3	00:34.00	00:35.63	00:01.63	01:12.72	01:16.48	00:03.76	00:59.33	01:00.88	00:01.55	01:05.87	01:06.55	00:00.68

Tasks	Task 3					
Users	**P 09**			**P 10**		
	Start	Finish	Time	Start	Finish	Time
Step 1	01:02.55	01:03.60	00:01.05	01:32.78	01:33.77	00:00.99
Step 2	01:04.51	01:06.41	00:01.90	01:34.65	01:36.40	00:01.75
Step 3	01:06.92	01:08.68	00:01.76	01:39.84	01:41.46	00:01.62

TASK 4:

Table G. 4 - User test results for task 4

Tasks	**Task 4**											
Users	**P 01**			**P 02**			**P 03**			**P 04**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	01:13.43	01:15.77	00:02.34	02:06.19	02:09.20	00:03.01	01:27.11	01:29.63	00:02.52	01:13.55	01:16.31	00:02.76
Step 2	01:16.00	01:17.16	00:01.16	02:10.24	02:16.21	00:05.97	01:30.45	01:30.99	00:00.54	01:17.26	01:17.50	00:00.24
Step 3	01:17.73	01:18.65	00:00.92	02:16.75	02:18.45	00:01.70	01:31.56	01:32.45	00:00.89	01:18.04	01:18.92	00:00.88
Step 4	01:19.36	01:20.58	00:01.22	02:19.19	02:20.04	00:00.85	01:33.16	01:34.55	00:01.39	01:19.60	01:20.68	00:01.08
Step 5	01:30.48	01:31.40	00:00.92	02:23.60	02:24.92	00:01.32	01:42.11	01:43.26	00:01.15	01:30.41	01:31.43	00:01.02

Tasks	**Task 4**											
Users	**P 05**			**P 06**			**P 07**			**P 08**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	00:40.48	00:42.85	00:02.37	01:23.18	01:26.00	02:02.82	01:07.97	01:10.01	00:02.04	01:20.11	01:22.17	00:02.06
Step 2	00:42.85	00:43.97	00:01.12	01:26.89	01:27.80	00:00.91	01:11.63	01:13.12	00:01.49	01:22.55	01:23.26	00:00.71
Step 3	00:44.51	00:45.60	00:01.09	01:28.34	01:32.01	00:03.67	01:13.73	01:15.22	00:01.49	01:23.87	01:25.94	00:02.07
Step 4	00:46.24	00:47.12	00:00.88	01:32.78	01:33.80	00:01.02	01:15.97	01:16.82	00:00.85	01:26.55	01:27.56	00:01.01
Step 5	00:56.04	00:56.78	00:00.74	01:41.04	01:42.23	00:01.19	01:25.33	01:26.17	00:00.84	01:35.97	01:37.09	00:01.12

Tasks	Task 4					
Users	P 09			P 10		
	Start	Finish	Time	Start	Finish	Time
Step 1	01:11.64	01:14.02	00:02.38	01:48.72	01:49.80	00:01.08
Step 2	01:16.45	01:18.00	00:01.55	01:50.65	01:51.36	00:00.71
Step 3	01:18.58	01:19.77	00:01.19	01:56.38	01:56.82	00:00.44
Step 4	01:20.41	01:21.29	00:00.88	01:57.50	01:58.55	00:01.05
Step 5	01:29.97	01:30.55	00:00.58	02:06.58	02:07.46	00:00.88

TASK 5:

