SAARLAND UNIVERSITY

Faculty of Mathematics and Computer Science
Department of Computer Science
MASTER THESIS

Understanding Autonomous Device Behavior in a Social Internet of Things environment through Personality Traits.

submitted by
Latifa Abdullayeva
Saarbrücken
July 2020

Advisor:
Donald Degraen,
German Research Center for Artificial Intelligence
Saarbrücken, Germany

Supervisor:
Prof. Dr. Antonio Krüger,
German Research Center for Artificial Intelligence
Saarbrücken, Germany

Reviewers:
Prof. Dr. Antonio Krüger,
German Research Center for Artificial Intelligence
Saarbrücken, Germany

Dr. Michael Schmitz,
Medieninformatik xm:lab
Saarbrücken, Germany

Saarland University
Faculty MI – Mathematics and Computer Science
Department of Computer Science
Campus - Building E1.1
66123 Saarbrücken
Germany

Erklärung

Ich erkläre hiermit, dass ich die vorliegende Arbeit selbständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel verwendet habe.

Statement

I hereby confirm that I have written this thesis on my own and that I have not used any other media or materials than the ones referred to in this thesis

Einverständniserklärung

Ich bin damit einverstanden, dass meine (bestandene) Arbeit in beiden Versionen in die Bibliothek der Informatik aufgenommen und damit veröffentlicht wird.

Declaration of Consent

I agree to make both versions of my thesis (with a passing grade) accessible to the public by having them added to the library of the Computer Science Department.

Saarbrücken,_____ _____

(Datum/Date) (Unterschrift/Signature)

Acknowledgements

I would like to thank my advisor, Donald Degraen, for his guidance and feedback. Without his patience, support, and valuable advice, this venture would not have been possible.

Further, I want to thank Prof. Dr. Antonio Krüger for giving me an opportunity to write this thesis under his supervision. Also, I would like to thank Prof. Dr. Antonio Krüger and Dr. Michael Schmitz for reviewing my thesis.

My deepest appreciation goes to my family for their moral support, their continuous encouragement, and their help whenever it was needed.

In addition, I would like to thank all people who participated in the user study and provided their feedback.

Abstract

In a Social Internet of Things environment, smart devices autonomously communicate with each other by establishing their own network. While social device interaction increases scalability and enhances network navigability, decisions made by smart devices are not always clear and may not be in line with a user's expectation. Our work aims to find an approach that will bring awareness of automated behaviors while taking the user's context into account.

In our prototype, a user's smartphone becomes their personal Mascot able to autonomously connect to four other devices, i.e., another Mascot, a lamp, a tablet, and speakers. While proximity is used to initiate communication between devices, the resulting behavior is influenced by a predefined "personality" of the user's Mascot.

In a user study, we explored different automated behaviors and investigated how users perceived the associated personality according to the Big Five Personality Trait model. Our results indicate that different types of actions, such as playing certain types of music, vibrating at a certain level, changing lighting, and altering screen color, are interpreted as certain personalities. This opens the path to utilizing personality traits as tools to predict and influence automated behaviors in an Internet of Things environment.

Contents

Chapter 1
Introduction

1.1 Motivation

The rapid development of the area of Information Technology led to the emergence of a new paradigm known as "Internet of Things". IoT adds a new dimension by focusing on not only the interaction between humans and devices but also the devices themselves. However, the concept of IoT does not ensure the effective discovery of the objects and the better reaction to the states of other objects. A new paradigm "Social Internet of Things" (SIoT) introduces more autonomous interaction between "things" by applying the notion of Social Relationship of things rather than explicit users' instructions. However, the ambition of having autonomous interaction of things increases the complexity of a system without having users in mind. Throughout this paper, "things" based on the SIoT concept will be called "social things" or "social devices" for convenience.

Social things interacting with each other act without making visible to the user the decisions made by a system. Thus, it is unrealistic to assume that the autonomous decisions made by social things will always be in line with users' expectations. Given this problem, we are motivated to find and investigate an approach that will take the user's context into account. The system that achieves the cooperation of social things where things are assigned with unique personalities is proposed. A user being able to configure the personality of the social device will be ensured about the consistent behavior of devices where the services provided by these devices will remain dynamic. We assume that the concept of the personality with predefined actions increases a user's awareness of a system and serves as an interaction mechanism inside the SIoT environment.

The system was inspired by the "Autonomous Cooperation of Social Things"

paper [10], where authors achieve the interaction between mascot and bench as case studies by representing to cooperation among private and public things. A more detailed description of a system and its contribution is described in Section 2.4. Additionally, authors introduce social things concept where things have unique personalities. However, they do not use personality from a design perspective. In their system, a mascot interacts with a bench which shows only static behavior based on the user's position in space. We plan to apply the personality concept as a design process and bring it to the behavior of social things where they will react to each other dynamically based on the personality of a social device. Thus, we envision that the concept of personality with preset actions will influence not only the interaction between social things but also between the user and social things.

1.2 Research Goals

As we mentioned in the previous Section 1.1, in the system introduced by the paper [10], social devices have static behavior when we consider it from a user perspective. Users are not able to configure devices or input some information and see the output accordingly. Considering the role of the human in the SIoT environment, in our system, the personality with preset actions serves as an interface for interaction between user and its environment including social devices.

Therefore, as an input, we use the configuration of mascot's personality and proximity information of the user's movements. As an output, we use actions that all social things in the environment display (i.e change of light, vibration, music play, and screen color alteration) based on the personality information that the user configured.

To wrap it up, we extended the system introduced in a paper [10] by adding:

- More case studies such as mascot-lamp, mascot-speakers, mascot-mascot, and mascot-tablet interactions.
- Preset actions for each case-study:
  - Yellow, orange, turquoise, pink, blood-red lighting color for a mascot-lamp interaction.
  - Sophisticated, contemporary, unpretentious music for mascot-speakers interaction.
  - Vibrations with five different durations starting from 100 to 500 milliseconds per time for mascot-mascot interaction.
  - Yellow, orange, turquoise, pink, blood-red screen background for mascot-tablet interaction.

Chapter 3 is completely dedicated to the design of a system and the concepts applied to the research in more detail.

Given the SIoT system, the main focus lies on how people interpret the interaction between user and social devices. A person holding a mascot changes the state of all devices in our system by his movements. Thus, the question that arises is: "How people will interpret the following actions of things such as lighting color, music, vibration duration and screen color in the context of personality traits?" We suppose that the interactions between a mascot and other social devices give a descriptive clue about the personality of this mascot. Therefore, we empirically investigate each action individually and see which personality trait it conveys most. Thus, for each case-study, the goal is to settle the question of how people understand devices' actions and measure the personality trait of the mascot based on the interactions between these social things.

1.3 Outline of Thesis

After presenting motivation and research goals (see Chapter 1), in Chapter 2, an overview of scientific publications that are relevant to the thesis is given. The related work chapter also describes current works that inspired us to investigate further and methodologies are applied to expand the existing system.

Chapter 3 introduces the papers that aid us to come up with case-studies; identify personality traits that each mascot will be assigned; identify such actions such as vibration, music play, lighting, and screen color change based on the personality trait concept.

Chapter 4 describes the implementation details of the system providing the interaction between social things with preset personality. The implementation chapter includes client and server architectures, the overall workload of a system, software, and hardware used to implement the system.

Chapter 5 includes the user study, namely, describes the design of experiments, procedures, tasks, and materials used to conduct the experiment.

Chapter 6 presents a statistical analysis of all four case-studies. The analysis measured from two perspectives framed into two separate sub-studies.

Chapter 7 covers the discussion of statistical results for each case-study.

The final Chapter 8 gives an overview of the results, contributions, possible limitations of a study, and future works that can extend existing study.

Chapter 2
Related Work

This chapter presents the background and current works related to our research and is organised as follows. Sections 2.1, 2.2, and 2.3 provide an introduction of basic concepts related to our prototype. Then, in Section 2.4, we present a system that inspired us to expand it. Starting from section 2.5, we discuss some methodologies that help us to expand the existing system.

2.1 Ubiquitous Computing

The attempts to make technologies invisible in the background of people's life led to the emergence of a new approach in the area of Information Technology whereby making the term Ubiquitous Computing prominent in recent years. The "Ubiquitous Computing" was initially put forward by Mark Weiser in "The computer for the 21st Century" [1]. In this paper, the author touched two issues related to the concept of Ubiquitous Computing such as the location and scale.

The traditional computers which existed before the introduction of this paradigm had no idea about their location. The location-aware system may have information about how far or close it is from other objects and may even later be able to adapt its behaviour accordingly. An example application that leveraged the location-aware paradigm was introduced by Hupfeld and Berge in their RAUM system [2]. The authors claim that information about the location of objects plays a more important role than their identities. They explain the essence of location by giving an example of people who prefer to communicate while standing in front of the person who participates in the conversation, rather than turning their backs on him. With the help of the concept of Ubiquitous Computing, the prototype presented in our research uses the location information in order to select a communication partner.

Another issue related to the concept of Ubiquitous Computing is the scale, that is, systems of various sizes serve different purposes. In the context of our prototype, mascot, tablet, lamp, and speakers are all in different sizes and, therefore, perform different tasks. Moreover, the size of objects is also reflected in its location, for example, a lamp, compared to other devices has a larger size, which limits its location to one point, whereas the mascot which is a pocket-size phone allows changing the location depending on the location of its owner.

2.2 Internet of Things

The rapid development of electronics led to the emergence of the concept of "Internet of Things". IoT can be both ubiquitous and non-ubiquitous technologies. Moreover, in the context of Ubiquitous Computing, IoT adds a new dimension to the interaction between objects: from any time, any place connectivity for everyone, we will have connectivity for anything [3]. Thus, in comparison to Ubiquitous technologies, IoT focuses not only on the interaction between humans and devices but also between the devices themselves.

The idea of IoT was first proposed by Kevin Ashton in 1999 [4] by linking the idea of RFID (Radio Frequency Identification) to the topic of the Internet. We can characterize IoT as one big network where all devices can share information about their status with each other allowing to achieve deeper automation and integration within a system. In "Internet of Things: A Literature Review" [5], authors describe the genesis of the term "IoT" which help us to understand the general concept behind it and corresponding key technologies that it uses. They explained the concept by dividing the definition of IoT into two components: "Internet" (as a global system of interconnected computer networks that use the Internet protocol to serve users worldwide) and "Thing" (as real objects in the physical or material world). This explanation helps us to understand that inanimate objects such as lamp, speakers, etc can communicate with other objects with the help of the Internet without any explicit human instructions. Thus, in our work, we use mascots, tablet, lamp, and speakers as a representation of inanimate objects called "things", which can interact with each other and send information over the local network. In addition, this paper provides key technology of IoT such as Radio Frequency Identification, Electronic Product Code, ZigBee, etc. From the technical point of view, RFID is primarily relevant to the unique identification of a "thing" in order to communicate with other objects. Moreover, ZigBee is widely used, short-range, low-rate wireless network technology, so in our prototype, the communication between mascot and lamp is built with the help of Zigbee Lighting protocol. Additionally, an inexpensive radio technology Bluetooth Low Energy is also very useful for our research for proximity sensing. In addition to these technologies which are considered as a pillar for communication between objects, the more detailed description of their usage can be found in the Implementation chapter (see chapter 4).

An example of research work in the area of IoT may be “Explorations on Reciprocal Interplay in Things Ecology” [6] where the authors are trying to stimulate scientists to a more detailed discussion on designing qualities of IoT devices. For that, Chung et al conducted the HiddenLocal workshop (HWL) in order to explore and design IoT systems, where they take into account reciprocal interplay believing that it makes the design of IoT systems more dynamic. As a starting point, authors show 7 perceptual qualities as follows: focus the senses; show explorative behaviour; subtleness of movement; react to the external event; recognize explorative behaviour subject; reflex contextual noise; remember and anticipate perception over time. Authors believe that these perceptual qualities are a good approach for designed explorative features of devices and therefore for the things-to-things interaction.

2.3 Social Internet of Things

According to the “The Internet of Things: A survey” paper [7], unfortunately, there are many research issues related to the IoT that require further research and need to be addressed. One of them is that people still cannot be sure about the privacy of the transferred data through IoT technologies. Another issue is network navigability which must ensure that the discovery of objects can be performed effectively and better reaction to the state changes of objects. Atzori et al [8] formalized a new paradigm of Social Internet of Things (SIoT) where the interaction among smart objects is based on the notion of Social Relationship of things rather than their owners. Thus, the application of this concept to the IoT can lead to the improvement of the network navigability and scalability. The architectural model of SIoT describes the establishment of the social relationships among objects in a fashion that is relatively similar to the human social network relationship.

Applying new paradigm to the IoT concept can lead to the following advantages:

- Establishing the level of trustworthiness by leveraging relationship types and by supporting services usable among things that are “friends”;
- Improvements in network navigability;
- A guarantee of the higher scalability and efficiency [9];

By integrating social networking concept to the Internet of Things, intelligent things establish a connection with other peers in an autonomous way by exploiting things’ social relationships. An exemplary connection between smart things that we also refer as "social things" in our study may be mascot-mascot, mascot-tablet, mascot-lamp and mascot-speakers interactions. The application of the SIoT concept will help to accomplish complex tasks such as changing object behaviour according to the given information. Thus, with the help of the

advantages provided by social networking principles the IoT evolves into the SIoT, in which social relationships can be established among the devices in order to advertise information about their current state and provide services to their peers.

2.4 Autonomous interaction of things

Most devices using the concept of IoT are designed to involve the user in the process where user's actions trigger certain functions of a system in order to effects the behaviour of objects. This design contradicts to the concept of a fully automated system where objects can cooperate with each other beyond the control of a human. The following paper [10], which is an inspiration for our work, introduces the design methodology to achieve a more autonomous system. The authors applied the concept of SIoT and consider objects as living beings which are able to communicate with others and exchange information autonomously. This approach allows objects to have their own social circle similar to human social network. This broadcast information calls certain functions that affect the behaviour of objects, thus, allowing objects to be aware of the status of other objects and the surrounding environment.

The concept of Social Things which is also an essential for our prototype helps the objects to know: own goals; what to do with the received information; and what actions need to be taken to achieve these goals. In our work, goals and the combination of actions that will be triggered depending on the received information, are all predefined.

As a case study, the authors developed a system with two devices. One of them is mascot (which is a small keychain of three colours: red, green and blue) presented in the form of a personal object that the user can carry with him everywhere. Another device is a Bench with built-in lamps presented as a more static device for public use. Moreover, in the prototype described in that work, two scenarios are considered:

- **Mascot - mascot** interaction, as one mascot approaches another, they both start to blink where the intensity of blink depends on the distance objects are from each other.
- **Mascot - bench** interaction, as mascot goes close to the bench, the lights start to change their colors based on the color of mascot that is approaching.

The biggest contribution of this paper was to introduce the autonomously cooperative system where mascot and bench represented as a private and public thing. Moreover, authors also considered proximity-based cooperation: devices blink more often when approaching closer than 30 cm and and blink with less intensity when approaching more than 150 cm. By using the concept presented in this study, namely, autonomous interaction between objects/things achieved with

the help of the SIoT concept, we are planning to expand the system by adding more objects. Afterwards, we are going to apply the theory of Proxemics and Personality Traits which will be covered in the following sections. In addition to the two categories that authors described in their paper (i.e. private and public "things") presented by two objects (mascot and bench, respectively), in Section 2.5 we are planning to look at more detailed divisions.

2.5 The Theory of Proxemics

Edward Hall [11, 12] conceptualized the idea of a personal space bubble by creating a whole system of notation in order to understand and record how people navigate shared space. He correlated physical distance to social distance. According to these papers, Hall identified four distances which are measured horizontally:

- **Intimate distance** which varies from 0 to 45 cm is a distance used for romantic partners and family members.
- **Personal distance** varies from 46 to 122 cm is a space bubble which allows your extended family members and close friends to enter this zone.
- **Social distance** varies from 122 to 370 cm is often used for acquaintances and colloquies
- **Public distance**, having a range of 370 cm and more, is often used in public speaking situation and with strangers you want to maintain your distance from.

He also analyzed vertical distances, for example, the difference in vertical distance between people can reflect the degree of dominance. However, in our study we focus only on horizontal distances.

Nowadays, there are many studies in which Proxemics has been used to design interactions. For example, Jo Vermeulen et al in their work [13] used zones to interact with vertical interactive displays where they suggested floor display as an auxiliary device. The contributions of using the secondary display are the following: it provides peripheral information about tracking status of a user; it shows interaction zones; it invites the user to interact with the main display; it suggests possible interaction steps. This kind of floor visualization with continuous feedback about proximity gives the user more control over their interaction with the system.

Another example system using Proxemics is Remote Controls system introduced by Ledo et.al in their [14] paper. Remote control devices were created in such a way that people could control appliances from a certain distance. However, with the increase in the number of home appliances, the number of remote controls

also increasing. For this purpose, the universal remotes have been proposed providing a one-remote-to-many-appliances solution. Unfortunately, this design has setup issues and poorly adaptable interface. Authors of this paper presented proxemic-aware controls that utilize the spatial relationship between mobile devices owned by user and appliances surrounding it. With this system user can discover and select the devices within large ecologies of appliances, view their current status and control their features. Moreover, as a user moves closer or farther to a particular device, the interface adjusts accordingly. For example, in the initial state, the tablet screen visualizes icons representing the location of appliances at the edge of the screen, these icons are dynamically updated as he moves. Through spatial interactions, people can leverage mobile devices to discover and select appliances. This allows for situated interaction that balances simple and flexible control while seamlessly transitioning between different control interfaces. Ubicomp, which they use as short for Ubiquitous Computing, may be a starting point for developing a new type of remote control interface within our increasingly complex world.

In addition, Ballendat, Nicolai Marquardt, and Saul Greenberg in their paper [15] introduce proxemic-aware interactive media player system, where they consider information regarding nearby people and devices in order to mediate the interaction. They cover a small space Ubicomp environment considering the relationships of people to devices; devices to devices; and non-digital objects to people and devices. The system reacts to a person's presence, distance and orientation regarding the display. Proxemic interaction also considers a person's relationship to nearby objects. The authors propose different cases, for example, the video displaying on the screen pauses when a person is having a phone conversation or when he picks a magazine to read it. Another case is when a person enters the room, the screen shows a video title as additional information for him. Moreover, the video is paused when both people face away from the screen in order to start a conversation with each other. Furthermore, the system turns off when everyone has left the room. However, the authors also emphasize that one of the biggest unsolved problems in this area might be how the system can respond to the received information about proxemics because sometimes the devices can make a mistake by taking a certain action. In spite of all these problems, the authors, as well as we believe that proxemics will become an important factor in the embodiment of the interaction between social objects where they can meet the social expectations of people.

In our research, we are planning to extend the autonomous system, which was described in Section 2.4, by categorizing devices according to the theory of Proxemics using only horizontal measurements. Our goal is to cover all four categories of Proxemics which are represented by four artefacts such as mascot, tablet, lamp and speakers, thereby, constituting four case studies. Thus, each of these devices is located at a certain distance from each other representing the relationships between them. These relationships will help us to conceptualize their interactions, come up with case study and possible actions.

2.6 Interaction design for SIoT

The following paper [18] motivated us to apply a concept of personality in the context of social devices. An example use of personality as a method to design an interactive object's behaviour was proposed in "Designing the Behaviour of Interactive Objects" [19]. The author came to the conclusion that in order to design a more stable and understandable for user behaviour of a device, it is necessary to add inner logic to which we can refer. Marco et al proposed to apply the concept of metaphor, which represents human stereotypes of personality in order to visualise the inner logic. Their system was based on a Big Five Personality Traits model, and thus, by assigning these personalities to objects, users could describe its behaviour more easily. The authors believe that stereotypes and metaphors are simplified descriptions of being and behaviour, and thus making it an ideal method for displaying the sustainable behaviour of a smart object. During the research, they used robotic sofa as a case study and tried to analyze how users perceive the consistency of its behaviour. The use of the personality model in the device design process, helps a user to create a mental model of how an autonomous sofa-bot will act in the future.