Table G. 5 - User test results for task 5

Tasks	Task 5											
Users	P 01			P 02			P 03			P 04		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	01:40.58	01:41.16	00:00.58	02:38.99	02:39.53	00:00.54	01:54.96	01:55.63	00:00.67	01:40.72	01:42.14	00:01.42
Step 2	01:41.46	01:42.04	00:00.58	02:39.74	02:40.65	00:00.91	01:55.94	01:58.85	00:02.91	01:42.34	01:43.50	00:01.16
Step 3	01:42.85	01:43.33	00:00.48	02:42.89	02:43.87	00:00.98	02:01.09	02:01.80	00:00.71	01:47.53	01:48.28	00:00.75
Step 4	01:43.84	01:44.45	00:00.61	02:44.25	02:45.09	00:00.84	02:02.24	02:03.30	00:01.06	01:48.72	01:49.43	00:00.71
Step 5	01:53.23	01:54.51	00:01.28	02:45.98	02:46.65	00:00.67	02:04.96	02:06.28	00:01.32	01:50.41	01:51.29	00:00.88
Step 6	01:55.13	01:55.94	00:00.81	02:47.40	02:47.91	00:00.51	02:06.96	02:07.80	00:00.84	01:51.94	01:52.85	00:00.91

Tasks	Task 5											
Users	P 05			P 06			P 07			P 08		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	01:04.82	01:05.73	00:00.91	01:51.94	01:53.40	00:01.46	01:35.43	01:36.14	00:00.71	01:43.87	01:45.02	00:01.15
Step 2	01:05.97	01:06.99	00:01.02	01:53.60	01:54.75	00:01.15	01:36.45	01:37.53	00:01.08	01:45.23	01:46.11	00:00.88
Step 3	01:09.43	01:10.14	00:00.71	01:55.50	01:56.38	00:00.88	01:40.24	01:41.12	00:00.88	01:47.36	01:48.07	00:00.71
Step 4	01:10.58	01:11.87	00:01.29	01:57.26	01:58.75	00:01.49	01:49.40	01:49.90	00:00.50	01:53.94	01:54.58	00:00.64
Step 5	01:12.58	01:13.39	00:00.81	01:59.60	02:01.36	00:01.76	01:51.53	01:52.01	00:00.48	01:55.46	01:56.31	00:00.85
Step 6	01:14.04	01:15.09	00:01.05	02:01.97	02:02.96	00:00.99	01:52.72	01:53.33	00:00.61	01:56.99	01:57.46	00:00.47

Tasks	Task 5					
Users	P 09			P 10		
	Start	Finish	Time	Start	Finish	Time
Step 1	01:42.38	01:43.80	00:01.42	02:16.28	02:17.74	00:01.46
Step 2	01:44.04	01:44.85	00:00.81	02:17.94	02:19.57	00:01.63
Step 3	01:45.70	01:46.62	00:00.92	02:20.35	02:21.67	00:01.32
Step 4	01:47.53	01:48.79	00:01.26	02:22.69	02:24.01	00:01.32
Step 5	01:49.70	01:50.41	00:00.71	02:24.99	02:26.42	00:01.43
Step 6	01:51.12	01:51.90	00:00.78	02:27.06	02:28.21	00:01.15

TASK 6:

Table G. 6 - User test results for task 6

Tasks	**Task 6**											
Users	**P 01**			**P 02**			**P 03**			**P 04**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	02:05.36	02:06.69	00:01.33	02:53.84	02:59.06	00:05.22	02:23.70	02:24.38	00:00.68	02:01.80	02:02.85	00:01.05
Step 2	02:06.96	02:09.63	00:02.67	02:59.54	03:00.48	00:00.94	02:24.65	02:28.96	00:04.31	02:03.16	02:04.89	00:01.73
Step 3	02:11.57	02:12.96	00:01.39	03:20.82	03:21.77	00:00.95	02:30.82	02:32.14	00:01.32	02:06.65	02:07.33	00:00.68
Step 4	02:14.18	02:15.67	00:01.49	03:22.38	03:28.86	00:06.48	02:32.96	02:33.26	00:00.30	02:08.62	02:08.96	00:00.34
Step 5	02:16.82	02:17.40	00:00.58	03:29.88	03:31.44	00:01.56	02:34.35	02:34.86	00:00.51	02:10.04	02:10.75	00:00.71
Step 6	02:19.40	02:20.18	00:00.78	03:32.52	03:33.54	00:01.02	02:36.28	02:37.13	00:00.85	02:12.11	02:13.67	00:01.56
Step 7	02:20.72	02:21.57	00:00.85	03:34.15	03:35.20	00:01.05	02:37.70	02:38.52	00:00.82	02:14.21	02:15.23	00:01.02
Step 8	02:22.18	02:22.75	00:00.57	03:35.81	03:36.42	00:00.61	02:39.20	02:39.74	00:00.54	02:15.80	02:16.52	00:00.72
Step 9	02:23.19	02:25.74	00:02.55	03:36.93	03:37.54	00:00.61	02:40.28	02:42.79	00:02.51	02:17.09	02:18.52	00:01.43
Step 10	02:36.18	02:37.33	00:01.15	03:48.18	03:49.88	00:01.70	02:52.59	02:53.64	00:01.05	02:28.52	02:30.31	00:01.79
Step 11	02:39.20	02:44.42	00:05.22	03:53.67	03:57.91	00:04.24	02:55.06	02:58.93	00:03.87	02:33.33	02:37.50	00:04.17
Step 12	02:44.65	02:45.03	00:00.38	03:58.05	03:58.32	00:00.27	02:59.06	02:59.74	00:00.68	02:37.70	02:38.82	00:01.12
Step 13	02:46.59	02:47.11	00:00.52	03:59.81	04:00.12	00:00.31	03:00.17	03:00.59	00:00.42	02:39.71	02:40.15	00:00.44
Step 14	03:06.18	03:07.74	00:01.56	04:17.98	04:19.44	00:01.46	03:17.43	03:19.81	00:02.38	03:06.94	03:08.59	00:01.65

Tasks	Task 6											
Users	**P 05**			**P 06**			**P 07**			**P 08**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	01:25.29	01:27.53	00:02.24	02:09.16	02:10.38	00:01.22	02:03.50	02:04.07	00:00.57	02:05.91	02:07.26	00:01.35
Step 2	01:27.80	01:29.46	00:01.66	02:10.65	02:12.75	00:02.10	02:08.04	02:09.87	00:01.83	02:07.84	02:11.06	00:03.22
Step 3	01:30.92	01:32.31	00:01.39	02:15.06	02:16.92	00:01.86	02:12.14	02:12.79	00:00.65	02:12.82	02:14.14	00:01.32
Step 4	01:32.99	01:33.56	00:00.57	02:18.65	02:19.19	00:00.54	02:14.01	02:14.35	00:00.34	02:14.89	02:17.23	00:02.34
Step 5	01:34.65	01:35.26	00:00.61	02:19.87	02:23.87	00:04.00	02:15.50	02:16.01	00:00.51	02:18.72	02:22.48	00:03.76
Step 6	01:36.51	01:37.84	00:01.33	02:29.43	02:29.84	00:00.41	02:17.67	02:18.25	00:00.58	02:24.04	02:24.75	00:00.71
Step 7	01:38.38	01:39.06	00:00.68	02:30.58	02:31.26	00:00.68	02:18.79	02:19.84	00:01.05	02:25.30	02:26.35	00:01.05
Step 8	01:39.67	01:40.14	00:00.47	02:31.91	02:32.38	00:00.47	02:20.75	02:21.30	00:00.55	02:26.96	02:27.47	00:00.51
Step 9	01:40.72	01:42.55	00:01.83	02:32.96	02:34.18	00:01.22	02:21.84	02:23.16	00:01.32	02:28.04	02:29.53	00:01.49
Step 10	01:54.04	01:55.77	00:01.73	02:44.72	02:45.70	00:00.98	02:33.26	02:35.26	00:02.00	02:42.25	02:43.81	00:01.56
Step 11	01:59.46	02:03.16	00:03.70	02:47.47	02:51.54	00:04.07	02:37.13	02:43.77	00:06.64	02:45.33	02:49.57	00:04.24
Step 12	02:03.23	02:04.52	00:01.29	02:51.70	02:52.52	00:00.82	02:43.91	02:44.35	00:00.44	02:49.67	02:51.67	00:02.00
Step 13	02:05.24	02:05.74	00:00.50	02:53.24	02:53.78	00:00.54	02:45.98	02:46.53	00:00.55	02:54.21	02:54.78	00:00.57
Step 14	02:28.92	02:30.61	00:01.69	03:16.19	03:17.20	00:01.01	03:03.63	03:04.94	00:01.31	03:07.18	03:08.79	00:01.61