Having a system, where tablet, lamp and speakers are considered as static objects, whereas mascots are dynamic, we can apply the Personality Model. And since only mascots are a major factor affecting the environment (for example, if mascot come close to the lamp, it changes the light color), we decided to assign a personality to dynamic objects (meaning to each mascot).

In our prototype we assume that this approach may help user to better understand mascot's behaviour. Knowing which goals and intentions this object follows, may help users to understand the behaviour and the reason of certain decisions of a mascot. We assume that these goals and intentions set certain boundaries in behaviour of social devices. And since the behaviour as a whole consists of actions, we suppose that personality model sets implicit instructions to the devices. Meaning that, instead of the user giving explicit instructions to the object, the object with the assigned personality makes decisions autonomously. Thus, the device with assigned personality can help users who knows the definition of that personality to understand the system behaviour at least in an intuitive way. This concept may give the system a more understandable and consistent behaviour, and to user a better awareness of object functionality In the following subsection we will describe the Personality Model in more details.

2.7 Definition of personality traits

Personality is important in human relationship, so we assume that it also may be important for device relationship. In order to assign a personality to each mascot, we first need to give a definition of personality in the context of social devices. We can try on an intuitively explain the meaning of a person's personality trait,

unfortunately, it is hard to apply it in the context of SIoT. For that, we need a generally accepted model, and we decided to use Big Five Personality Traits (aka OCEAN) for the description of each personality. We expect that providing a description of personality will help to define goals and more targeted actions which in turn will lead the system to more stable behaviour. The following book [20] gives a good introduction to the personality types describing possible existing personality models. One of the models that can be used was introduced by Costa and McCrae's five-factor model which is also known as Big Five Personality Traits and the OCEAN model. Moreover, their concept formed a basis for the widely used NEO-Personality Inventory-Revised (NEO-PI-R) measurement scale.

The OCEAN model consists of the following features: Openness to experience, Conscientiousness, Extroversion, Agreeableness and Neuroticism. The authors lists the facets associated with each of these five domains:

- **Openness to experience**: creativity, innovative quality; quick receptivity to new and abstract ideas, high intelligence and openness to novelty;
- **Conscientiousness**: organized, well-prepared, discipline, likes planned action more than spontaneity, more focused.
- **Extroversion**: energetic, assertive personality, like to be the center of attention, like to dominate, feel comfortable around people;
- **Agreeableness**: friendliness, compassion for other people, interested in people, sympathize with the feelings of others, soft-hearted;
- **Neuroticism**: irritability, more hostile towards others, most often feel anxiety when they are surrounded by others, frequent mood swings, emotionally unstable;

We assigned a set of personalities to dynamic objects each of which is described in the above-mentioned list. In addition, in spite of the fact that people usually have a combination of these five traits, we are going to consider only extreme cases.

Chapter 3
Concept

This chapter introduces the main concept of our research. Section 3.1 describes the theory that helps us to come up with the case-studies and the possible interactions of social devices. Section 3.2 identifies the mascots' personality traits that they will display during interactions described in previous section. From Section 3.3, based on the assigned personalities, we explore the possible actions that social devices can show while interacting with each other. In Section 3.3, we identify the vibration levels that convey personality traits. In Section 3.4, we associate the music genre with personality traits. Section 3.5 describes colors that convey mascots' personality traits.

3.1 Identifying case studies and actions

In our research, we extended the "Autonomous Cooperation of Social Things" [10] by applying Proxemics Theory and Personality Traits Model.

Based on Proxemics theory, we classify our devices in the following way: mascot will belong to the intimate, tablet to a personal, lamp will be considered as a social and speakers as public distance. In this way, these objects represent cooperation among these distances. According to this theory, the distance between people represents their relationship which affects the way how they interact with each other. Having understood how people use distance when interacting with each other, and then applying this concept to social devices, we can come up with four case studies: mascot-mascot, mascot-tablet, mascot-lamp and mascot-speakers interactions.

Intimate distance has a very narrow range (i.e from 0 to 45 cm), and in the context of human-human interaction, this distance used for romantic partners or family

members. Thus, by applying it in the context of a device-device interaction, we can come up with a device whose functionality is only visible and accessible for their owners such as phone vibration. In our study, we substitute a phone with a term mascot represented as a ubiquitous personal thing.

Personal distance varied from 45 to 122 cm can be presented by tablet. In comparison to phone vibration where information is only available for owners, the size of tablet allows to display information for more members.

Social distance covers from 122 to 370 cm and can be reflected by lighting of the lamp. Our prototype contains only one lamp which can be visible for the large number of members.

Public distance is used for public speaking situations. In the context of SIoT, we can use speakers as a representative of this distance. We suppose that the functionality of speakers (i.e music play) will be available for everyone in the room. In comparison to the visibility of the lamp light which is limited due to the size of the lamp, speakers with the fixed volume of music play will be available for larger members.

Thus, Proxemics Theory helps us to choose devices, conceptualise their interactions, come up with case-studies and possible actions that these devices represent.

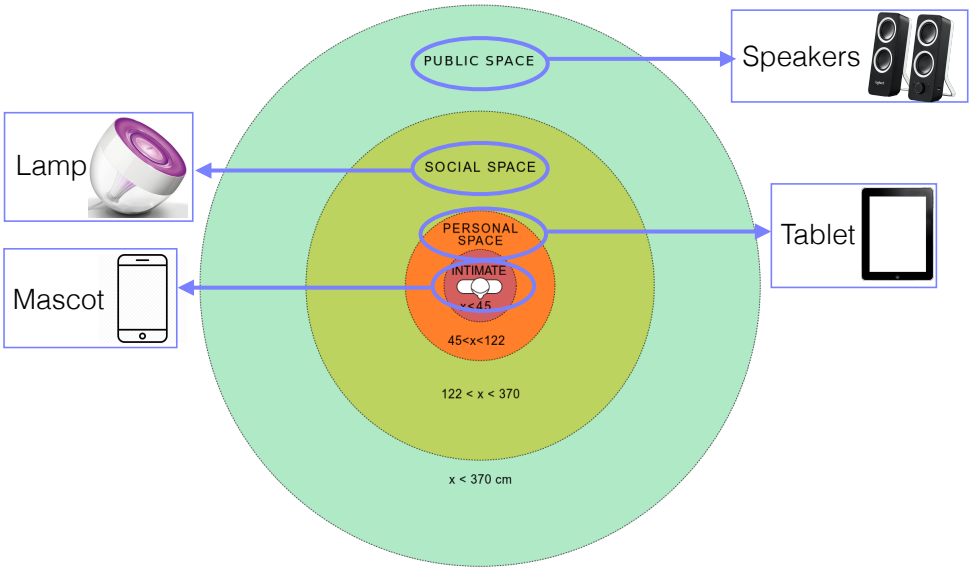


Figure 3.1: Visual representation of Procexics Theory with distances and associated devices selected for this study.

After identifying case-studies, we apply the concept of personality in the context of social devices by assigning personality trait to each mascot. In our prototype, mascots are dynamic and tablet, lamp and speakers are static devices. The movements of dynamic devices, interacting with all other devices effect the environment (i.e the state of interacted devices). Thus, we assigned a unique

personality to each dynamic device which we cover in the following section.

We now can take a closer look at the interactions represented by each case study:

- **Mascot - mascot** interaction, as mascot approaches another, they both start to vibrate where the duration of vibration depends on the personality of approaching mascot.
- **Mascot - tablet** interaction, as mascot goes close to the tablet, the background color of a screen starts to change based on the personality of approaching mascot.
- **Mascot - lamp** interaction, as mascot goes close to the lamp, the lights start to change their colors based on the personality of approaching mascot.
- **Mascot - speakers** interaction, as mascot approaches speakers, the music start to play the genre based on the personality of approaching mascot.

Each of these interaction types are characterized by actions such as phone vibration, background screen color change, lighting color transformation and music play. Since these actions are triggered based on the personality trait of approaching mascot, we need to associate personalities with more specific actions. The identification of these action will be described in Sections 3.3, 3.4 and 3.5.

3.2 Identifying personality traits

In our prototype, personality is the primary focus of our investigation and it is based on the Big Five Personality Models which we briefly described in the related work Section 2.7. Costa and McCrae integrated their five factors model with many other personality schemes of that time. Moreover, their enhanced scheme forms the basis of the "NEO-Personality Inventory-Revised" which is a widely used measurement scale [31]. The NEO-PI-R constitutes five personality traits which we also refer as personality dimensions or domains. These personality traits are **O**penness, **C**onscientiousness, **E**xtraversion, **A**greeableness and **N**euroticism (also known as OCEAN Model). Each of these personality dimensions is composed of six facets which are described in Table 3.1.

In addition, the enhanced scheme of Costa and McCrae (see Table 3.1) helps us in forming questionnaire that we use in our study. The questionnaire is a Likert scale containing 30 personality facets instead of five personality dimensions. Participants measured each facet with such device behavior as music, color and vibration level (see Chapter 5). The questionnaire consists of 30 questions including all six facets of all five dimensions based on NEO-PI-R measured scale [31]. The reason of not giving participants five questions consisting of the personality dimensions as a measurement is the desire to get more detailed feedback from them. Personality dimension are too broad, and as a result leads

Personality Traits	Personality Facets
Openness	Fantasy, aesthetics, feelings, actions, ideas, values
Conscientiousness	Competence, order, dutifulness, achievement striving, self-discipline, deliberation
Extraversion	Warmth, gregariousness, assertiveness, activity, excitement seeking, positive emotions
Agreeableness	Trust, straightforwardness, altruism, compliance, modesty, tender-mindedness
Neuroticism	Anxiety, angry hostility, depression, self-consciousness, impulsiveness, vulnerability

Table 3.1: Personality facets associated with the five dimensions of the Costa and McCrae five factor model of personality

to less powerful predictions of behavior [32]. Moreover, participants may not be familiar with OCEAN model and giving them the description of each personality domain might assign them our opinion and might be biased. In this sense, it would be desirable to have a longer questionnaire which measured traits at both the domain and facet level to have a better understanding of which features of a trait influence aesthetic preference. Facets would provide greater descriptive details and a better understanding of the personality in comparison to traits.

In addition, considering human-human interaction, people reflect the mixture of all these personality traits with a different proportions. A person who is highly straightforward and modest (facets of agreeableness personality see Table 3.1) also can have such facets as achieving striving and dutifulness in different proportions (facets of conscientiousness personality). Thus, since human personality has a more complex pattern, while applying this concept to social devices, we decided to simplify it. That means, If the mascot is assigned agreeable personality, we are planning to consider only this trait, by making this device, for example, highly trustworthy, and extremely modest and neglecting all other personality traits.

3.3 Identifying the vibration level based on the personality traits

First, we can consider the case of vibrating mascots, where the vibration level represents or at least gives a clue about which type of personality the approaching mascot has. In order to associate the level of vibration with a certain personality trait, we make an assumption about the vibration being conceptualized as a quality of self-expression that can be characterized as assertive behaviour. Depending on the personality of the device, the levels of assertiveness, which are presented as vibration levels, will differ. Since we decided to base our theory on the Big Five Personality Model, which, as its name implies, is characterized by five factors, the

vibration levels in our system will vary from one to five (where L1 is scored as the lowest level of assertiveness and L5 represented as a highly assertive personality). Subsequent studies [26, 27, 28, 29] investigated the relationship between assertiveness and five personality factors (i.e extraversion, neuroticism, openness to experience, agreeableness, and conscientiousness). The consistent findings of the differences in personality traits between assertive and non-assertive behaviors which are described in these papers can aid in developing our prototype.

In the following study [26], authors describe the correlation between assertiveness and personality traits based on regression analysis. This analysis together with a correlation coefficient presented in Table 3.2 [26] shows that neuroticism, extraversion and conscientiousness factors are the main predictors of assertiveness having a p-value<.01 (denoted with asterisks) which indicates the significance of the relationship between these variables. The factors of agreeableness and openness to experience have shown no significant relationship in predicting assertiveness.

	N	**E**	**O**	**A**	**C**
N	1.000				
E	-.423**	1.000			
O	-.047	-.001	1.000		
A	-.253**	.351**	.057	1.000	
C	-.356**	.387**	.091	.0263**	1.000
asseriveness	**-.253****	**.241****	**-.002**	**.064**	**.225****

Table 3.2: Correlation Coefficients between personality traits and assertiveness

Based on Table 3.2, there is a linear correlation between extraversion and conscientiousness with assertiveness. Conversely, the inverse relationship between neuroticism and assertiveness makes this personality traits the lowest predictor. In addition, the authors did not find any significant relation between agreeableness and openness with assertiveness. We considered this table as an example, and the results found in other works [27, 28, 29] are also consistent with the results shown in this table. On the one hand, the high level of assertiveness and extraversion can be explained as individuals with this type of personality tend to seek stimulation from the environment that helps them to assert their opinions without hesitation or to take the initiative while starting a communication with others. In the case of conscientiousness, since these individuals are more concentrated and goal-oriented, they may see assertiveness as a tool to achieve these goals. A neurotic personality trait, on the other hand, is characterized by people who are unable to assert or approve themselves and have difficulty in coping with stressful interpersonal situations which explains why assertiveness and neuroticism are inversely correlated to each other.

However, the relationship between openness and agreeableness personality traits

with assertiveness is more ambiguous, in order to draw a conclusion out of it. Unfortunately, in many research papers that we studied, the correlation between these personality types and the level of assertiveness is not significant. In order to make an assumption about what level of vibration would better characterize these two personality dimensions, we need to refer to other factors. For example, in addition to assertiveness, we can also consider which motives or needs these individuals pursue and therefore, make an assumption based on this additional factor. The authors of the following papers [30] studied the relationship between personality traits and needs and provided us PRF (The Personality Research Form) pattern, which measures 20 needs that each personality trait may have. Before we study the PRF pattern, let us examine what are the characteristic features inherent in these two types of personalities.

In the following book [20], openness to experience personality trait is described as a more open individuals with a deep imagination, who are always open to new knowledge, to some extent even curious and inquisitive and have wide interests. Given these characteristics, we can consider the needs and motives that these traits have according to the PRF pattern. The examination of this pattern may help us to understand how individuals behave in a wide variety of situations. For example, according to Table 3.3, the high score of CH describes that individuals with openness personality dislike routine and avoid it, readily adapts to changes in the environment, which show how much they appreciate variety. The high level of UN scale shows that open individuals want to understand different areas in order to satisfy intellectual curiosity. Whereas the low level of HA describes their adventurous side of the personality. All these scales demonstrate the types of behaviors that openness personality may show to fulfill their needs. Consequently, we can make an assumption that individuals high in openness personality trait generally behave in a relatively assertive manner (i.e they take the initiative, lead discussions) in order to broaden their knowledge. By relatively, we mean that the level of assertiveness needs to be less than the in extravert and conscientiousness and more than neuroticism personality since they are the main predictors of assertiveness and the results have high significant value. The level of vibration that we can assign to our mascot with this personality trait is L3.

Agreeableness is described as a personality trait that is perceived as sympathetic, kind, warm, generous, helpful, forgiving, friendly, unselfish and gentle personality [20]. In addition to this definition, having examined the Table 3.3 we will analyze their goals, motives and needs that they fulfill while communicating with others. For example, this type of personality has a high score in AB, NU, HA and low level of AG, DO. To summarize, the Table 3.3 gives us clues that individuals who are high in agreeable personality like to be modest, tend to be self-effacing, does not need and want to be the centre of attention. According to the needs of this personality trait, they can also be interpreted as being shy individuals who feel tense in the presence of others. Thus, making plausible for us to assume that, in general, people high in agreeableness behave less assertive than ones who are low in this personality trait. This shows that the level of assertiveness that

Table 3.3: Joint Factor Loadings for NEO-PI Factors and PRF Scales

PRF scores	**O**	**A**
Social Recognition (SR)	-10	-19
Defendence (DE)	-13	**-48**
Succorance (SU)	**-34**	18
Affiliation (AF)	-13	19
Exhibition (EX)	23	**-31**
Play (PL)	07	-06
Understanding (UN)	**64**	10
Change (CH)	**60**	-12
Sentience (SE)	**53**	13
Autonomy (AU)	**47**	-26
Harmavoidance (HA)	**-52**	**32**
Abasement (AB)	12	**58**
Nurturance (NU)	10	**55**
Dominance (DO)	**45**	**-46**
Aggression (AG)	14	**-68**
Achievement (AC)	**46**	02
Order (OR)	-25	-17
Endurance (EN)	**33**	15
Impulsivity (IM)	24	03
Desirability (DY)	07	10

agreeable people have should be relatively less than who have high openness personality. The level of vibration that we can assign for this personality trait is L2.

To summarize, the vibration level values that we assigned for each personality traits in our system are the following:

- L1 is assigned to the mascot with neuroticism personality trait where the vibration has the lowest level of amplitude (i.e 100 milliseconds per time).
- L2 is assigned to agreeableness (i.e 200 milliseconds per time)
- L3 is assigned to openness to experience (i.e 300 milliseconds per time)
- L4 is assigned to conscientiousness (i.e 400 milliseconds per time)
- L5 which represents the highest vibration level and the longest duration is assigned to extravert personality trait (i.e 500 milliseconds per time)

3.4 Identifying the music preferences based on the personality traits

The next case-study that we consider is the mascot-speakers interaction. When a person holding a mascot approaches the speakers, the music starts to play according to the personality of an approaching device.

People use their favourite music as a badge of social identity to share information about themselves with others [33, 34]. Given that they see music as a tool for revealing one's personality characteristics [35], in our study, we make the assumption that music can be a good representation of the personality of social devices.

For years researchers have investigated the correlation between genres of the music and personality traits [40, 39, 36, 41]. However, the genre labels can be biased and subjective, meaning that the user or participant might have a different understanding of these genres [37]. Thus, genre labels might not be able to fully describe someone's music preference. The preferences focused on genres are limited in several ways and the authors of the following paper tried to give a more nuanced assessment of music preferences.

Rentfrow and Gosling [38] were first who provided a categorisation of musical genre preferences that were not based on exemplary genres but on the musical characteristics that make the genre within a dimension unique. They developed a five-factor model of music preferences in terms of the following orthogonal dimensions: **M**ellow, **U**npretentious, **S**ophisticated, **I**ntense, and **C**ontemporary abbreviated as MUSIC [37]. The fact that preferences for each dimensions are independent of the preferences from the other dimensions makes this model orthogonal. Before associating these music dimensions with the Big Five personality factors, we would like to take a close look at other music patterns.

While categorizing music preferences, other authors proposed a different number of music genres and dimensions. For example, George et al [39] studied 30 music styles and revealed eight categories. Schafer and Sedlmeier [40] used 25 genres and found six dimensions. Whereas, Rentfrow and Gosling decided to arranged 23 styles into five dimensions. The authors also validated their categories in 3 different studies using a large sample size which makes this model robust. Moreover, using the parsimonious number of musical genres is important since otherwise, it would result in too few studies falling within a single category. Thus, we expect that the MUSIC model is the most elaborate and robust multidimensional framework to date for conceptualising and measuring music preferences and personality traits.

We, now, take a close look at each dimension of MUSIC pattern. The factor analysis of the music preferences from each of three studies proposed five dimensions: **m**ellow, **u**npretentious, **s**ophisticated, **i**ntense, and **c**ontemporary:

- The first factor features the following attributes: romantic, relaxing, quiet,

slow, sad, unaggressive. Examples of music genre that might describe this category are smooth jazz, R B/soul, soft rock, adult contemporary, electronica, mainstream country and so on.

- The second factor is described with uncomplicated, soft, acoustic pieces of music and is from new country, bluegrass, rock-n-roll, mainstream country, soft rock, religious, pop music genres.
- The third factor is perceived as inspiring, intelligent, complex, and dynamic including avant-grade classic, classical, traditional jazz, world beat, electronica, adult contemporary genres.
- The fourth factor features loud, aggressive, and not relaxing attributes. The music genres that describe this factor are punk, classic rock, heavy metal, and power pop.
- The fifth factor is defined as not sad, percussive, and electric pieces of music and are from rap, R B/soul, europop, electronica genres.