Tasks	**Task 6**					
Users	**P 09**			**P 10**		
	Start	Finish	Time	Start	Finish	Time
Step 1	02:01.23	02:02.41	00:01.18	02:41.26	02:43.03	00:01.77
Step 2	02:02.72	02:04.18	00:01.46	02:43.37	02:44.72	00:01.35
Step 3	02:05.84	02:06.65	00:00.81	02:46.31	02:47.57	00:01.26
Step 4	02:07.50	02:08.11	00:00.61	02:48.42	02:51.03	00:02.61
Step 5	02:09.13	02:09.74	00:00.61	02:52.18	02:53.03	00:00.85
Step 6	02:10.92	02:11.19	00:00.27	02:54.48	02:55.57	00:01.09
Step 7	02:11.80	02:13.16	00:01.36	02:56.08	02:57.33	00:01.25
Step 8	02:13.74	02:14.24	00:00.50	02:58.01	02:58.93	00:00.92
Step 9	02:14.82	02:15.74	00:00.92	02:59.37	03:01.10	00:01.73
Step 10	02:25.06	02:26.58	00:01.52	03:11.64	03:12.65	00:01.01
Step 11	02:29.06	02:30.96	00:01.90	03:14.42	03:19.03	00:04.61
Step 12	02:31.09	02:31.50	00:00.41	03:19.13	03:20.01	00:00.88
Step 13	02:32.86	02:33.40	00:00.54	03:21.21	03:21.72	00:00.51
Step 14	02:55.25	02:57.84	00:02.59	03:38.49	03:41.74	00:03.25

TASK 7:

Table G. 7 - User test results for task 7

Tasks	Task 7											
Users	**P 01**			**P 02**			**P 03**			**P 04**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	03:15.79	03:17.23	00:01.44	04:30.00	04:31.00	00:01.00	03:29.94	03:31.40	00:01.46	03:11.20	03:12.76	00:01.56
Step 2	03:17.54	03:18.55	00:01.01	04:31.13	04:35.07	00:03.94	03:36.96	03:37.47	00:00.51	03:13.16	03:14.38	00:01.22
Step 3	03:20.11	03:20.49	00:00.38	04:36.52	04:39.00	00:02.48	03:38.93	03:39.98	00:01.05	03:16.01	03:16.52	00:00.51
Step 4	03:20.96	03:28.83	00:07.87	04:39.44	04:46.49	00:07.05	03:40.45	03:48.69	00:08.24	03:17.33	03:27.98	00:10.65
Step 5	03:29.06	03:29.44	00:00.38	04:46.69	04:47.24	00:00.55	03:50.45	03:50.62	00:00.17	03:28.22	03:29.03	00:00.81
Step 6	03:29.71	03:31.03	00:01.32	04:47.44	04:49.30	00:01.86	03:51.10	03:52.39	00:01.29	03:29.10	03:31.47	00:02.37
Step 7	03:31.20	03:31.57	00:00.37	04:49.47	04:49.85	00:00.38	03:52.56	03:53.00	00:00.44	03:31.67	03:32.35	00:00.68
Step 8	03:31.94	03:32.52	00:00.58	04:50.25	04:51.10	00:00.85	03:53.37	03:54.79	00:01.42	03:32.72	03:34.28	00:01.56
Step 9	03:49.06	03:49.91	00:00.85	05:07.85	05:09.54	00:01.69	04:12.73	04:13.61	00:00.88	03:50.72	03:53.20	00:02.48
Step 10	03:51.30	03:55.81	00:04.51	05:11.14	05:15.41	00:04.27	04:15.07	04:20.59	00:05.52	03:54.83	03:58.35	00:03.52
Step 11	03:56.01	03:56.52	00:00.51	05:15.61	05:15.85	00:00.24	04:20.79	04:21.17	00:00.38	03:58.56	03:59.10	00:00.54
Step 12	03:57.84	03:58.01	00:00.17	05:17.37	05:17.80	00:00.43	04:22.05	04:22.40	00:00.35	04:01.05	04:01.43	00:00.38
Step 13	04:20.08	04:21.13	00:01.05	05:38.63	05:40.09	00:01.46	04:44.56	04:46.29	00:01.73	04:29.20	04:32.22	00:03.02

Tasks	Task 7											
Users	P 05			P 06			P 07			P 08		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	02:33.67	02:35.70	00:02.03	03:19.98	03:22.45	00:02.47	04:13.17	04:13.84	00:00.67	03:23.84	03:24.72	00:00.88
Step 2	02:36.04	02:38.38	00:02.34	03:22.76	03:23.84	00:01.08	04:14.22	04:15.20	00:00.98	03:24.96	03:25.67	00:00.71
Step 3	02:40.25	02:41.06	00:00.81	03:25.37	03:26.52	00:01.15	04:17.03	04:19.47	00:02.44	03:27.23	03:28.05	00:00.82
Step 4	02:41.57	02:48.99	00:07.42	03:26.99	03:35.81	00:08.82	04:19.91	04:30.56	00:10.65	03:28.69	03:35.77	00:07.08
Step 5	02:49.16	02:49.67	00:00.51	03:36.05	03:36.89	00:00.84	04:30.73	04:31.20	00:00.47	03:35.88	03:36.59	00:00.71
Step 6	02:49.98	02:51.16	00:01.18	03:37.13	03:37.94	00:00.81	04:31.44	04:32.56	00:01.12	03:36.83	03:38.72	00:01.89
Step 7	02:51.26	02:52.48	00:01.22	03:38.18	03:38.96	00:00.78	04:32.69	04:33.41	00:00.72	03:39.00	03:39.47	00:00.47
Step 8	02:52.82	02:53.70	00:00.88	03:39.33	03:40.96	00:01.63	04:33.81	04:34.63	00:00.82	03:39.84	03:40.86	00:01.02
Step 9	03:11.81	03:13.10	00:01.29	05:50.80	05:52.39	00:01.59	05:41.24	05:42.46	00:01.22	03:57.37	03:58.66	00:01.29
Step 10	03:14.62	03:17.50	00:02.88	05:55.17	05:57.38	00:02.21	05:43.92	05:48.39	00:04.47	04:07.78	04:11.03	00:03.25
Step 11	03:17.64	03:18.52	00:00.88	05:57.58	05:58.29	00:00.71	05:48.49	05:49.00	00:00.51	04:11.10	04:11.44	00:00.34
Step 12	03:17.65	03:18.12	00:00.47	05:59.30	06:00.01	00:00.71	05:49.50	05:49.98	00:00.48	04:12.90	04:13.34	00:00.44
Step 13	03:46.25	03:48.01	00:01.76	06:19.45	06:21.14	00:01.69	06:17.30	06:19.31	00:02.01	04:34.91	04:36.62	00:01.71