Given the description of each of the musical dimensions, we can now correlate them to personality traits. The scientific predictions or assumptions that we are going to make are based on empirical patterns. In a review of the following papers, we found a relatively stable relationship between the above-mentioned MUSIC factors and Big Five personality [44, 45, 46, 47, 48]. The most consistent positive correlation that we have noticed within all these papers was between openness to experience and Sophisticated dimension. Meaning that participants who scored high in openness liked Sophisticated music more than those participants who scored low. However, one should expect them also show heightened preference for Mellow musical styles. The next significant relationship that the authors mentioned was the linear correlation between extraversion and Contemporary which includes rap, R B/soul, europop, electronica music genres. Agreeableness is correlated with linking for Unpretentious music category. Comparing the relationship between openness and extraversion and the music categories fits them, the correlation between agreeableness and its musical dimension is more weak. Moreover, it was also difficult to find the strong correlations between conscientiousness and neuroticism personality traits and MUSIC factors which are also consistent across all above-mentioned studies. Thus, we are planning to make a weak assumption that individuals with the conscientiousness and neuroticism are inclined to enjoy Unpretentious and Contemporary music respectively. In addition, the results across all these papers suggest the negative correlation between neuroticism and conscientiousness with Intense dimension. We believe that the knowledge of the negative relationship between these variables will aid us to eliminate the possibility that participant during experiments might assign this personality traits to this music genre.

To summarise the categories that we decided to assign to each personality trait in our prototype are the following:

- Openness to experience will be linked with Sophisticated dimension. Meaning that when the mascot with this personality trait will approach the speakers, the avant-grade classic, classical, traditional jazz, world beat, electronica, adult contemporary music genres will be played.
- Extraversion which will be linked with Contemporary music will imply that as soon as the extravert mascot will come close to the speakers, the rap, R B/soul, europop, electronica music genres will be played.
- Agreeableness will be linked to the Unpretentious dimension which consists of new country, bluegrass, rock-n-roll, mainstream country, soft rock, religious, pop music genres.
- Conscientiousness will be linked Unpretentious
- Neuroticism will be linked Contemporary

Additionally, we assume that assigning a music category to each personality trait, as opposed to assigning a particular genre, will help participants to broaden the understanding of music preferences. Therefore, with the help of the arrangement of these genres into categories, the correlation between personality traits and Music categories will be less varied. Moreover, in order to help participants to better understand the system and the personality of a mascot, instead of giving to them a questionnaire with the list of songs and with the genres that they belong to, our system plays the music from each dimension category. The main reason for doing that is to measure the personality traits at the right level of specificity. Zuckerman, Kuhlman, and Camac [42] pointed out that the level at which one should evaluate personality characteristics depends on the purposes for which these characteristics are being assessed. This leads us to the decision to add a context to our experiments. We expect that participants seeing the mascot affecting the environment (e.g triggering speakers to play the music), will be able to measure mascots' personality according to their activities and the change of environment as a result of that behavior.

3.5 Identifying the color based on personality traits

In this section we consider two case studies: mascot-lamp and mascot-tablet interactions. Both of these interaction types are represented by the color change such as lighting color and background screen color respectively. The two scenarios that we considered are the following: when a person holding a mascot comes close to the lamp in first scenario and to the tablet in the second scenario, the lighting or the screen changes their color according to the personality of approaching mascot.

Before we design the system, it is necessary to understand and clarify the characteristics of the colors and therefore associate them with a description of the

personality traits. There are many research papers from a variety of disciplines that describe the relationship between color, behaviors, and personality traits. For example, Max Lüscher [21] found out the effect of color preferences on the human behavior which, therefore, may help to determine personality trait. Herman Cerratto in his work [22] characterizes colors by dividing them on their positive and negative aspects. The following table 3.4 is adapted from various research papers [21, 22, 23] and summarizes the characteristics of the colors that we later apply to the design of our prototype.

Colors	**Affective Aspects**
Red	energy, strength, attention-seeking, exciting, warm, spontaneous, assertive and confident, aggression and anger, quick-tempered, ruthless, fearful, intolerant, pain
Black	depressing and pessimistic, secretive and withholding, conservative and serious, sadness and negativity
Yellow	cheerful, happy, playful, fun, optimistic, uplifting, illuminating, logical, mental clarity, aids decision-making, originality, creativity, challenging, academic and analytical, communication of new ideas
Orange	warm, sociable, optimistic, enthusiastic, cheerful, adventurous, risk-taking, vibrant, flamboyant, stimulating to the senses, self-confident, independent, extroverted and uninhibited, attention-seeking, encourages to socialize
Pink	compassion and understanding, nurturing, warmth, hope, calming, sweetness, naiveté, innocence and inexperience
White	innocence, purity, cleanliness, simplicity, self-sufficient, pristine and open, new beginnings
Turquoise	communication, clarity of thought, balance and harmony, calmness, idealism and inspiration, self-expression
Green	growth and vitality, renewal and restoration, self-reliance, reliability, being tactful, emotionally balanced and calm, practical and down to earth, generous, kind and loyal with a high moral sense, adaptable and flexible
Blue	loyalty, trust and integrity, tactful, caring and concerned, reliability, responsibility, perseverance, idealistic and orderly, authority, devotion and contemplation, peace and calm

Table 3.4: Color meaning

Based on the characteristics describes in Table 3.1, we now can correlate some aspects of colors to Big Five personality dimensions. For example, according to the following papers [24, 25], the black color represents intense anxiety, fears, depression, upset, hostility and the red color may connote facets that varies from happiness, excitement, intense, stimulating to aggression, hate, hostility. Some

of these facets [30] belong to the neuroticism personality trait. Thus, in order to convey the **neuroticism personality trait**, we decided to apply the mixture of these two colors which lead us to the dark shade of the red which we refer to as blood-red color.

Herman Cerrato in his paper explains the meaning of turquoise color as a separate color, whereas all other research papers concentrate on blue and green colors. Since turquoise is a mixture of pale blue and green colors, we decided to combine these colors and refer it as turquoise. Based on the reported aspects of these colors (see Table 3.4), we can associate turquoise with **conscientiousness personality trait**. Especially, the characteristics of turquoise color such as clarity of thought, self-expression, self-sufficiency reported in Table 3.4 matches the facets that constitute conscientiousness personality.

Yellow color signifies warmth, creativity, adventures, logic, openness to new ideas, freedom (see Table 3.4). According to the Max Lüscher, this color refers to one's desire for development with which emotions and feeling are associated. Since openness personality portrays such facets as imagination, adventurousness, intellect, ideas and so on [30], we assume that the meaning of yellow color matches these facets. Therefore, we expect yellow color to convey **openness to experiences personality trait**.

Despite the fact that some characteristics of red color also can connote extraversion personality, there are also some negative aspects of this color such as aggression, fearfully, hostility and so on which may also represent neuroticism personality trait. Thus, we decided to emphasize the negative side of red color by mixing it with black color, in order to highlight the neurotic personality trait even more. Meanwhile, for extraversion personality trait we decided to pick orange color. According to the spectral colors, orange is the color between red and yellow on the spectrum of visible light. Orange combines the energy of red color and the cheerfulness of yellow [22]. Orange color represents optimism, cheerfulness, self-confidence, encouraging to socialize which constitute the facets of **extraversion personality trait**. Thus, by assigning an orange color to our social device, we hope that participants will interpret our mascot as an extravert.

For **agreeableness**, we assume that softer shade of pink can convey this personality trait. Psychologically pink is associated with compassion, understanding, warmth, innocence and calming aspects. White color also represents innocence, purity, openness in terms of straightforwardness (see Table3.4). The affective aspects of both of these colors constitute the facets of agreeable personality trait [30]. Since white is achromatic and has no hue, we decided to combine pink and white colors, which lead us to the softer shade of pink color. Therefore, we hope that pink color (i.e soft pink) connotes agreeableness personality trait.

To summarise the colors that we decided to assign to personality traits in our mascot-tablet and mascot-lamp interaction are the following:

- Blood-red color is assigned to the mascot with neuroticism personality trait

- Turquoise color is assigned to the mascot with conscientiousness personality trait
- Yellow color is assigned to the mascot with openness personality trait
- Orange color is assigned to the mascot with extraversion personality trait
- Pink color is assigned to the mascot with agreeableness personality trait

Vibration

Neuroticism	L-1 (100 ms)
Agreeableness	L-2 (200 ms)
Openness	L-3 (300 ms)
Conscientiousness	L-4 (400 ms)
Extraversion	L-5 (500 ms)

Music

Neuroticism	Contemporary
Agreeableness	Unpretentious
Openness	Sophisticated
Conscientiousness	Unpretentious
Extraversion	Contemporary

Colors

Neuroticism	Blood-Red
Agreeableness	Pink
Openness	Yellow
Conscientiousness	Turquoise
Extraversion	Orange

Figure 3.2: The assignment of all personality traits with corresponding actions.

Chapter 4
Implementation

This chapter is structured in the following way. In Section 4.1 we assist end users to use the system. In Section 4.2 we will take a look at the project structure. Section 4.3 describes how the project can be deployed and configured. Section 4.4 covers system architecture, namely the communication protocols, frameworks and APIs that are used in the prototype. Finally, in Section 4.5, we describe technical requirements and hardware used in the system.

4.1 User Documentation

When a user runs the android application for the first time, it displays the form that a user has to fill in order to configure his phone. For that, the user needs to follow the steps:

- User can choose the beacon ID that will help this application to measure the distance between devices.
- User can give his mascot a custom name.
- User is required to choose one out of five personalities displayed on the screen.

After pressing the next button, such information as beacon ID, the type, name and the personality of th device send as post request to the server and saved in the database. Starting from here, user can put his phone into pocket and interact the environment by walking around and approaching other devices such as other phones, lamps, speakers and tablets. The application start to measure

the distance to all other beacons according to the users's movements and sends this information to a server.

4.2 Project Presentation

The project consists of client side which are two Android applications for phone and tablet; and server side which maintains the decision point for the whole system.

The `AutonomousSystemThesis` consists of three directories:

- `MyMascotApp`: The android application registers the phone in the system and measures the distance from phone and to all beacon tags located in the room.
- `MyTabletApp`: The android application that is registering the tablet in the system and displaying colors according to the personality of approaching mascot
- `server`: allows the managements of all devices and beacons and maintains the decision point

The structure of the whole system is demonstrated in Figure 4.1.

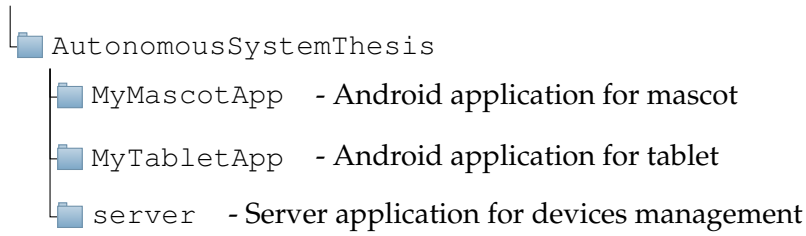


Figure 4.1: The folder structure of the whole system

4.3 Configuration

The `AutonomousSystemThesis` can be configured in the following way.

To run the server, we pass the following arguments in the terminal:

```
1 mvn spring-boot:run -e -X -Dspring-boot.run.arguments= –hueUsername=<hue_username>,
      –hueIPAddress=<hue_ip_address>
```

Here, *hueIPAddress* is a IP address assigned to our Philips Hue bridge. Since you will have your own smart lamps, you will need to discover the IP address of

your bridge. The more detailed instruction of how to discover IP address and username of your bridge you can find in official Philips Hue Documentation:[1]

4.4 System Architecture

For multi-device support used centralised architecture, where all devices inform the server about their state in real-time. Subsequently, server changes the states of all other devices accordingly. Moreover, centralised system has a simpler design which excludes any consensus problem. All devices communicate with each other through the server that makes the main decision.

4.4.1 Module descriptions

`MyMascotApp` is an Android application that has the following features:

- The application registers the phone in the system, namely the ID of a beacon that it is attached, mascot custom name and the personality of a mascot.
- The application measures the distance from the device (phone) to all other beacons in the system.
- The application vibrates the phone with the vibration duration that server sent to it.

`MyTabletApp` is an Android application that has the following functionalities:

- The application registers the tablet in the system, namely ID of a beacon that it is attached to it.
- Every second, the tablet application polls data from the server, where as a response it gets specific color code.
- The application changes the background color of a screen to a color that it retrieved from server.

`server` is an server application that has the following features:

- Manages a database that consists of three tables (devices, distances and personality).
- Implements controllers that handle the client requests such as post requests of device initialisation, distances and get requests of required data from database.

[1] `https://developers.meethue.com/develop/get-started-2/`

- Server checks with if else statements whether the distance of all devices falls into the predefined distance range of the Proxemics theory.
- When the user reaches the lamp, the server requests Philips Hue API to change color based on the personality retrieved from the database.
- When the user approaches speakers, play audio files concurrently using the Audio File Play utility ors `afplay`.

The structure of the server application is demonstrated in Figure 4.2.

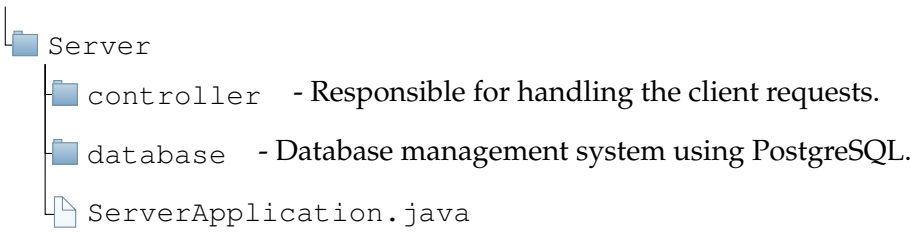


Figure 4.2: The folder structure of the server application

The communication between devices and the workflow of the system is described in Figure 4.3. The figure describes the interaction between two phones and step by step including requests that client and server send each other.

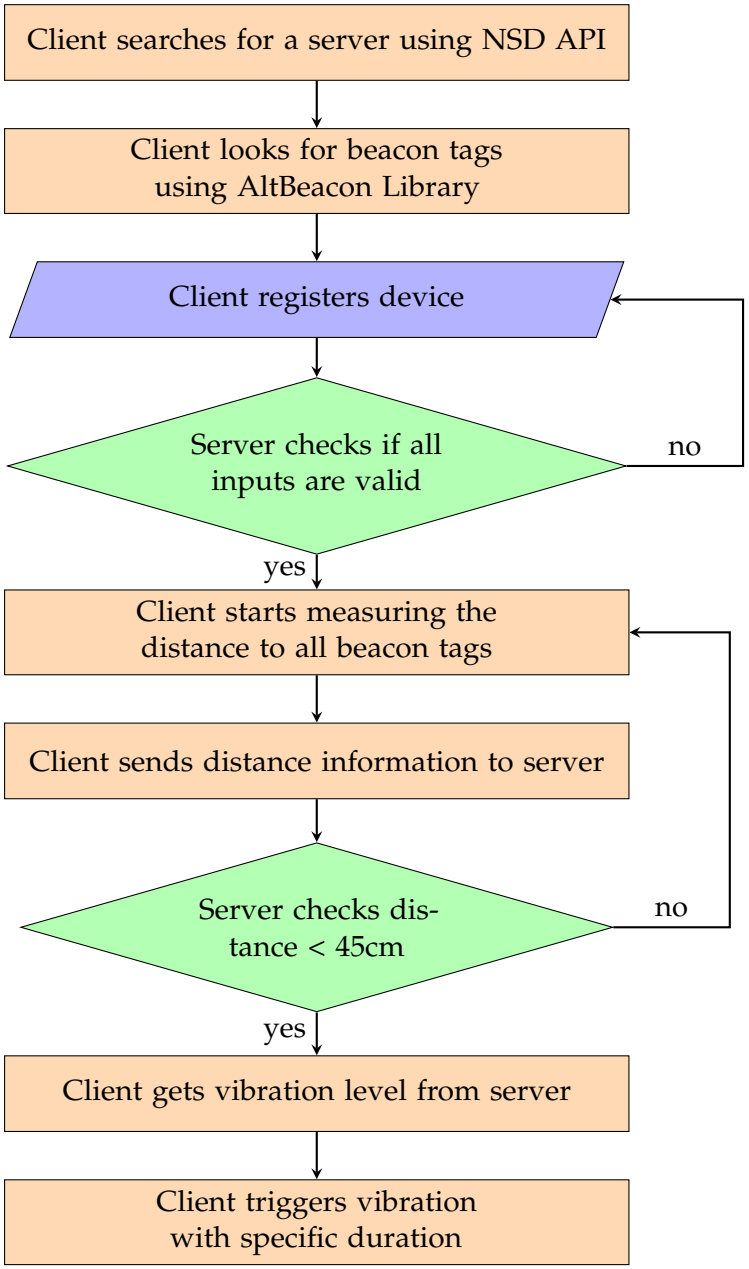


Figure 4.3: The interaction between two phones and a server with the libraries and APIs that it is using

4.4.2 Software Stacks

The following programming languages, frameworks and APIs were used to implement the system.

For the client applications:

- Android framework with Java language.
  - NSD API (Network Service Discovery)
- AltBeacon Library.

For the server side:

- Spring Framework with Java language.
- DNS-SD.
- Philips Hue API.
- Music Playback component.

AltBeacon Library is a library that provides APIs to interact with beacon tags. Beacon tags are broadcast-only which communicate by signaling their proximity to the Android applications. With the help of AltBeacon Library, `MyMascotApp` detects beacon tags nearby and use this information to measure the distance. The accuracy precision that `MyMascotApp` can measure the distance is around .5 meters with a 10 second margin for new positions.

NSD API (Network Service Discovery) is an Android implementation of Multicast DNS. In order to make requests the Android applications need to know the IP address and port of services. NSD API helps the client to discover the server. `NSDHelper.java` module allows the client-applications to find an HTTP server in the local network that supports services that clients are interested in.

DNS-SD. The specification that we have given to the terminal are:

```
1 dns-sd -R mythesis _socialiot._tcp local 8080
```

In these specifications, ***mythesis*** is a service name; ***_socialiot._tcp*** is a service type; ***8080*** is a port number with domain type ***local***.

Philips Hue API helps our server to control the hue system. With the help of API server can directly input commands such as changing light color. First server retrieves such parameters as hue, brightness and saturation from database and sends them to the Hue bridge through specific API. All philips hue lamps in the system needs to be connected to the Philips Hue Bridge which in turns help them to communicate with each other via internet.

The important note for the implementation part is that all devices such as Philips Hue Bridge, server, phones and tablet have to be connected to the same network.

4.5 Technical Requirements and Hardware

The system comprises of the following devices: the phone with an attached beacon tag, the lamp with a beacon tag, the tablet with a beacon tag and speakers with beacon tag. Using the beacon tags that are located right near all devices, Android applications will be able to measure the distance from themselves to all other devices.

Additionally, the following pre-requisites have to be met:

- Philips Hue lamps to be connected to the local network.
- The android application with the location and the Bluetooth permissions granted.
- The android application the operating system in order to use Bluetooth BLE should be higher than 6+.
- The server must be running on macOS to use `afplay` utility.

Chapter 5
User Study

5.1 Participants

In total, 25 volunteers participated in this study, where 13 of them were male and 12 female students. The sample was drawn from university populations having an age range from 19 to 31 years with a mean age of M = 26.12 (SD = 3.1). Participants were selected from various discipline areas (see Figure 5.1). We consider academic disciplines as three categories (Social, Natural and Formal Science) where almost 30% of participants are from social sciences and 70% from formal sciences. Moreover, the participants had a different education levels: the majority of them were studying Masters's degrees, and only 32 percent were Bachelors's and Ph.D level students (see Figure 5.2).