Tasks	Task 7					
Users	**P 09**			**P 10**		
	Start	Finish	Time	Start	Finish	Time
Step 1	03:04.62	03:05.10	00:00.48	03:51.20	03:52.93	00:01.73
Step 2	03:05.33	03:06.21	00:00.88	03:53.20	03:54.22	00:01.02
Step 3	03:07.84	03:08.42	00:00.58	03:56.35	03:57.27	00:00.92
Step 4	03:08.86	03:16.42	00:07.56	03:58.18	04:08.25	00:10.07
Step 5	03:16.52	03:17.30	00:00.78	04:08.42	04:09.91	00:01.49
Step 6	03:17.57	03:18.42	00:00.85	04:10.18	04:11.57	00:01.39
Step 7	03:18.49	03:18.96	00:00.47	04:11.84	04:12.62	00:00.78
Step 8	03:19.44	03:20.18	00:00.74	04:12.96	04:14.25	00:01.29
Step 9	03:38.15	03:39.03	00:00.88	04:31.91	04:32.69	00:00.78
Step 10	03:40.45	03:45.33	00:04.88	04:34.32	04:39.51	00:05.19
Step 11	03:45.37	03:46.08	00:00.71	04:39.61	04:40.22	00:00.61
Step 12	03:47.40	03:47.84	00:00.44	04:41.32	04:41.71	00:00.39
Step 13	04:16.79	04:18.05	00:01.26	05:02.66	05:04.09	00:01.43

TASK 8:

Table G. 8 - User test results for task 8

Tasks	Task 8											
Users	**P 01**			**P 02**			**P 03**			**P 04**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	04:27.81	04:28.56	00:00.75	05:46.83	05:48.56	00:01.73	04:54.42	04:55.58	00:01.16	04:38.56	04:39.51	00:00.95
Step 2	04:29.24	04:30.96	00:01.72	05:49.34	05:50.77	00:01.43	04:56.49	04:57.47	00:00.98	04:40.32	04:42.32	00:02.00
Step 3	04:31.54	04:32.80	00:01.26	05:51.38	05:52.36	00:00.98	04:58.02	04:59.34	00:01.32	04:42.83	04:43.78	00:00.95
Step 4	04:33.44	04:34.22	00:00.78	05:53.00	05:53.88	00:00.88	05:00.02	05:01.81	00:01.79	04:44.56	04:45.61	00:01.05
Step 5	04:43.44	04:45.98	00:02.54	06:03.61	06:06.12	00:02.51	05:11.03	05:15.00	00:03.97	04:55.58	04:57.30	00:01.72
Step 6	05:03.92	05:09.68	00:05.76	06:06.32	06:11.14	00:04.82	05:15.20	05:22.87	00:07.67	04:57.47	05:03.24	00:05.77
Step 7	05:09.68	05:09.78	00:00.10	06:11.38	06:11.65	00:00.27	05:23.04	05:24.05	00:01.01	05:03.44	05:04.76	00:01.32
Step 8	05:12.78	05:13.14	00:00.36	06:14.01	06:14.22	00:00.21	05:25.05	05:25.43	00:00.38	05:05.45	05.05.98	00:00.53
Step 9	05:37.00	05:39.82	00:02.82	06:32.60	06:35.79	00:03.19	05:50.80	05:54.97	00:04.17	05:28.43	05:32.97	00:04.54

Tasks	**Task 8**											
Users	**P 05**			**P 06**			**P 07**			**P 08**		
	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time	Start	Finish	Time
Step 1	03:51.74	03:53.27	00:01.53	06:25.31	06:26.09	00:00.78	06:27.17	06:28.12	00:00.95	05:34.36	05:37.41	00:03.05
Step 2	03:54.05	03:55.27	00:01.22	06:26.90	06:29.68	00:02.78	06:29.01	06:29.99	00:00.98	05:37.88	05:38.63	00:00.75
Step 3	03:57.81	03:59.95	00:02.14	06:30.26	06:32.16	00:01.90	06:30.56	06:31.65	00:01.09	05:39.21	05:40.66	00:01.45
Step 4	04:00.56	04:01.81	00:01.25	06:32.70	06:33.45	00:00.75	06:32.26	06:33.01	00:00.75	05:41.24	05:42.05	00:00.81
Step 5	04:11.68	04:14.79	00:03.11	06:43.11	06:44.53	00:01.42	06:53.82	06:55.68	00:01.86	05:53.04	05:56.26	00:03.22
Step 6	04:15.10	04:21.30	00:06.20	06:44.63	06:53.24	00:08.61	06:55.85	07:02.70	00:06.85	05:56.49	05:59.58	00:03.09
Step 7	04:21.51	04:22.32	00:00.81	06:53.48	06:54.53	00:01.05	07:02.80	07:04.36	00:01.56	05:59.61	05:59.88	00:00.27
Step 8	04:23.52	04:23.99	00:00.47	06:55.49	06:55.89	00:00.40	07:05.81	07:06.18	00:00.37	06:01.54	06:01.97	00:00.43
Step 9	04:51.34	04:56.12	00:04.78	07:13.21	07:18.16	00:04.95	07:26.57	07:32.20	00:05.63	06:31.55	06:33.94	00:02.39

Tasks	Task 8					
Users	P 09			P 10		
	Start	Finish	Time	Start	Finish	Time
Step 1	04:27.54	04:29.34	00:01.80	05:10.29	05:11.98	00:01.69
Step 2	04:30.15	04:30.66	00:00.51	05:12.83	05:13.81	00:00.98
Step 3	04:31.20	04:32.35	00:01.15	05:14.32	05:15.58	00:01.26
Step 4	04:32.90	04:33.88	00:00.98	05:16.09	05:17.34	00:01.25
Step 5	04:45.37	04:48.32	00:02.95	05:27.00	05:30.60	00:03.60
Step 6	04:48.52	04:55.30	00:06.78	05:30.66	05:37.41	00:06.75
Step 7	04:55.47	04:55.71	00:00.24	05:37.61	05:39.24	00:01.63
Step 8	04:58.30	04:59.07	00:00.77	05:40.34	05:40.78	00:00.44
Step 9	05:23.24	05:27.44	00:04.20	06:05.78	06:08.39	00:02.61

ÖĞRENCİ İŞLERİ DAİRE BAŞKANLIĞI
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05.12.2013

BİLGİ İŞLEM DAİRE BAŞKANLIĞI

Üniversitemiz Bilişim Sistemleri Ana Bilim Dalı Yüksek Lisans Programı öğrencisi Nihan Ocak'ın 01 Aralık 2013 – 15 Ocak 2014 tarihleri arasında *"Bilişsel Modelleme Aracı ve Kullanıcı Performans Testi Karşılaştırması Sonucu Mobil Arayüz Tasarımına Yönelik Optimum Kullanılabilirlik Yöntemi"* başlıklı araştırma çalışmasına ilişkin Orta Doğu Teknik Üniversitesi Bilgi İşlem Daire Başkanlığı İnsan Bilgisayar Etkileşimi Araştırma ve Uygulama Laboratuarı'nda uygulama yapmak için, öğrencinin isteği doğrultusunda görevlendirilmesi Etik Komite onayı ile uygun görülmüştür.

Uygulamanın yapılabilmesi için gereğini arz ederim.

Saygılarımla.

Nünsal
Nesrin Ünsal
Öğrenci İşleri Daire Başkanı

Sn FE,
Gereği rica ederim.
09.12.2013 F.A

Ekler:
1- İAEK Başvuru Formu
2- İAEK Değerlendirme Sonucu
3- İAEK Başvuru Formu Proje Bilgi Formu
4- Anket

SSD/

TEZ FOTOKOPİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : ....
Adı : ....
Bölümü : ....

TEZİN ADI (İngilizce) : ....
....
....
....
....

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☐

1. Tezimin tamamı dünya çapında erişime açılsın ve kaynak gösterilmek şartıyla tezimin bir kısmı veya tamamının fotokopisi alınsın. ☐
2. Tezimin tamamı yalnızca Orta Doğu Teknik Üniversitesi kullancılarının erişimine açılsın. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐
3. Tezim bir (1) yıl süreyle erişime kapalı olsun. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐

Yazarın imzası .... Tarih ....