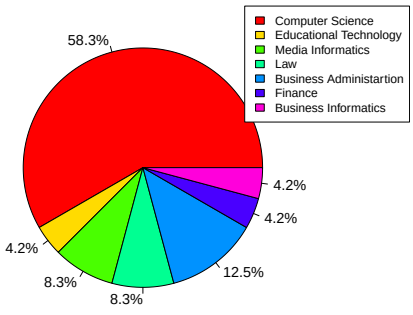


Figure 5.1: Participants' majors obtained from Demographics questionnaires

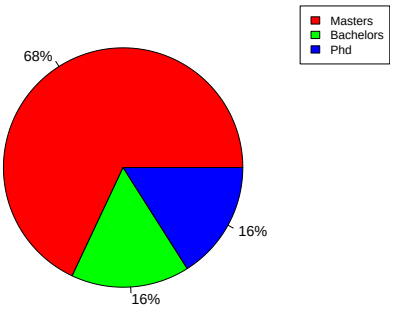


Figure 5.2: Participants' education level obtained from Demographics questionnaires

In the demographics form, participants also informed how frequently they used such devices as phones, smart lamps, tablets, and speakers (see Figure 5.3 and Figure 5.4).

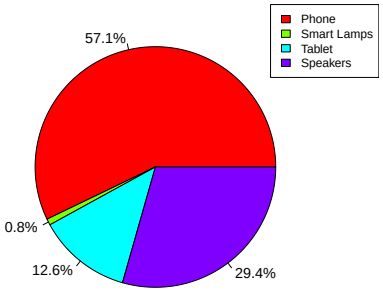


Figure 5.3: Participants' use of devices obtained from Demographics questionnaires

Overall, the experience level with above mentioned devices is listed in descending order: phone, speakers, tablet, and smart lamps. Figure 5.4 shows how many hours participants spend on these devices per day. The demographics questionnaire showed that the most popular device among our participants were phone with approximately 1/3 of participants who spent more than 6 hours on them. In all time ranges, the speakers were the second most used devices in comparison to the number of participants using of tablet and smart lamps.

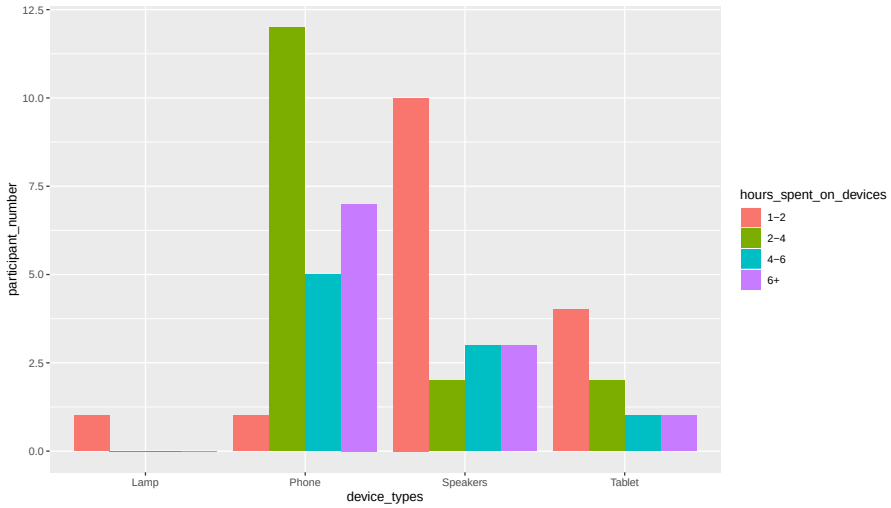


Figure 5.4: Participants' device use in hours obtained from Demographics questionnaires

In addition, Table 5.1 describes the participants' preference of the music genres. The more fluent the participant would be with the music, the more rapid becomes the assessment of genre-specific features [Gjerdigen, R.O., Perrot, D., 2008. Scanning the dial: the rapid recognition of music genres]. Moreover, if the majority of participants prefer to listen or like certain genre of music, it may result in biased opinions. The mascot that triggers genre that they prefer may give participants more positive impression about their personality. Thus, the main reason of gathering data regarding participants' the music preferences was to see whether the liking factor affects the study or not.

According to the One-Sample t-test with $p>.05$, there was no significant effect of the participants' music preference on the music genres that we chose for our study. Thus, we have insufficient evidence to conclude that one music genre is more preferable than the other. Meaning that, among the genres of music that we have chosen for our experiments, there were no distinguishably favorite genres and the participants had different music tastes (see Table 5.1).

5.2 Procedure and Tasks

When the experiment started, first, the participants were given an introductory paper describing the following aspects:

- The implemented prototype introducing the devices used in our study
- The key idea of a study
- The purpose of the experiment

	t-value	df	mean	p-value	95 percent confidence interval	
					lower	upper
Country	1	24	.04	.32	-.04	.12
Pop	3.7	24	.36	.001	.15	.57
Hip-hop	1.8	24	.12	.08	-.02	.26
Rap	1	24	.04	.33	-.04	.12
Jazz	2.4	24	.2	.022	.03	.37
Classic	3.1	24	.28	.005	.09	.47
Rock&Roll	1	24	.04	.32	-.04	.12

Table 5.1: T-test for participants' familiarity with music genres used in our study

- The goal of the participants during experiment
- The number of phases and the overall duration of the experiment

Regardless of the introductory paper, the participant was allowed to ask open questions. After agreeing and signing the consent form (see appendix A), the main part of the experiment took place.

In general, we have 4 phases for each of interaction types: mascot-mascot, mascot-lamps, mascot-tablet, mascot-speakers. The order of all phases were counterbalanced by using Latin Square. Each phase consists of 5 videos with a duration of 20 seconds, with the exception of mascot-speakers interactions where we have 9 videos with duration 40 seconds long. Moreover, for each participant, there were a different order of displaying the videos which are also randomized inside each phase based on the Latin Square. All phases and all videos within those phases were counterbalanced across all participants. Moreover, each participant was tested alone to ensure that the opinions of other participants do not affect their own.

Before each phase, we describe the participant what kind of interaction they should expect from video and remind them their goals during that experiment. The goal is that, after watching short videos, participants will need to evaluate the personality of a mascot according to the interaction that they have seen in the videos. When accomplishing watching the video, the participants were given a questionnaire (see appendix B) with 30 Likert scale questions and were asked to rank the personality trait on a scale of 'Strongly Inaccurate' to 'Strongly Accurate'. When this is done the experiment continues to the next video. After accomplishing watching all the videos in one phase, we move forward to the next phase.

In addition, the only phase where the participants are given an extra phone is the mascot-mascot interaction phase, where two mascots start to vibrate with a different duration based on the personality of approaching mascot. Since it is difficult to see or hear the vibration from these videos, the phone runs an application to simulate the different levels of a vibration that we showed

participants in the video. After watching the video, the participants were again given a questionnaire in order to assess the personality of a mascot based on the video that they have seen and the vibration that they have felt.

After finishing the experiment, the participants were given a demographic questionnaire with general information about themselves and their preferences. The reason for giving this questionnaire at the end of the experiment was in order to not to affect the opinion of the participants. Giving personal questions up-front, respondents can feel concerned that their personal information is going to be linked to the experiment and therefore, knowing which characteristics will be taken into the account by the researchers, they may try to fit their responses to the demographic questions that they filled.

The experiment, overall, lasts from one hour to hour and a half, depending on the speed of participant to fill the questionnaires.

Figure 5.5: The snapshots of videos from each case-study presented to the participants[2]

5.3 Design of experiments

It should be noted that as a design of the experiment we did not include a real-life interaction with devices, but instead, we showed participants videos containing the interaction between these devices. The main reason for that was the distraction of participants on various factors.

From an implementation perspective, the application using BLE (low-energy

[2]During the experiments the faces in the videos were not hidden, for this document we hided faces with a nice smiley icon.

Bluetooth) technology measures the distance between objects is highly accurate and precision, it can measure the distance from the phone to the beacon tag with a margin error of 1cm which is a very good result. However, the position histories are saved every few seconds [Location Aware Tracking with Beacons Gary Mansell, Kevin Curran] and since the application measures the distance every millisecond, the current distance can only be saved after a few seconds.

Moreover, the step of one person covers several centimeters at once, and the application calculates each of these centimeters at a time. Since asking participants to move slower or with small steps may distract them by focusing on their own behavior rather than on the assessment of the mascot's personality, we decided to use videos in our experiments. Moreover, having tested many other commercial applications that measures the distance between objects, we noticed the same limitation.

Another design decision was instead of showing one video with all interaction types, we split it into 5 short videos for mascot-lamp, mascot-table, mascot-mascot each and into 9 short videos for mascot-speakers cases. Even thought our prototype supports multi dimensional device interactions (i.e multiple mascots can interact with lamp, tablet, speakers and other mascots at the same time), we decided to split interaction types into four phases. The main goal was to help participant to focus on one interaction and make it easier for them to evaluate the personality of mascot.

5.4 Apparatus and Materials

The experiment's setup consisted of the following devices:

- MacBook Pro running Mac OS Catalina (Version 10.15.2)
- 55-inch monitor with built-in speakers for music play
- tablet to fill questionnaire in the google forms
- Nexus One for simulating the vibration during mascot-mascot interaction

As a survey tool for collecting data from participants, we used Google Form which consisted of the thirty Likert scale type questions scaling from 'Strongly Inaccurate' to 'Strongly Accurate' scales. Subsequently, in order to use obtained data in our statistical analysis, the questions from our survey tool were transformed in a more permanent form (i.e four CSV files were generated, one for each phase).

5.5 Design of a study

The study consists of four case-studies: mascot-lamp, mascot-table, mascot-mascot and mascot-speakers interactions which, therefore, designed as four phases during experiments. The experiment was a within-subjects design where each participant tests all conditions within each phase. For example, for mascot-lamp phase each participant watch all five videos and evaluates the personality of a mascot for each lighting color separately. The within-subjects in comparison to the between-subjects design can help us to reduce errors associated with individual differences. Individual participants have different backgrounds, contexts, levels of concentration and so on. The same participant interacting with all 4 phases, will affect the result in the same way which can the lower the probability that individual differences will skew the results. Moreover, the within-subject design requires fewer participants, which may lead us to the streamlined process of an experiment.

In our study the independent variables (IVs) are factors that are triggered due to the behavior of a mascot. For each case-study, we have different number of IVs which are the followings:

- For mascot-lamp case-study, there are five variable: turquoise, blood-red, yellow, orange and pink lighting colors
- For mascot-mascot case-study, there are five vibration levels varying from 100 to 500 milliseconds per time
- For mascot-speakers case-study, there are nine songs categorized to three variables: Sophisticated, Contemporary and Unpretentious categories
- For mascot-tablet case-study, there are five variable: yellow, orange, turquoise, blood-red and pink background screen colors

In fact, we do not compare case-studies with each other, namely, the interaction types has a more effect on the measurements of the personality trait of mascots. We consider one case as a separate study, where we only compare IVs.

Our dependent variable is the measurements of the personality traits based on the OCEAN model. The main research question that we asked: "Is the interpretation or the measure of the mascot's personality effected by these factors?"

5.6 Measures

As a measurements of the experiments we used questionnaires that were given after each video watch. Overall, there were 24 questionnaires with five questionnaires for each phase, except mascot-speakers interaction phase, where we had nine questionnaires. Each questionnaire consists of 30 questions portraying six

facets of each personality based on NEO-PIP survey. The questionnaire items were answered using a Likert-scale (Very inaccurate, Inaccurate, neutral, Accurate, Very accurate). These questionnaires were given via Google Forms which are further transformed into cvs formats.

Chapter 6
Results

This chapter presents the statistical analysis where the results for each case-study, such as mascot-speakers, mascot-lamp, mascot-mascot, and mascot-tablet are reported in separate sections. Each section consists of two subsections describing tests for two studies: the within personality traits study and the within conditions such as types of music, lighting colors, vibration levels, or screen colors.

Since the gathered data are ordinal and the outcome is not normally distributed, the analysis of all case-studies is focused on the non-parametric tests. Specifically, since each case-study consists of more than two compared groups (i.e. each described in Sections 6.1, 6.2, 6.3, and 6.4) and data is compared against a within-subject factor (i.e. each participant tested all conditions), the Friedman tests followed by the Wilcoxon Signed-rank tests are used for statistical analysis.

For each study, the Wilcoxon tests compare 10 groups with each other except from a study one for the mascot-speakers interaction where it compares 6 groups. Since there are a large number of statistical tests, some of the results may have $p<.05$ purely by chance. Thus, in order to control the family-wise error rate, the Bonferroni correction is used. This adjustment method will divide all p-values in 10 and 6 according to the number of compared groups.

In addition, in each subsection, the results of Wilcoxon tests after Bonferroni correction are displayed graphically using box plots. The complete tables of these tests can be found in appendices (see Appendix A).

6.1 The analysis of the mascot-speakers interaction.

This section describes the mascot-speakers case-study, where is analyzed the effect of music on the measurement of the mascots' personality traits. As discussed

in Section 3.4, the choice of the music genre is based on the MUSIC pattern. For statistical analysis, all songs that were used in the experiments are distributed into the following categories:

- Sophisticated: jazz, classical and contemporary adult.
- Contemporary: rap and soul.
- Unpretentious: pop, rock&roll / country and bluegrass.

In addition, the raw data consists of 30 personality facets for each music condition (see Section 3.2). During analysis, all facets are grouped into five personality traits. Thus, each personality trait consists of the mean scores given for six personality facets. The analysis of the mascot-speakers interaction is performed by two studies.

In the first study, we compare three types of music within each personality trait to find the effects of each music on participant's measurements of mascot's personality. In the second study, the second iteration on the same dataset is performed by comparing five personality traits within each music category.

Figure 6.1 depicts both studies for mascot-speakers interaction where vertical arrows represent the first study i.e. analysis of the within personality trait and horizontal arrows represent the analysis of the within condition study. In the first study, we determine the effect of music on the measurements of personality traits. Thus, we compare all music types with each other within a specific personality trait. It results in music that is significantly different and rated higher in comparison to all other music types. Since we compare all conditions within each personality separately (see vertical arrows in Figure 6.1), one music may be associated with multiple personality traits. We aim to conclude with one music condition being associated with a specific personality trait. In the second study, we compare all personality traits within each music type (see horizontal arrows in Figure 6.1) which helps us to find personality trait that is conveyed by specific music most.

In addition, we apply the same statistical tests for each case-study (see Sections 6.2, 6.3, and 6.4).

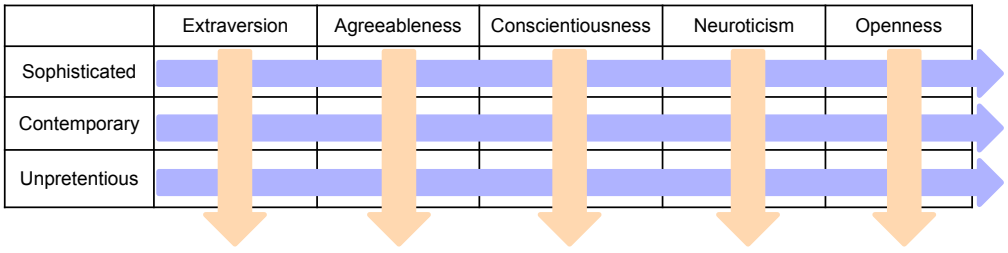


Figure 6.1: Visual representation of compared groups in study-1 for vertical arrows and study-2 for horizontal arrows in case of mascot-speakers interaction.

In this chapter, the abbreviations for all tables (i.e. Tables 6.2 - 6.16,) and figures (i.e. Figures 6.2 - 6.9) are described in the footnotes [1] [2] [3] [4] [5].

6.1.1 The analysis of the within personality trait study.

In this subsection, we report a statistical analysis of how the impact of the music category varies within each personality trait. Compared factors are sophisticated, contemporary, and unpretentious music.

Extraversion. The Friedman tests show the significant effect of all predefined music categories on the ratings of extraversion personality with $p<.01$, df=2 (see Table 6.1). The Wilcoxon tests revealed that the significant difference is concentrated on contemporary music compared to all other categories with $p_{adj}<.01$ (see Figure 6.2). According to Table 6.2, the contemporary category has the highest median with med = 3.9.

Agreeableness. All three categories significantly influenced participants' measurements of mascot's agreeableness personality trait with $p<.01$, df=2 (see Table 6.1). The main difference fault in the following groups: sophisticated and contemporary; contemporary and unpretentious with $p<.01$. According to Figure 6.2, the boxplot distinguishes most of the contemporary samples from the other two categories having very low ratings to convey the agreeableness personality trait.

Conscientiousness. There is a significant difference in all music categories within conscientiousness personality trait with $p<.05$, df=2 (see Table 6.1. Scores for mascot being measured as conscientiousness personality trait increased sharply during playing sophisticated and unpretentious (med = 3.2) music in comparison to scores for contemporary music (med = 2.8) The Wilcoxon test confirms the statistically significant difference between the following groups: sophisticated and contemporary ($p_{adj}<.01$); unpretentious and contemporary ($p_{adj}<.05$).

Neuroticism. Overall, all three categories have an effect on the measurement of mascot's neuroticism personality with $p<.01$, df=2 (see Table 6.1). Table 6.2 shows that the scores given for contemporary music while assessing neuroticism personality traits are the highest with med = 3.1 compared to the other two categories. Moreover, there are two significant differences between groups: sophisticated and contemporary; contemporary and unpretentious music with $p_{adj}<.01$ (see Figure 6.2).

Openness. Table 6.1 reveals a substantial difference between all three music types

[1] The abbreviations for stars: ** $p_{adj}<.01$ and * $p_{adj}<.05$

[2] The abbreviations for personality traits: ^{E} extraversion, ^{A} agreeableness, ^{C} conscientiousness, ^{N} neuroticism and ^{O} openness personality trait

[3] The abbreviations for music types: ^{S} sophisticated, ^{C} contemporary, ^{U} unpretentious music

[4] The abbreviations for vibrations: ^{L1} vibration level-1, ^{L2} level-2, ^{L3} level-3, ^{L4} level-4 and ^{L5} level-5

[5] The abbreviations for colors: ^{Y} yellow, ^{O} orange, ^{T} turquoise, ^{B} blood-red and ^{P} pink color

within an openness personality trait. Particularly, there is a good separation of the sophisticated with med = 3.8 and max = 4.9 from other music categories (see Table 6.2). There is a large difference between sophisticated and contemporary, and sophisticated and unpretentious with p_{adj}<.01 (see Figure 6.2).

Personality traits	χ^2	**df**	**p**
Extraversion	21.4	2	p<.01
Agreeableness	29.0	2	p<.01
Conscientiousness	6.5	2	p<.05
Neuroticism	15.1	2	p<.01
Openness	25.8	2	p<.01

Table 6.1: The results of the Friedman test for five personality traits in the case of mascot-speakers interaction.

	E			**A**			**C**			**N**			**O**		
	S	C	U	S	C	U	S	C	U	S	C	U	S	C	U
Min	1.4	3.2	2.2	2.9	1.1	2.5	2.4	1.0	1.9	1.0	2.3	1.3	3.1	2.0	2.5
Med	3.1	3.9	3.3	3.3	2.9	3.7	3.2	2.8	3.2	2.4	3.1	2.5	3.8	2.9	3.4
Max	3.8	5.0	4.0	4.7	4.3	4.7	4.6	4.0	4.7	3.4	4.5	3.2	4.9	4.0	4.7

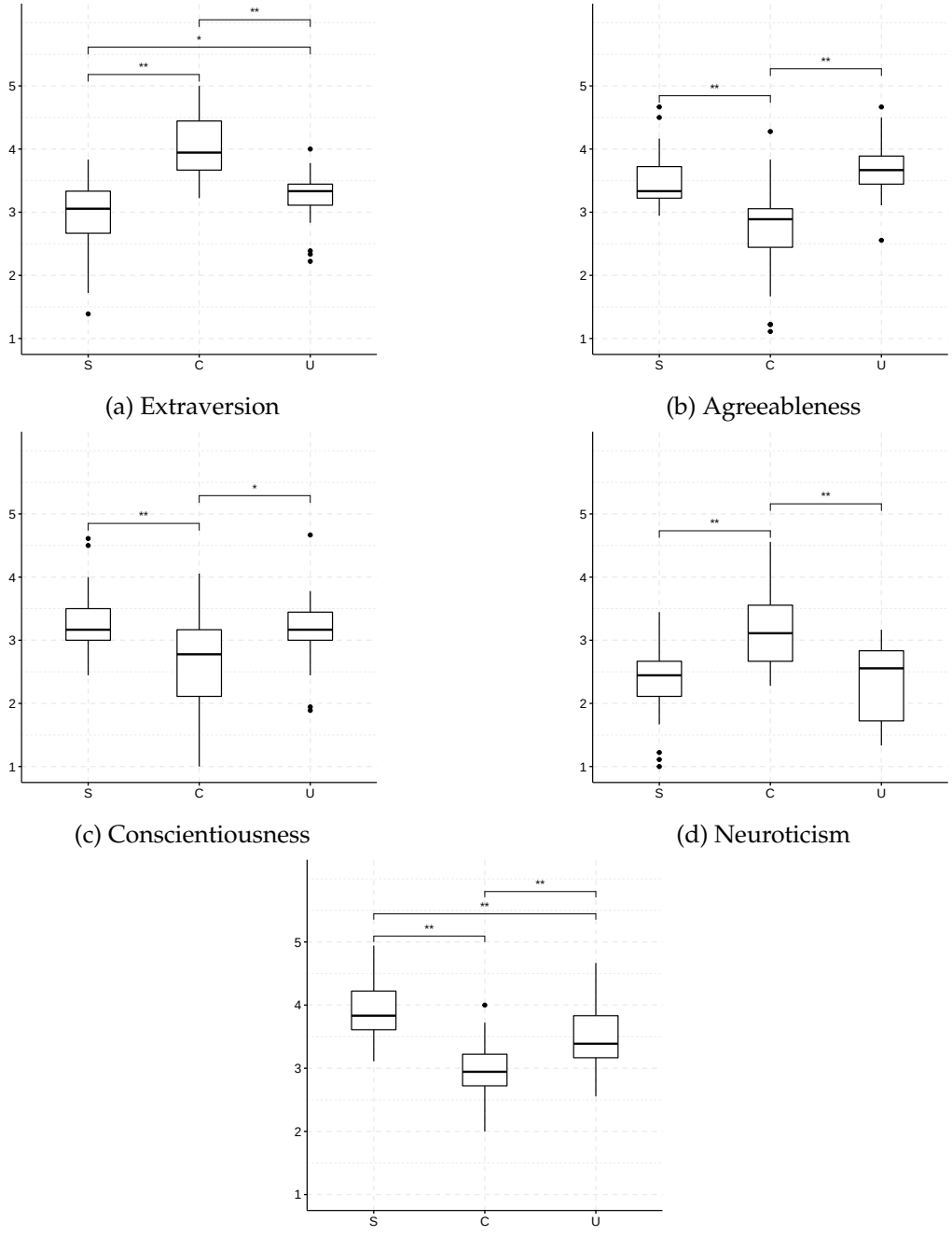
Table 6.2: A summary table of the median, minimum, and maximum rates given for each personality trait.

6.1.2 The analysis of the within music category study.

In this study, we analyze the effect of each music category, particularly on how each personality trait is assessed differently within one music condition. Compared groups are extraversion, agreeableness, conscientiousness, neuroticism, and openness personality traits.

Sophisticated. On average, sophisticated music has a significant effect on all five personality traits with p<.01, df=2 (see Table 6.3). When sophisticated is played, in comparison to all the personality traits, openness is rated very high with med = 3.8, and neuroticism is rated very low with med = 2.4 (see Table 6.4). According to Figure 6.3, openness to experience shows a significant difference from all other personality traits in the group.

Contemporary. The Friedman test shows a significant difference between the ratings of all personality traits and contemporary music with p<.01, df=2 (see Table 6.3). According to Figure 6.3, for mascot triggering contemporary music, there is a clear separation of extraversion samples from all other personality traits with p_{adj}<.01. The median value for extraversion is very high being med = 3.9 compared to all other personality traits (med $\approx$ 3).



(a) Extraversion

(b) Agreeableness

(c) Conscientiousness

(d) Neuroticism

(e) Openness

Figure 6.2: A boxplot for the mascot-speakers interaction in study-1. Stars represent the significance of p_{adj} after Bonferroni correction.

Unpretentious music substantially affects the measurements of all personality traits with p<.01, df=4 (see Table 6.3). Based on Wilcoxon tests, neuroticism personality trait is rated very low when unpretentious music was played with

p_{adj}<.01 (see Figure 6.3). The median values of all other personality traits slightly differ from each other, condensed around 'neutral' rating which is med $\approx$ 3 (see Table 6.4).

Music categories	χ^2	**df**	**p**
Sophisticated	66.6	4	p<.01
Contemporary	44.4	4	p<.01
Unpretentious	57.4	4	p<.01

Table 6.3: The results of the Friedman test for all music categories in the case of mascot-speakers interaction.

	Sophisticated					**Contemporary**					**Unpretentious**				
	E	A	C	N	O	E	A	C	N	O	E	A	C	N	O
Min	1.4	2.9	2.4	1.0	3.1	3.2	1.1	1.0	2.3	2.0	2.2	2.5	1.9	1.3	2.5
Med	3.0	3.3	3.2	2.4	3.8	3.9	2.9	2.8	3.1	2.9	3.3	3.7	3.2	2.5	3.4
Max	3.8	4.7	4.6	3.4	4.9	5.0	4.3	4.0	4.5	4.0	4.0	4.7	4.7	3.2	4.7

Table 6.4: A summary table of the median, minimum, and maximum rates given for each music category.

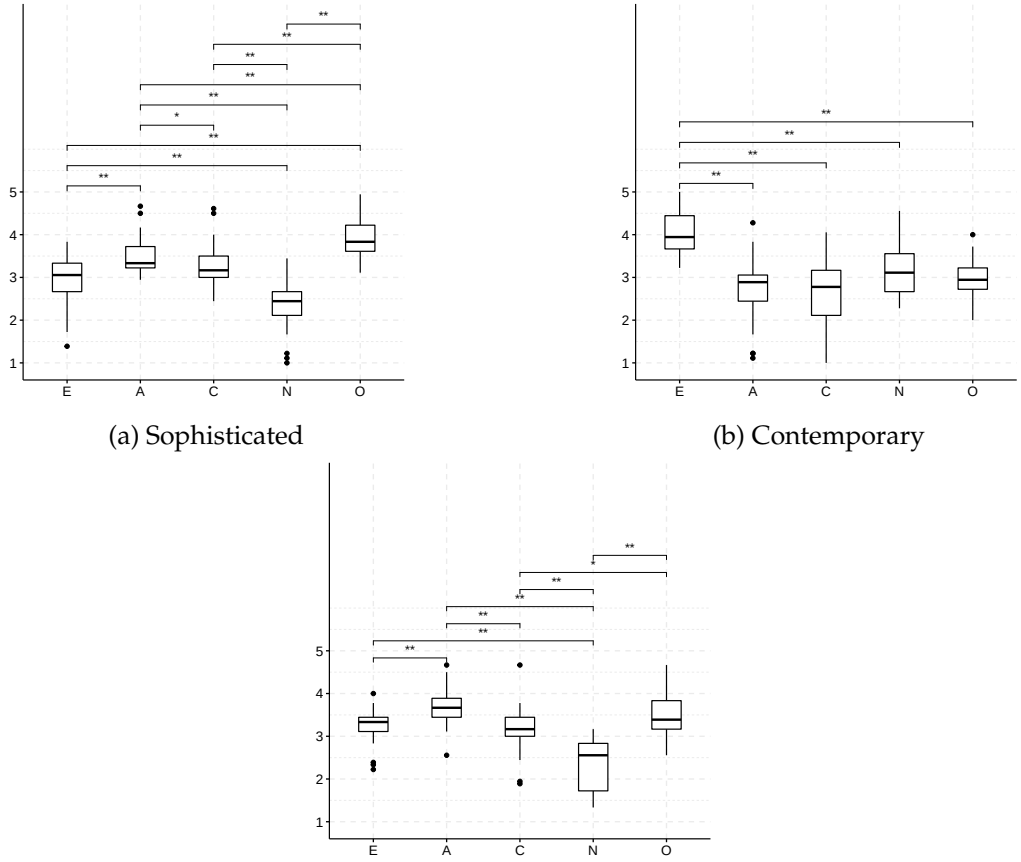
6.2 The analysis of the mascot-lamp interaction.

This section investigates the effect of the lighting color on the measurement of the mascots' personality traits. Subsection 6.2.1 describes the results for the within personality study and subsection 6.2.2 for the within the lighting color study.

6.2.1 The analysis of the within personality trait study.

In the first study, that compared factors are orange, turquoise, yellow, blood-red, and pink lighting colors.

Extraversion. According to Table 6.5, all lighting colors significantly influenced the measurements of extraversion personality with p<.01, df=4. Figure 6.4 shows where exactly this effect is concentrated reporting six groups of colors with p_{adj}<.01. Yellow showed a significant difference compared to turquoise, blood-red and pink lighting colors being rated very high on conveying extraversion personality trait. In contrast, the mascot interacting with blood-red lighting was rated very low on being an extravert. This is also reported in Table 6.6, the blood-red color having the lowest median (med = 1.7, max = 4.5, min = 1.0) and yellow having the highest value (med = 3.7, max = 4.8, min = 2.3) for extraversion personality.



(a) Sophisticated

(b) Contemporary

(c) Unpretentious

Figure 6.3: A boxplot for the mascot-speakers interaction in study-2. Stars represent the significance of p_{adj} after Bonferroni correction.

Agreeableness. There is a significant impact of lighting colors and the participants' measurements of agreeableness personality with p<.01 (see Table 6.5) According to Figure 6.4, in comparison to all other colors, mascots triggering blood-red and orange lighting are rated very low to have an agreeableness personality (p_{adj}<.01). Moreover, Table 6.6 shows that compared to all other colors, blood-red has the smallest median with med = 2.0. The median values, in descending order, for pink, turquoise, and yellow lights are approximately similar with med = 4.0, med = 3.5 and med = 3.7 respectively.

Conscientiousness. The Friedman test shows a statistically significant effect of all predefined lighting colors on the ratings of conscientiousness personality (see Table 6.5). The Wilcoxon tests show that effect is noticeable when we compare mascot that triggers blood-red and orange with ones that triggered turquoise, yellow, pink colors (see Figure 6.4). In fact, the mascot interacting blood-red and orange were assessed as being very low on the conscientious personality trait. Table 6.6 indicates that blood-red has the lowest median (med = 2.2), whereas

turquoise, pink and yellow have relatively similar high medians (med = 3.7, med = 3.5, med = 3.5 respectively). The latest values show that the mascot triggering these colors is rated high on having orderly, dutiful, disciplined, and other facets that constitute conscientiousness personality.

Neuroticism. Overall, there is an impact of the predefined colors on the ratings of the neuroticism personality with p<.01 reported in Table 6.5. The blood-red color showed a significant difference in rating neuroticism comparing to all other colors with p_{adj}<.01 (see Figure 6.4). Moreover, blood-red presents the highest values with med = 4.3, max = 5.0, min = 3.2 (see Table 6.6).

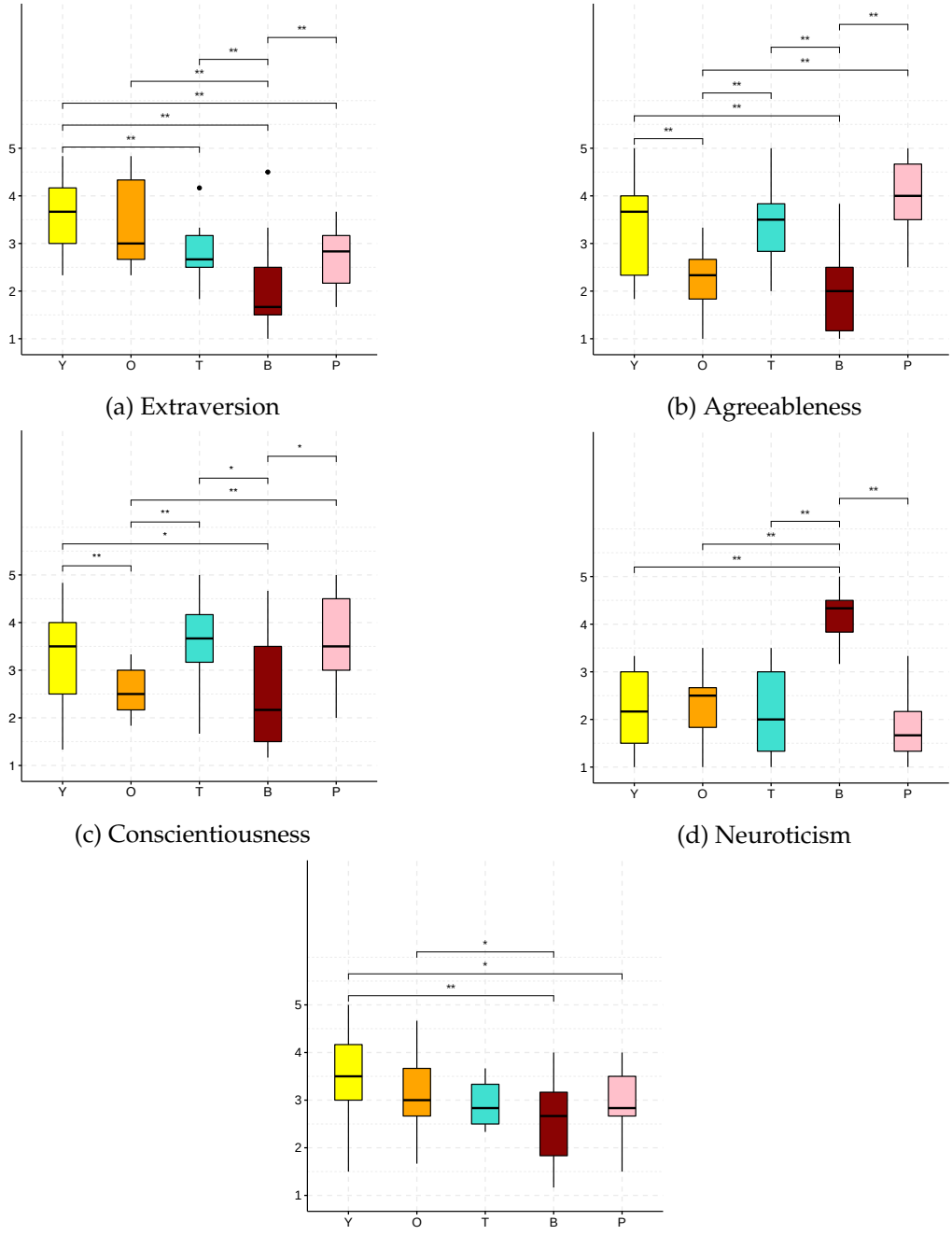
Openness. There is a significant difference of all colors within openness personality with p<.01 (see Table 6.5). The main differences are concentrated between the following groups: yellow and pink; yellow and blood-red; blood-red and orange with p_{adj}<.01 (see Figure 6.4). Table 6.6 shows the similarity of the median values for all colors concentrating around neutral attitude for mascot being measured as openness which is represented by med $\approx$ 3.

Personality traits	χ^2	**df**	**p**
Extraversion	40.0	4	p<.01
Agreeableness	56.4	4	p<.01
Conscientiousness	25.8	4	p<.01
Neuroticism	52.4	4	p<.01
Openness	18.2	4	p<.01

Table 6.5: The results of the Friedman test for all personality traits for the first study in the case of mascot-lamp interaction.

	Extraversion					**Agreeableness**					**Conscientiousness**				
	Y	O	T	B	P	Y	O	T	B	P	Y	O	T	B	P
Min	2.3	2.3	1.8	1.0	1.7	1.8	1.0	2.0	1.0	2.5	1.3	1.8	1.7	1.2	2.0
Med	3.7	3.0	2.7	1.7	2.8	3.7	2.3	3.5	2.0	4.0	3.5	2.5	3.7	2.2	3.5
Max	4.8	4.8	4.2	4.5	3.7	5.0	3.3	5.0	3.8	5.0	4.8	3.3	5.0	4.7	5.0
	Neuroticism					**Openness**									
	Y	O	T	B	P	Y	O	T	B	P					
Min	1.0	1.0	1.0	3.2	1.0	1.5	1.7	2.3	1.2	1.5					
Med	2.1	2.5	2.0	4.3	1.7	3.5	3.0	2.8	2.7	2.8					
Max	3.3	3.5	3.5	5.0	3.3	5.0	4.7	3.7	4.0	4.0					

Table 6.6: A summary table of the median, minimum, and maximum rates given for each personality trait.



(a) Extraversion

(b) Agreeableness

(c) Conscientiousness

(d) Neuroticism

(e) Openness

Figure 6.4: A boxplot for the mascot-lamp interaction in study-1. Stars represent the significance of p_{adj} after Bonferroni correction.

6.2.2 The analysis of the within lighting color study.

The second study considers the effect of the lighting color on how each personality trait is assessed within one color condition. Compared groups are five personality traits such as extraversion, agreeableness, conscientiousness, neuroticism, and openness.

Yellow. The Friedman test shows a significant difference in the ratings of each personality trait within yellow lighting color with $p<.01$, df=4 (see Table 6.7). When mascot triggers yellow light, the difference is concentrated on neuroticism which is rated very low compared to other personality traits. According to Figure 6.5, 80% of scores given for extraversion, agreeableness, conscientiousness, and openness are higher than all scores given for neurotic personality. Also, the similarity of the median values for all personality traits except neuroticism (med = 3.7, med = 3.7, med = 3.5, med = 3.5) reveals a small effect of yellow color on these four personality traits (see Table 6.8).

Orange. There is a statistically substantial difference between personality trait measurements within orange color with $p<.01$, df=4 (see Table 6.7). When orange color is triggered, the mascot with extraversion and openness traits show distinguishable ratings in comparison to all other personalities with $p<.05$ (see Figure 6.5). Moreover, tests did not show any significant differences between extraversion (med = 3.0, max = 4.8, min = 2.3) and openness (med = 3.0, max = 4.7, min = 1.7) within orange color (see Table 6.8). However, the median values of extraversion and openness are higher compared to the values of all other personality traits.

Turquoise. Overall, all personality traits are measured differently when the light was transformed to turquoise color with $p<0.01$, df=4 (see Table 6.7). Wilcoxon test reveals that when the turquoise is displayed, the agreeableness and conscientiousness personality traits are substantially distinguishable from other personality traits with $p<.05$ (see Figure 6.5). Both of them are measured high when mascot triggers turquoise color. However, these two personalities are not distinguishable from each other within turquoise color. In spite of that fact, the median value of conscientiousness (med = 3.7) is slightly higher than for agreeableness (med = 3.5) (see Table 6.8).

Blood-red lighting color reveals a significant difference in measurements of all personality traits with $p<.01$, df=4 (see Table 6.7). According to Figure 6.5, there is an excellent separation of neuroticism boxplot from all other personality traits. Table 6.8 shows a very high median value for neuroticism compared to other personality traits with med = 4.3, max = 5.0 and min = 3.2.

Pink. There is a significant difference in ratings of the mascots' personality when the pink light is triggered having $p<.01$, df=4 (see Table 6.7). According to Figure 6.5, pink light shows a significant effect on the agreeableness and conscientiousness with $p_{adj}<.01$ comparing to extraversion, neuroticism, and openness personality traits. Based on the medians reported in Table 6.8, agreeableness has

the highest (med = 4.0) in contrast to neuroticism which has the lowest value (med = 1.7).

Color conditions	χ^2	**df**	**p**
Yellow	23.6	4	p<.01
Orange	38.2	4	p<.01
Turquoise	37.1	4	p<.01
Blood-red	45.5	4	p<.01
Pink	60.1	4	p<.01

Table 6.7: The results of the Friedman test for five color conditions in the case of mascot-lamp interaction.

	Yellow					**Orange**					**Turquoise**				
	E	A	C	N	O	E	A	C	N	O	E	A	C	N	O
Min	2.3	1.8	1.3	1.0	1.5	2.3	1.0	1.8	1.0	1.7	1.8	2.0	1.7	1.0	2.3
Med	3.7	3.7	3.5	2.2	3.5	3.0	2.3	2.5	2.5	3.0	2.7	3.5	3.7	2.0	2.8
Max	4.8	5.0	4.8	3.3	5.0	4.8	3.3	3.3	3.5	4.7	4.2	5.0	5.0	3.5	3.7
	Blood-red					**Pink**									
	E	A	C	N	O	E	A	C	N	O					
Min	1.0	1.0	1.2	3.2	1.2	1.7	2.5	2.0	1.0	1.5					
Med	1.7	2.0	2.2	4.3	2.7	2.8	4.0	3.5	1.7	2.8					
Max	4.5	3.8	4.7	5.0	4.0	3.7	5.0	5.0	3.3	4.0					

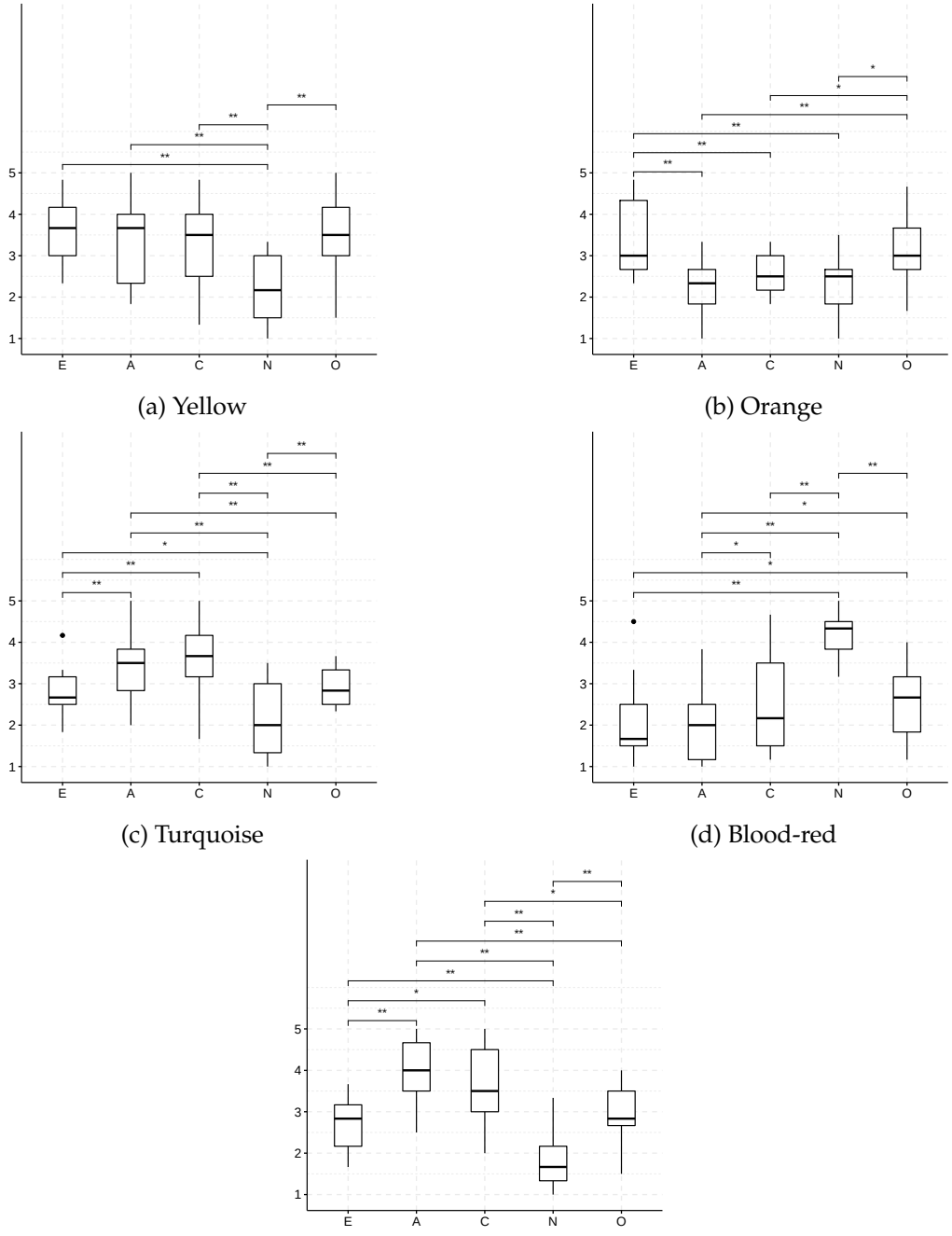
Table 6.8: A summary table of the median, minimum, and maximum rates given for each color condition.

6.3 The analysis of the mascot-mascot interaction.

This section covers the analysis of the effect of each level of vibration on the perception of the personality trait of approaching mascot which triggers this vibration. In Subsection 6.3.1, the statistical tests are conducted for the within personality trait study and in Subsection 6.3.2 for the within vibration level. Besides, from now on each vibration level is abbreviated accordingly. For example, the vibration with 500-millisecond duration is abbreviated as 'level-5', and with 100-millisecond long as 'level-1' and so on.

6.3.1 The analysis of the within personality trait study.

In the first study, compared factors are five levels of vibration starting from level-1 to level-5.



(a) Yellow

(b) Orange

(c) Turquoise

(d) Blood-red

(e) Pink

Figure 6.5: A boxplot for the mascot-lamp interaction in study-2. Stars represent the significance of p_{adj} after Bonferroni correction.

Extraversion. The Friedman test shows a significant difference between all levels of vibration in the ratings of an extraversion personality trait with p<.01 (see Table 6.9). In comparison to all other levels, level-5 and level-4 show a significant

difference in the measurements of the extraversion personality with p<.05 (see Figure 6.6). Both of these levels are highly scored as the behavior of an extravert mascot with med = 4.0 for level-5 and med = 3.0 for level-4 (see Table 6.10).

Agreeableness. All vibration levels substantially affects the measurements of an agreeableness personality trait with p<.01, df=4 (see Table 6.9). Both level-2 and level-3 revealed a significant effect for mascot being assessed as agreeable with p_{adj}<.05 (see Figure 6.6). Overall, the majority of votes given for level-2 (med = 4.0, max = 4.7, min = 2.0) and level-3 (med = 3.5, max = 5.0, min = 2.5) are higher than most votes given for other vibration levels (see Table 6.10).

Conscientiousness. There is a significant impact of all vibration levels on the assessment of conscientiousness personality trait with p<.01, df=4 (see Table 6.9). The analysis revealed a strong difference of levels three and four from scores given for other vibrations with p_{adj}<.01 (see Figure 6.6). Moreover, the median values for level-3 (med = 3.8) and level-4 (med = 4.0) are high enough to show a strong impact of these levels to measure mascot as conscientious (see Table 6.10).

Neuroticism. There is a significant difference in measurements of each level of vibration within neuroticism personality trait with p<.01, df=4 (see Table 6.9). Especially, this difference is concentrated on the ratings for level-1 with med = 3.7 in comparison to other levels having med < 2.5 (see Table 6.10). According to Figure 6.6, for a neuroticism personality trait, there is a good separation of samples for level-1 from all other vibration levels with p_{adj}<.05.

Openness. Table 6.9 reveals a difference between all five vibration levels within openness personality trait with p<.05, df=4 (see Table 6.9). The Wilcoxon test revealed a significant difference between levels one and two, during the measurements of the openness personality trait with p<.05 (see Figure 6.6). The median values for levels five, four, two, and one imply the overall similarity of votes concentrated on the 'neutral' scale with med < 2.7 (see Table 6.10).

Personality traits	χ^2	**df**	**p**
Extraversion	30.8	4	p<.01
Agreeableness	19.8	4	p<.01
Conscientiousness	43.2	4	p<.01
Neuroticism	28.2	4	p<.01
Openness	11.2	4	p<.05

Table 6.9: The results of the Friedman test for all personality traits in the case of mascot-mascot interaction.

6.3.2 The analysis of the within vibration level study.

The second study analyzes each vibration level individually and the difference of each personality trait within a specific vibration level. Compared groups

	Extraversion					Agreeableness					Conscientiousness				
	L1	L2	L3	L4	L5	L1	L2	L3	L4	L5	L1	L2	L3	L4	L5
Min	1.2	1.7	1.3	2.2	2.3	1.7	2.0	2.5	1.3	1.3	1.7	1.5	2.8	2.2	1.7
Med	2.0	2.0	2.7	3.0	4.0	2.5	4.0	3.5	2.8	2.7	2.5	2.7	3.8	4.0	2.8
Max	3.8	4.0	4.3	4.7	4.7	4.0	4.7	5.0	4.0	3.8	3.8	4.2	5.0	5.0	3.8
	Neuroticism					**Openness**									
	L1	L2	L3	L4	L5	L1	L2	L3	L4	L5					
Min	2.0	1.3	1.3	1.0	1.0	1.1	1.8	1.5	1.0	1.3					
Med	3.7	2.1	1.8	2.2	2.3	2.3	2.5	3.3	2.7	2.7					
Max	4.7	3.7	4.2	3.5	3.3	4.2	4.5	4.3	4.5	4.0					

Table 6.10: A summary table of the median, minimum, and maximum rates given for each personality trait.

are extraversion, agreeableness, conscientiousness, neuroticism, and openness personality traits.

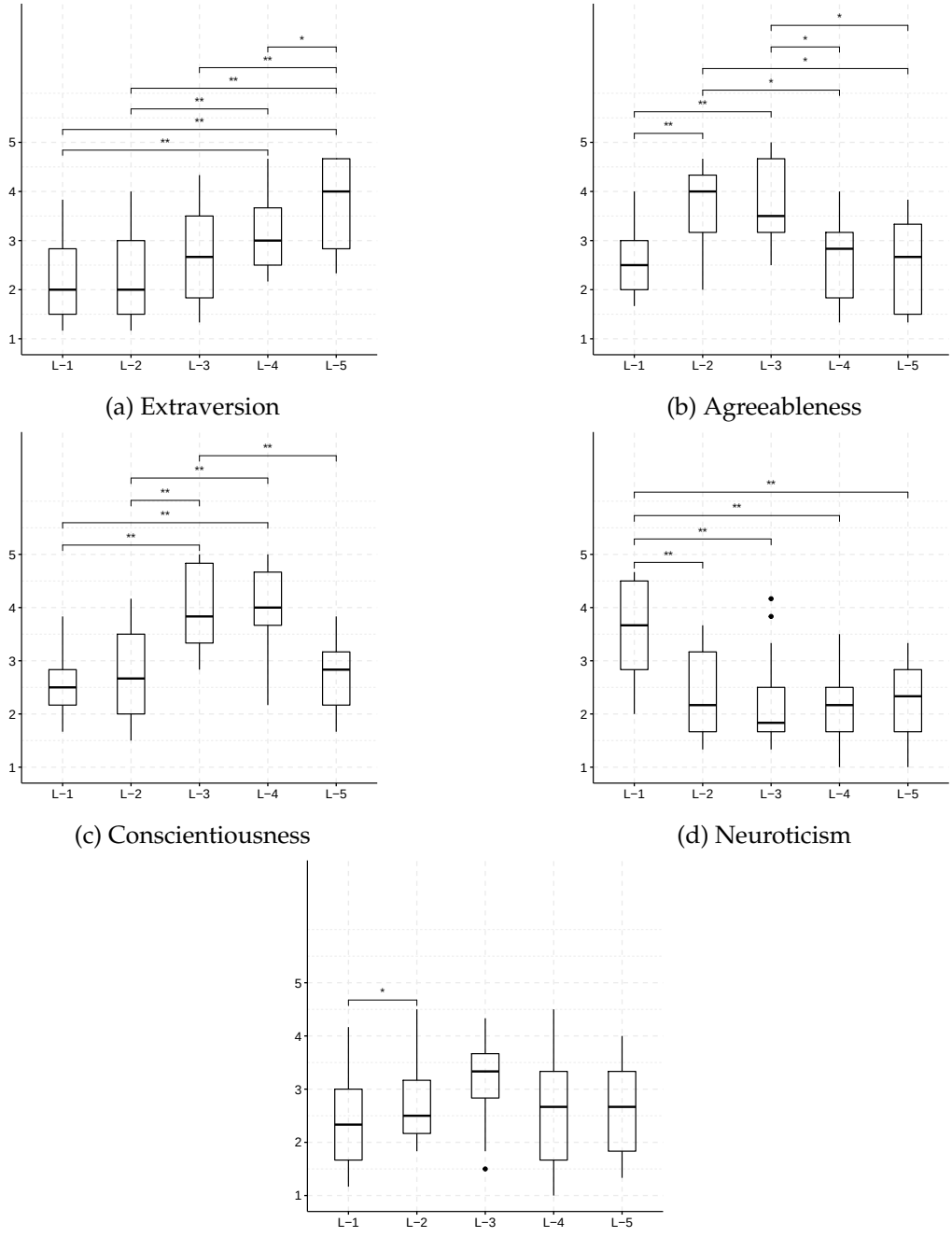
Level-1. The Friedman test shows a significant difference between the ratings of all personality traits and vibration level one with $p<.01$, df=4 (see Table 6.11). This difference especially is concentrated on neuroticism which distinguished it from all other personality traits with $p_{adj}<.05$ (see Figure 6.7). In comparison to neuroticism (med = 3.7), the median rates given for extraversion, agreeableness, conscientiousness, and openness personality traits are relatively similar being 2.0, 2.5, 2.5, 2.3 respectively (see Table 6.12).

Level-2. On average, level-2 has a significant effect on the ratings of all five personality traits with $p<.01$, df=4 (see Table 6.11). Based on Wilcoxon tests, there are four groups of personality traits being effected by vibration level-2 with $p_{adj}<.05$ (see Figure 6.7). Agreeableness is the most distinguishable being rated higher (med = 4.0) than all other personality traits (med < 2.8) (see Table 6.12).

Level-3 has a substantial impact on the measurements of a personality trait with $p<.01$, df=4 (see Table 6.11). Level-3 effects the ratings of two personality traits: agreeableness and conscientiousness with $p_{adj}<.05$ (see Figure 6.7).

Level-4. There is a statistically significant difference between the measurements of all personality traits within level-4 with $p<.01$, df=4 (see Table 6.11). Level-4 has an impact on the ratings of two personality traits with the highest scores (max = 4.7 and max = 5.0) such as conscientiousness and extraversion with a very significant $p_{adj}<.01$ (see Figure 6.7).

Level-5. Overall, all personality traits show different results when each mascot vibrating 500 milliseconds per time (i.e. level-5) with $p<.01$, df=4 (see Table 6.11). Level-5 distinguishes extraversion from all other personality traits having the highest ratings with $p_{adj}<.05$ (see Figure 6.7). The median values for all other personality traits are lower than the neutral scale (med < 3.0) in comparison to neuroticism with med = 4.0 (see Table 6.12).



(a) Extraversion

(b) Agreeableness

(c) Conscientiousness

(d) Neuroticism

(e) Openness

Figure 6.6: A boxplot for the mascot-mascot interaction in study-1. Stars represent the significance of p_{adj} after Bonferroni correction.

Vibration levels	χ^2	df	p
Level-1	24.0	4	p<.01
Level-2	24.5	4	p<.01
Level-3	35.2	4	p<.01
Level-4	46.6	4	p<.01
Level-5	24.1	4	p<.01

Table 6.11: The results of the Friedman test for all vibration levels in the case of mascot-mascot interaction.

	Level-1					**Level-2**					**Level-3**				
	E	A	C	N	O	E	A	C	N	O	E	A	C	N	O
Min	1.2	1.7	1.7	2.0	1.2	1.2	2.0	1.5	1.3	1.8	1.3	2.5	2.8	1.3	1.5
Med	2.0	2.5	2.5	3.7	2.3	2.0	4.0	2.7	2.2	2.5	2.7	3.5	3.8	1.8	3.3
Max	3.8	4.0	3.8	4.7	4.2	4.0	4.7	4.2	3.7	4.5	4.3	5.0	5.0	4.2	4.3
	Level-4					**Level-5**									
	E	A	C	N	O	E	A	C	N	O					
Min	2.2	1.3	2.2	1.0	1.0	2.3	1.3	1.7	1.0	1.3					
Med	3.0	2.8	4.0	2.2	2.7	4.0	2.7	2.8	2.3	2.7					
Max	4.7	4.0	5.0	3.5	4.5	4.7	3.8	3.8	3.3	4.0					

Table 6.12: A summary table of the median, minimum, and maximum rates given for each vibration level.

6.4 The analysis of the mascot-tablet interaction.

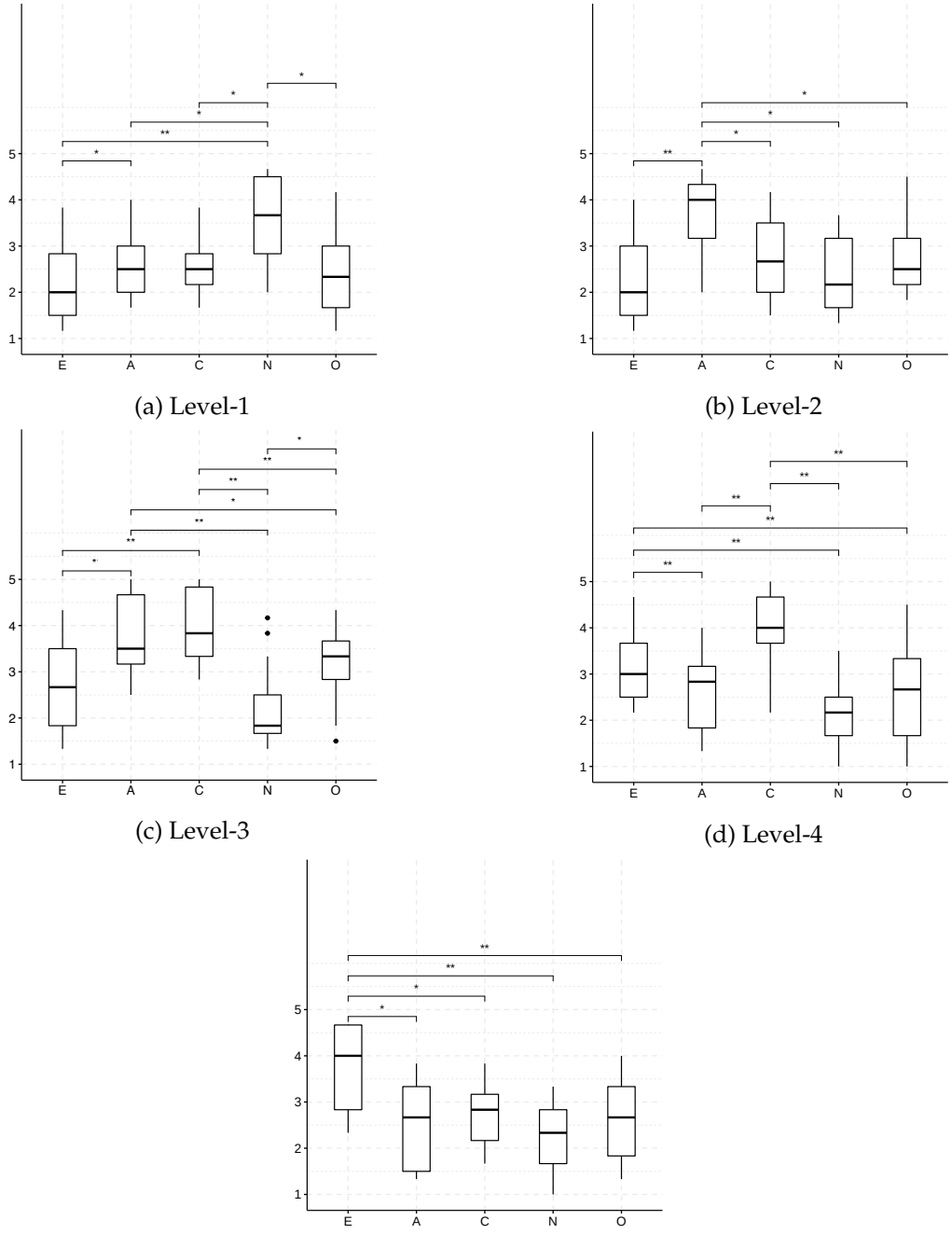
The section describes the impact of the screen color of a tablet on the assessment of the personality trait that mascot conveys. Subsection 6.4.1 shows the analysis of the within personality study and Subsection 6.4.2 of within condition study (i.e. color).

6.4.1 The analysis of the within personality trait study.

The first study is focused on each personality by comparing the scores given for each color within that personality trait. Compared factors are yellow, orange, turquoise, blood-red, and pink screen colors.

Extraversion. For the measurements of extraversion personality, the most significant difference was observed when yellow and orange was compared to blood-red and pink colors with p_{adj}<.05 (see Figure 6.8). Moreover, in comparison to other colors most samples for orange are concentrated around an 'accurate' score (med = 4.2, max = 5.0) (see Table 6.14).

Agreeableness. The change in tablet's screen color significantly influenced the



(a) Level-1

(b) Level-2

(c) Level-3

(d) Level-4

(e) Level-5

Figure 6.7: A boxplot for the mascot-mascot interaction in study-2. Stars represent the significance of p_{adj} after Bonferroni correction.

participants' ratings of an agreeableness personality trait with p<.01, df=4 (see Table 6.13). Figure 6.8) shows a good separation of turquoise and pink colors from all others implying that there is a difference in ratings of the agreeableness

personality traits having p_{adj}<.01. However, there is no strong difference between turquoise and pink colors having the same value med = 3.7 (see Table 6.14).

Conscientiousness. There is a significant difference in the rating of conscientiousness personality trait when comparing screen colors with p<.01, df=4 (see Table 6.13). According to Figure 6.8, there is a distinguishable impact of the tablet displaying turquoise color on the measurements of the mascot as conscientiousness with p_{adj}<.05. The median values for yellow (med = 2.7), pink (med = 2.8) and orange (med = 2.7) colors are concentrated around the 'neutral' scale, whereas turquoise (med = 4.2) is concentrated near 'accurate' scale (see Table 6.14).

Neuroticism. All predefined screen colors substantially affects the measurements of the neuroticism personality trait with p<.01, df=4 (see Table 6.13). According to Figure 6.8, there is a great separation of blood-red samples from all other screen colors with p_{adj}<.05. The ratings for the blood-red are higher with med = 3.8 compared to all other colors with M $\leq$ 2.5 (see Table 6.14).

Openness. Table 6.13 shows the different effects based on all colors within openness personality trait with p<.01, df=4 (see Table 6.13). According to the Wilcoxon tests, during the measurements of a mascot's openness to experience personality traits, the yellow is significantly different from all other screen colors with p_{adj}<.05 (see Figure 6.8). In comparison to all other colors (M $\leq$ 3.0), most of the samples of yellow color are discriminated from all others concentrating around an 'accurate scale with a med = 4.0 (see Table 6.14).

Personality traits	χ^2	**df**	**p**
Extraversion	28.8	4	p<.01
Agreeableness	52.9	4	p<.01
Conscientiousness	32.9	4	p<.01
Neuroticism	30.5	4	p<.01
Openness	37.7	4	p<.01

Table 6.13: The results of the Friedman test for all personality traits in the case of mascot-tablet interaction.

6.4.2 The analysis of the within screen color study.

The second study is focused on each color by comparing the different measurements of five personality traits within each screen color. Compared groups are extraversion, agreeableness, conscientiousness, neuroticism, and openness personality traits.

Yellow. The Friedman test showed a significant difference in the ratings each personality trait within yellow lighting color with p<.01, df=4 (see Table 6.15). When mascot triggers yellow background color, tests reveal openness to be rated

	Extraversion					Agreeableness					Conscientiousness				
	Y	O	T	B	P	Y	O	T	B	P	Y	O	T	B	P
Min	2.0	1.7	2.0	1.2	1.7	1.5	1.2	1.8	1.0	1.7	1.8	2.2	2.0	1.0	2.0
Med	3.3	4.2	2.8	1.7	2.5	3.0	2.3	3.7	1.8	3.7	2.7	2.7	4.2	2.3	2.8
Max	4.0	5.0	4.3	4.7	3.8	3.7	4.5	4.2	3.3	5.0	3.5	4.5	5.0	4.3	4.7
	Neuroticism					**Openness**									
	Y	O	T	B	P	Y	O	T	B	P					
Min	1.3	1.5	1.0	1.5	1.2	2.5	1.3	2.0	1.0	1.5					
Med	2.2	2.5	2.5	3.8	2.3	4.0	3.0	3.0	2.7	2.7					
Max	3.7	4.3	3.5	5.0	4.2	5.0	5.0	4.2	3.8	3.8					

Table 6.14: A summary table of the median, minimum, and maximum rates given for each personality trait.

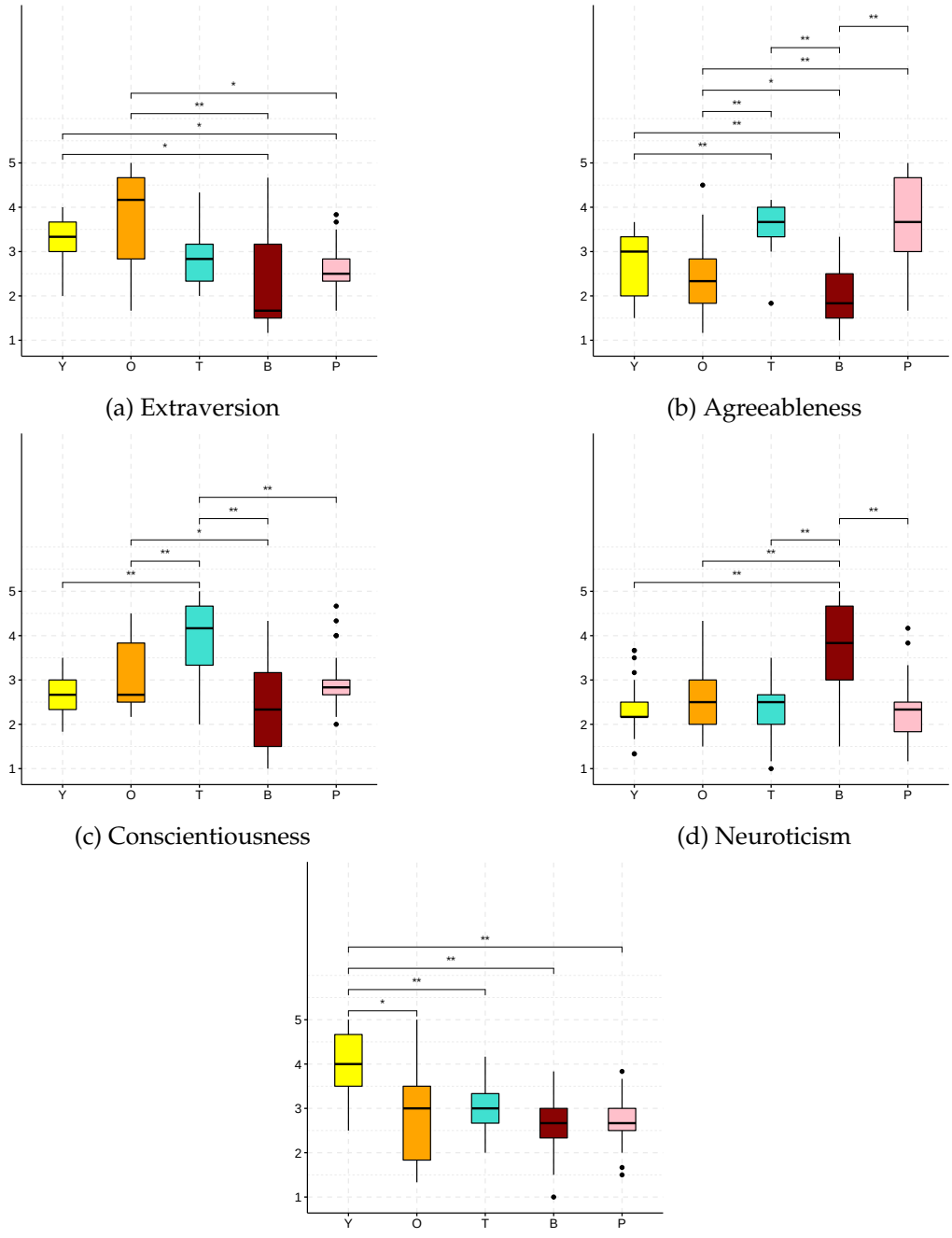
very high with p<.01 (see Figure 6.8).

Orange. There is a statistically substantial difference between personality trait measurements within orange color with p<.01, df=4 (see Table 6.7). The Wilcoxon tests show the following three groups having significantly different ratings when orange color is triggered: extraversion and agreeableness; extraversion and neuroticism; agreeableness and conscientiousness personality traits (see Figure 6.8). The extraversion seems to have the highest average ratings with median = 4.2 (see Appendix A.8)

Turquoise. Overall, all personality traits show different results when the light was transformed to turquoise color with p<.01, df=4 (see Table 6.7). Particularly, the measurements of conscientiousness and agreeableness personality traits are the most conveyed by turquoise colors with a p_{adj}<.05 (see Table 6.9). The median value for conscientiousness (med = 4.2) is higher than for agreeableness (med = 3.7) and all other personality traits (med $\leq$ 3.0) (see Table 6.15).

Blood-red lighting color reveals a significant difference in the measurements of all personality traits with p<.01, df=4 (see Table 6.7). Especially, there is a significant difference in ratings of neuroticism being higher than for all other personality traits with p_{adj}<.01. The box plots display a great separation of neuroticism samples from all other personality traits (see Figure 6.8).

Pink. There is a significant difference in the rating mascots' personality when the pink light is triggered with p<.01, df=4 (see Table 6.7). Particularly, there is a substantial impact of pink on the scores given for agreeableness personality with p_{adj}<.05. However, we could not find any difference in the ratings of pink color when we compare agreeableness and conscientiousness personality traits (p_{adj}>.05 see Figure 6.9).



(a) Extraversion

(b) Agreeableness

(c) Conscientiousness

(d) Neuroticism

(e) Openness

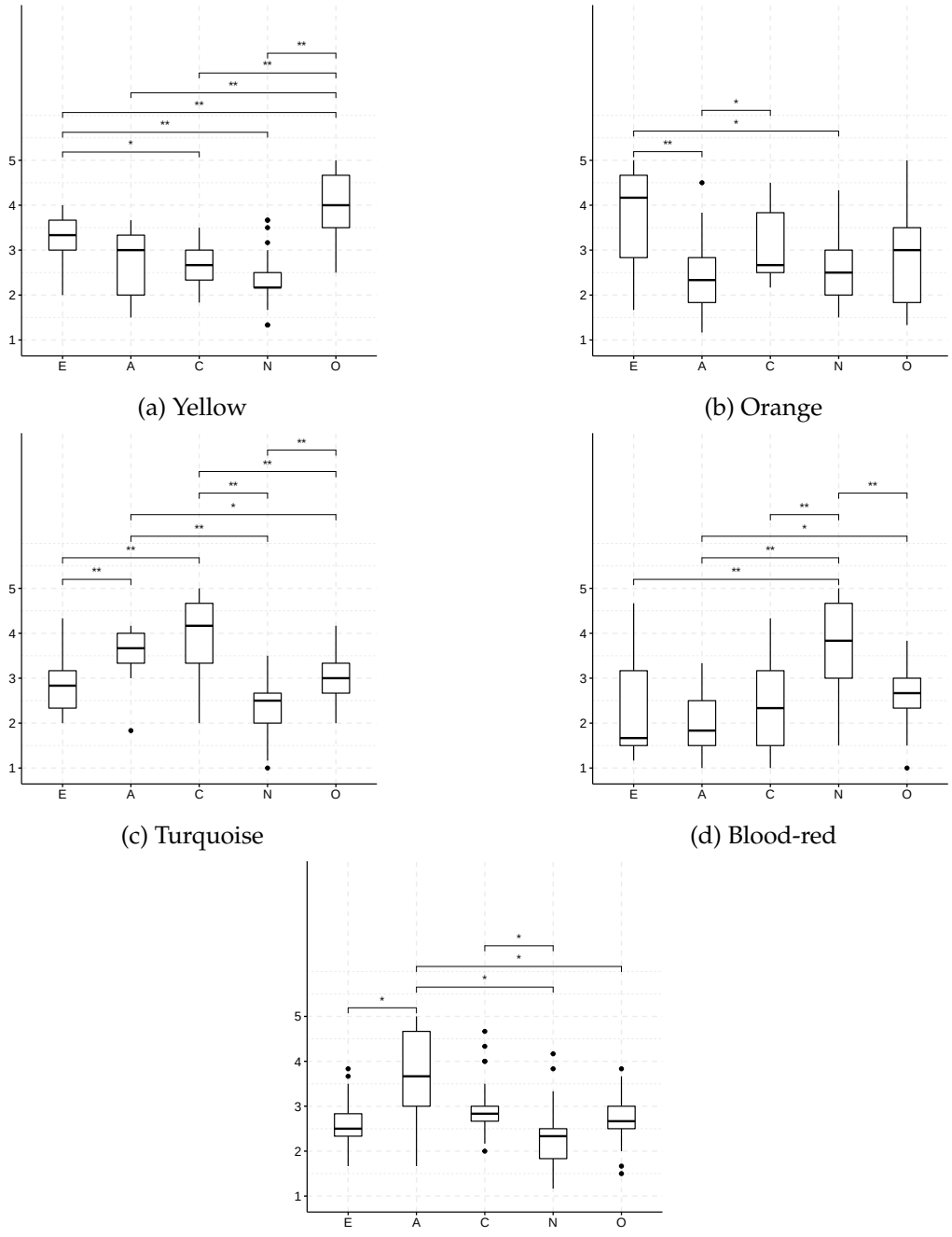
Figure 6.8: A boxplot for the mascot-tablet interaction in study-1. Stars represent the significance of p_{adj} after Bonferroni correction.

Color conditions	χ^2	**df**	**p**
Yellow	38.1	4	p<.01
Orange	20.0	4	p<.01
Turquoise	46.2	4	p<.01
Blood-Red	30.0	4	p<.01
Pink	21.7	4	p<.01

Table 6.15: The results of the Friedman test for all color conditions in the case of mascot-tablet interaction.

	Yellow					**Orange**					**Turquoise**				
	E	A	C	N	O	E	A	C	N	O	E	A	C	N	O
Min	2.0	1.5	1.8	1.3	2.5	1.7	1.2	2.2	1.5	1.3	2.0	1.8	2.0	1.0	2.0
Med	3.3	3.0	2.7	2.2	4.0	4.2	2.3	2.7	2.5	3.0	2.8	3.7	4.2	2.5	3.0
Max	4.0	3.7	3.5	3.7	5.0	5.0	4.5	4.5	4.3	5.0	4.3	4.2	5.0	3.5	4.2
	Blood-red					**Pink**									
	E	A	C	N	O	E	A	C	N	O					
Min	1.2	1.0	1.0	1.5	1.0	1.7	1.7	2.0	1.2	1.5					
Med	1.7	1.8	2.3	3.8	2.7	2.5	3.7	2.8	2.3	2.7					
Max	4.7	3.3	4.3	5.0	3.8	3.8	5.0	4.7	4.2	3.8					

Table 6.16: A summary table of the median, minimum, and maximum rates given for each color condition.



(a) Yellow

(b) Orange

(c) Turquoise

(d) Blood-red

(e) Pink

Figure 6.9: A boxplot for the mascot-tablet interaction in study-2. Stars represent the significance of p_{adj} after Bonferroni correction.

Chapter 7
Discussions

This chapter covers discussion of the results obtained from the statistical tests. In this study, the behavior of a mascot is conceptualized four interaction types which are referred as case-studies. Sections 7.1, 7.2, 7.3, and 7.4 discuss each interaction type for the within personality and the within condition studies.

7.1 Mascot-speakers interaction

The empirical evidence for mascot-speakers case-study shows that the type of music influences the participants' interpretation of the personality trait. The mascot triggering sophisticated, contemporary, or unpretentious song can be associated with a specific personality trait.

The discussion of the first study.

On the one hand, the interaction between mascot and contemporary was interpreted to be more extravert which is characterised as being more friendly, sociable, cheerful and so on. On the other hand, this type of interaction also was rated very high on conveying neuroticism personality trait which is described as being more emotionally unstable, angry, vulnerable, depressive and so on. The mascot triggering sophisticated music was perceived to be more open to new experiences. Such songs as classical, jazz and contemporary adult were interpreted as more artistic intelligent, thoughtful, and other facets representing openness personality trait (see Table 2.7). Agreeableness and conscientiousness personality traits were associated with sophisticated and unpretentious compared to contemporary music. However, this study does not provide statistical evidence for these two personality traits to be conveyed by a specific music type.

The discussion of the second study.

The within music condition study revealed that mascot interacting with sophisticated music was perceived to be more open to new experiences. In addition, the first study associated contemporary with both extraversion and neuroticism personality traits. By comparing the ratings of all personality traits within contemporary music, the second study revealed that this music condition conveys extraversion personality trait most.

7.2 Mascot-lamp interaction

The study shows that the change in color of the lamp has an impact on the way how participants interpret the personality of a mascot. This shows that the lamp that mascot interact with was not only interpreted as an artificial light source but also gave clues about mascot's personality trait

The discussion of the first study.

Participants associated mascot triggering blood-red lighting neuroticism personality trait which is characterized as to be to be highly anxious, angry, depressive, self-conscientious, impulsive and vulnerable. Extraversion personality was rated very high to be conveyed with yellow lighting only compared to turquoise, blood-red, and pink. With agreeableness and conscientiousness, participants rated mascots interacting with pink, yellow, turquoise lighting to be more associated with these personality traits. However, for all personality traits except neuroticism, it is hard to distinguish a specific color that conveys these personality traits.

The discussion of the second study.

The mascot triggering the blood-red lighting is interpreted to be mor neuroticism as an anxious, highly depressive, angry, vulnerable, and that has an immoderate behavior. The second study confirms that how personality of a mascot was measured, except for neuroticism, all other personality traits cannot be conveyed by a single color. For example, both turquoise and pink lights convey agreeableness and conscientiousness personality traits. Also, orange color was interpreted to be more extravert and openness to new experiences.

7.3 Mascot-mascot interaction

The statistical analysis showed that the levels of vibration have a significant effect on the measurement of mascot's personality.

The discussion of the first study.

Participants experiencing 500 milliseconds vibration duration interpreted the approaching mascot as more energetic, assertive, forceful, energetic, friendly, sociable, cheerful which constitutes extraversion personality trait. The mascot interacting with level-2 and level-3 was perceived to be more agreeable which is described as being modest, cooperative, trustworthy and so on. Mascot interacting with level-3 and level-4 vibration are interpreted as conscientiousness. The participants experiencing 100 millisecond vibration aka level-1 interpreted approaching mascot as neuroticism which is characterized by being anxious, angry, depressive and so on (see Table 2.7).

The discussion of the second study.

Participants experiencing the vibration with the shortest duration perceived approaching mascot (i.e. the mascot that triggered their device) as neurotic. The mascot causing 200 milliseconds per time interpreted as agreeable. Th mascot making participant's phone to vibrate with the duration of 500 milliseconds conveys extraversion personality trait.

7.4 Mascot-tablet interaction

The empirical evidences revealed that, overall, the change of background color effects which personality trait will be perceived by this interaction.

The discussion of the first study.

For the within personality study, turquoise which is distinguished from all other colors represents conscientiousness personality trait. Also, blood-red color is associated with neuroticism personality that is characterized by having immoderate behavior, being aggressive, depressive and so on. Openness personality is best conveyed by yellow screen color.

The discussion of the second study.

The analysis of within each color condition shows that yellow background portrays openness personality trait which makes the results from the first study even more consistent. Also, blood-red screen is significantly associated with neuroticism personality. The first study revealed conscientiousness personality conveyed by turquoise color. However, when all personality traits were compared within turquoise color, the ratings of conscientiousness personality trait did not distinguish from the scores given for agreeableness personality. Thus, according to the second study turquoise color failed to be associated only with conscientiousness personality.

7.5 Overview of the discussion

Associate conditions with the personality traits. The representation of all types of behavior and associated personality traits. The results that we obtained from the study is the following:

⇒ **Music type**

Extraversion: contemporary songs

Openness: sophisticated songs

⇒ **Lighting color**

Neuroticism: blood-red

⇒ **Vibration level**

Neuroticism: level-1 (100 ms)

Agreeableness: level-2 (200 ms)

Extraversion: level-5 (500 ms)

⇒ **Screen color**

Neuroticism: blood-red

Openness: yellow

Chapter 8
Conclusion

Section 8.1 of the final chapter gives a conclusive overview of the results achieved during this study. Section 8.2 describes the contribution, Section 8.3 provides certain limitations, and Section 8.4 covers the ideas explored in this project can be continued further.

8.1 Overview

In this study, both psychological and user-experience approaches helps us to better understand thing to thing interaction. The interaction between a mascot and other inanimate devices gave a descriptive clue about the personality of a social device. In this study, we explore how people interpret the interaction between a user and social devices. The preset behaviors such as playing music, vibrating with certain duration, changing lighting colors, and altering screen color were investigated to find an association with the concept of personality trait.

8.1.1 Overview of the results

In the first study, we observe the personality trait and the variation of all conditions within each personality individually. In our second study, we take a closer look at each condition and the variation of all personality traits within a specific condition. The second study is supplementary for the first study. Thus, the second study results in a specific personality trait that is conveyed most by this condition.

The following guideline to associate predefined actions with a specific personality

trait is introduced:

- For **Mascot-speakers interaction**, in order to convey extraversion personality trait, contemporary music will be the best choice. For the mascot that attributes an openness personality trait, the good choice will fall on sophisticated music.
- For **Mascot-lamp interaction**, if the mascot triggers blood-red lighting as a representation of its behavior, it will convey the neuroticism personality trait.
- For **Mascot-mascot interaction**, the extraversion mascot can be presented by showing the highest level of vibration, namely level-5 with 500 milliseconds duration. The best representation of agreeableness personality trait will be level-2 vibrating 200 milliseconds per time. When the neuroticism is chosen, the behavior that conveys this personality trait most is the vibration level-1.
- For **Mascot-tablet interaction**, in order to convey the openness personality trait, the most associated behavior is choosing yellow screen. For neuroticism personality trait, the blood-red is a good and distinctive choice.

In addition, a social device interacting with the same color in various environment was interpreted differently. For example, yellow screen conveyed openness for mascot-tablet interaction, whereas for mascot-lamp, it failed to convey any personality trait. One reason might be that the lamp emitting yellow light can be perceived as the typical color you get from incandescent bulbs. Meanwhile, the yellow screen color is perceived as a more vivid color framed in a screen. The same observation is made for blood-red color which conveys a neurotic personality trait for both interaction types. However, the mascot triggering the blood-red lighting is perceived as more aggressive than the one triggering the same color in the tablet. By illuminating the whole room with blood-red color people may get a more negative impression about mascot's personality than seeing the same color in a tablet-size screen. The above mentioned explanations are assumptions and can be investigated in the further studies.

8.2 Contributions and findings

The main contribution is an achieving cooperation among mascot and other interactive objects in a system where each mascot has a unique personality trait. This can, in turn, serve as a contribution for designing social devices in SIoT environment. Thus, the system that produces four types of interactions with predefined actions was implemented.

We also empirically investigated how people interpret the behavior, particularly such signals as lighting color change, music play, vibration, and screen color

alternation. The important finding was the relationship between personality trait and behavior of interactive objects. Although this relationship is not as clear and vivid as we observe in human-human interaction, it is a good insight that personality trait and behavior are interconnected concepts even for inanimate objects.

Finally, we used personality based on the Big Five Personality Trait Model as an interaction between people and social devices, where personality was conveyed by the predefined actions. This shed a light on using personality model as a tool to predict and influence automated behaviors in the context of Internet of Things environment.

8.3 Limitations

The study was based on relatively small (N=25) and homogeneous (e.g. having 70% of participants from formal sciences and age mean of 26) samples which limited the power of analyses and make it difficult to extrapolate findings to a general population. However, the experiment design was counterbalanced in terms of other important characteristics such as gender, participants' overall music preferences for mascot-speakers interaction and the order in which participants watched the videos.

Another limitation could be that the study was held in a laboratory setting where participants only had a limited time to assess the personalities of them. On the one hand, there is a possibility that spending more time (i.e. hours or days) with social devices could affect participant's opinions on the measurements of the personality trait of devices. On the other hand, during these experiments participants reflected their very first impressions while seeing the interaction between devices and their initial reaction while measuring the personality traits of mascots based on these interactions.

Also, during study, some signals especially some colors in the mascot-lamp interaction was hard to associate with specific personality traits. However, this study gave us an insight that personality traits and the behavior of social devices are two interrelated concepts. Also, for the preset actions and signals that were associated to personality traits, the guideline was introduced.

The limitation regarding the implementation was to have a centralized system that gives a control to the server instead of the social devices themselves.

8.4 Future work

From the implementation perspective, a distributed system for communication between social devices can be designed. Thus, the realization of a protocol that helps all devices in a system to come to common agreement can also be

performed.

Another idea might be improving mascot-tablet interaction in addition to screen colors some other functionalities can be added. For example, when mascot approaching tablet it can show some favorite pictures in order to give more information about mascot. In fact, the design of such system should also take into account security aspects for not leaking personal photos.

Also, using the interaction between social devices as a trigger or motivation for people to socialize and communicate more. The behavior of mascots such as trigger lighting or music play or vibrate some other person's mascot when you approach it, can be an icebreaker for people to communicate with each other.

Appendix A
Tables and Figures

	Group 1	Group 2	Wilcoxon tests		r	padj
			z	p		
E	Sophisticated	Contemporary	-4.2111	p<0.01	0.842	p<0.01
	Sophisticated	Unpretentious	-2.7188	p<0.01	0.544	p<0.05
	Contemporary	Unpretentious	3.8751	p<0.01	0.775	p<0.01
A	Sophisticated	Contemporary	4.2864	p<0.01	0.872	p<0.01
	Contemporary	Unpretentious	-4.2121	p<0.01	0.842	p<0.01
C	Sophisticated	Contemporary	3.0545	p<0.01	0.611	p<0.01
	Contemporary	Unpretentious	-2.7863	p<0.01	0.546	p<0.05
N	Sophisticated	Contemporary	-3.9739	p<0.01	0.797	p<0.01
	Contemporary	Unpretentious	3.7269	p<0.01	0.745	p<0.01
O	Sophisticated	Contemporary	4.2932	p<0.01	0.859	p<0.01
	Sophisticated	Unpretentious	2.9869	p<0.01	0.595	p<0.01
	Contemporary	Unpretentious	-3.9709	p<0.01	0.794	p<0.01

Table A.1: The statistically significant comparisons of each group individually using the Wilcoxon signed-rank test and Bonferroni correction while measuring Five Personality Traits for Mascot-Speakers interaction. In addition reporting effect sizes which are large

	Group 1	Group 2	Wilcoxon tests		r	padj
			z	p		
Sophisticated	E	A	-3.9431	p<0.01	0.789	p<0.01
	E	N	3.6469	p<0.01	0.729	p<0.01
	E	O	-4.3459	p<0.01	0.869	p<0.01
	A	C	2.8937	p<0.01	0.579	p<0.05
	A	N	4.3732	p<0.01	0.875	p<0.01
	A	O	-3.3377	p<0.01	0.668	p<0.01
	C	N	4.1446	p<0.01	0.829	p<0.01
	C	O	-3.8436	p<0.01	0.762	p<0.01
	N	O	-4.373	p<0.01	0.875	p<0.01
Contemporary	E	A	4.2574	p<0.01	0.861	p<0.01
	E	C	4.2659	p<0.01	0.853	p<0.01
	E	N	4.1175	p<0.01	0.824	p<0.01
	E	O	4.2866	p<0.01	0.872	p<0.01
Unpretentious	E	A	-3.1034	p<0.01	0.630	p<0.05
	E	N	4.3736	p<0.01	0.875	p<0.01
	A	C	3.4615	p<0.01	0.742	p<0.01
	A	N	4.3463	p<0.01	0.869	p<0.01
	C	N	3.7949	p<0.01	0.759	p<0.01
	C	O	-2.9387	p<0.01	0.569	p<0.05
	N	O	-4.3734	p<0.01	0.875	p<0.01

Table A.2: Mascot-Speakers

	Group 1	Group 2	Wilcoxon tests		r	padj
			z	p		
E	Yellow	Turquoise	3.5315	p<0.01	0.706	p<0.01
	Yellow	Blood-Red	4.185	p<0.01	0.837	p<0.01
	Yellow	Pink	3.8951	p<0.01	0.781	p<0.01
	Orange	Blood-Red	4.1461	p<0.01	0.829	p<0.01
	Turquoise	Blood-Red	3.3966	p<0.01	0.682	p<0.01
	Blood-Red	Pink	-3.5166	p<0.01	0.711	p<0.01
A	Yellow	Orange	3.6211	p<0.01	0.724	p<0.01
	Yellow	Blood-Red	4.0237	p<0.01	0.805	p<0.01
	Orange	Turquoise	-4.0613	p<0.01	0.832	p<0.01
	Orange	Pink	-4.294	p<0.01	0.859	p<0.01
	Turquoise	Blood-Red	4.2807	p<0.01	0.856	p<0.01
	Blood-Red	Pink	-4.1868	p<0.01	0.842	p<0.01
C	Yellow	Orange	3.3333	p<0.01	0.660	p<0.01
	Yellow	Blood-Red	3.1945	p<0.01	0.657	p<0.05
	Orange	Turquoise	-3.8186	p<0.01	0.767	p<0.01
	Orange	Pink	-3.7784	p<0.01	0.755	p<0.01
	Turquoise	Blood-Red	3.2405	p<0.01	0.644	p<0.05
	Blood-Red	Pink	-3.1456	p<0.01	0.619	p<0.05
N	Yellow	Blood-Red	-4.3193	p<0.01	0.864	p<0.01
	Orange	Blood-Red	-4.2602	p<0.01	0.862	p<0.01
	Turquoise	Blood-Red	-4.287	p<0.01	0.872	p<0.01
	Blood-Red	Pink	4.3738	p<0.01	0.875	p<0.01
O	Yellow	Blood-Red	3.4619	p<0.01	0.692	p<0.01
	Yellow	Pink	2.8482	p<0.01	0.574	p<0.05
	Orange	Blood-Red	3.0702	p<0.01	0.614	p<0.05

Table A.3: The statistically significant comparisons of each group individually using the Wilcoxon signed-rank test and Bonferroni correction while measuring Five Personality Traits for Mascot-Lamp interaction. In addition reporting effect sizes which are large.

	Group 1	Group 2	Wilcoxon tests		r	padj
			z	p		
Yellow	E	N	3.9296	p<0.01	0.789	p<0.01
	A	N	3.561	p<0.01	0.722	p<0.01
	C	N	3.4599	p<0.01	0.692	p<0.01
	N	O	-3.6295	p<0.01	0.721	p<0.01
Orange	E	A	4.0294	p<0.01	0.818	p<0.01
	E	C	0.679	p<0.01	0.679	p<0.01
	E	N	0.661	p<0.01	0.661	p<0.01
	A	O	-4.1086	p<0.01	0.840	p<0.01
	C	O	-2.9182	p<0.01	0.587	p<0.05
	N	O	-3.1376	p<0.01	0.636	p<0.05
Turquoise	E	A	-3.8621	p<0.01	0.776	p<0.01
	E	C	-3.339	p<0.01	0.668	p<0.01
	E	N	3.0291	p<0.01	0.617	p<0.05
	A	N	3.7697	p<0.01	0.754	p<0.01
	A	O	2.8456	p<0.01	0.552	p<0.05
	C	N	4.1879	p<0.01	0.843	p<0.01
	C	O	3.4339	p<0.01	0.687	p<0.01
	N	O	-3.4777	p<0.01	0.690	p<0.01
Blood Red	E	N	-4.3464	p<0.01	0.869	p<0.01
	E	O	-2.9088	p<0.01	0.596	p<0.05
	A	C	-2.9421	p<0.01	0.597	p<0.05
	A	N	-4.2335	p<0.01	0.857	p<0.01
	A	O	-3.2177	p<0.01	0.631	p<0.05
	C	N	-3.8625	p<0.01	0.773	p<0.01
	N	O	3.9709	p<0.01	0.794	p<0.01
Pink	E	A	-3.9842	p<0.01	0.797	p<0.01
	E	C	-3.4545	p<0.01	0.714	p<0.01
	E	N	3.6722	p<0.01	0.735	p<0.01
	A	N	4.2394	p<0.01	0.848	p<0.01
	A	O	3.9193	p<0.01	0.792	p<0.01
	C	N	4.2392	p<0.01	0.848	p<0.01
	C	O	3.1883	p<0.01	0.638	p<0.05
	N	O	-3.9322	p<0.01	0.794	p<0.01

Table A.4: Mascot-Lamp interaction

	Group 1	Group 2	Wilcoxon tests		r	padj
			z	p		
E	Level-1	Level-4	-3.9316	p<0.01	0.786	p<0.01
	Level-1	Level-5	-3.5756	p<0.01	0.714	p<0.01
	Level-2	Level-4	-3.687	p<0.01	0.743	p<0.01
	Level-2	Level-5	-3.4301	p<0.01	0.678	p<0.01
	Level-3	Level-4	-3.545	p<0.01	0.708	p<0.01
	Level-3	Level-5	-2.9168	p<0.01	0.582	p<0.05
A	Level-1	Level-2	-3.5566	p<0.01	0.703	p<0.01
	Level-1	Level-3	-3.6336	p<0.01	0.727	p<0.01
	Level-2	Level-4	3.028	p<0.01	0.595	p<0.05
	Level-2	Level-5	3.0421	p<0.01	0.608	p<0.05
	Level-3	Level-4	3.0827	p<0.01	0.617	p<0.05
	Level-3	Level-5	2.8476	p<0.01	0.552	p<0.05
C	Level-1	Level-3	-3.8995	p<0.01	0.809	p<0.01
	Level-1	Level-4	-4.0659	p<0.01	0.813	p<0.01
	Level-2	Level-3	-3.3019	p<0.01	0.657	p<0.01
	Level-2	Level-4	-3.817	p<0.01	0.767	p<0.01
	Level-3	Level-5	3.3624	p<0.01	0.671	p<0.01
	Level-4	Level-5	3.8499	p<0.01	0.784	p<0.01
N	Level-1	Level-2	3.326	p<0.01	0.665	p<0.01
	Level-1	Level-3	3.8172	p<0.01	0.779	p<0.01
	Level-1	Level-4	3.8607	p<0.01	0.776	p<0.01
	Level-1	Level-5	3.4724	p<0.01	0.694	p<0.05
O	Level-1	Level-2	-2.8243	p<0.01	0.578	p<0.01

Table A.5: The statistically significant comparisons of each group individually using the Wilcoxon signed-rank test and Bonferroni correction while measuring Five Personality Traits for Mascot-Mascot interaction. In addition reporting effect sizes which are large

	Group 1	Group 2	Wilcoxon tests		r	padj
			z	p		
Level-1	E	A	-2.9843	p<0.01	0.609	p<0.05
	E	N	-3.3934	p<0.01	0.671	p<0.01
	A	N	-3.0749	p<0.01	0.603	p<0.05
	C	N	-3.0975	p<0.01	0.620	p<0.05
	N	O	3.0542	p<0.01	0.604	p<0.05
Level-2	E	A	-3.7586	p<0.01	0.757	p<0.01
	A	C	3.1519	p<0.01	0.620	p<0.05
	A	N	3.3024	p<0.01	0.654	p<0.01
	A	O	3.1503	p<0.01	0.617	p<0.05
Level-3	E	A	-2.9298	p<0.01	0.584	p<0.05
	E	C	-3.3928	p<0.01	0.660	p<0.01
	A	N	3.8758	p<0.01	0.775	p<0.01
	A	O	3.303	p<0.01	0.660	p<0.01
	C	N	4.039	p<0.01	0.808	p<0.01
	C	O	3.6229	p<0.01	0.722	p<0.01
	N	O	-3.1867	p<0.01	0.627	p<0.05
Level-4	E	A	3.5903	p<0.01	0.719	p<0.01
	E	N	4.1601	p<0.01	0.837	p<0.01
	E	O	3.8034	p<0.01	0.765	p<0.01
	A	C	-3.7747	p<0.01	0.759	p<0.01
	C	N	4.1315	p<0.01	0.826	p<0.01
	C	O	3.7164	p<0.01	0.738	p<0.01
Level-5	E	A	2.9346	p<0.01	0.587	p<0.05
	E	C	3.1512	p<0.01	0.617	p<0.05
	E	N	3.7113	p<0.01	0.748	p<0.01
	E	O	3.4195	p<0.01	0.684	p<0.01

Table A.6: Mascot-Mascot

	Group 1	Group 2	Wilcoxon tests		r	padj
			z	p		
E	Yellow	Blood-Red	3.1011	p<0.01	0.627	p<0.05
	Yellow	Pink	3.2335	p<0.01	0.650	p<0.05
	Orange	Blood-Red	3.7314	p<0.01	0.751	p<0.01
	Orange	Pink	3.1295	p<0.01	0.627	p<0.05
A	Yellow	Turquoise	-3.8448	p<0.01	0.780	p<0.01
	Yellow	Blood-Red	3.7734	p<0.01	0.781	p<0.01
	Orange	Turquoise	-4.0936	p<0.01	0.819	p<0.01
	Orange	Blood-Red	3.1542	p<0.01	0.650	p<0.05
	Orange	Pink	-3.305	p<0.01	0.653	p<0.01
	Turquoise	Blood-Red	4.3755	p<0.01	0.875	p<0.01
	Blood-Red	Pink	-3.7573	p<0.01	0.757	p<0.01
C	Yellow	Turquoise	-3.9161	p<0.01	0.791	p<0.01
	Orange	Turquoise	-3.204	p<0.01	0.641	p<0.05
	Orange	Blood-Red	3.4736	p<0.01	0.697	p<0.01
	Turquoise	Blood-Red	4.0152	p<0.01	0.802	p<0.01
	Turquoise	Pink	3.7126	p<0.01	0.749	p<0.01
N	Yellow	Blood-Red	-3.8045	p<0.01	0.786	p<0.01
	Orange	Blood-Red	-3.5754	p<0.01	0.724	p<0.01
	Turquoise	Blood-Red	-4.1588	p<0.01	0.837	p<0.01
	Blood-Red	Pink	3.6195	p<0.01	0.724	p<0.01
O	Yellow	Orange	3.1986	p<0.01	0.658	p<0.05
	Yellow	Turquoise	3.461	p<0.01	0.704	p<0.01
	Yellow	Blood-Red	4.2273	p<0.01	0.845	p<0.01
	Yellow	Pink	4.2307	p<0.01	0.856	p<0.01

Table A.7: The statistically significant comparisons of each group individually using the Wilcoxon signed-rank test and Bonferroni correction while measuring Five Personality Traits for Mascot-Tablet interaction. In addition reporting effect sizes which are large

	Group 1	Group 2	Wilcoxon tests		r	padj
			z	p		
Yellow	E	C	2.9954	p<0.01	0.599	p<0.05
	E	N	3.4443	p<0.01	0.717	p<0.01
	E	O	-3.7585	p<0.01	0.751	p<0.01
	A	O	-3.8775	p<0.01	0.807	p<0.01
	C	O	-4.0453	p<0.01	0.810	p<0.01
	N	O	-4.1998	p<0.01	0.840	p<0.01
Orange	E	A	3.6158	p<0.01	0.724	p<0.01
	E	N	3.0578	p<0.01	0.603	p<0.05
	A	C	-3.1027	p<0.01	0.628	p<0.05
Turquoise	E	A	-3.7457	p<0.01	0.743	p<0.01
	E	C	-3.9292	p<0.01	0.787	p<0.01
	A	N	3.8643	p<0.01	0.773	p<0.01
	A	O	3.1941	p<0.01	0.639	p<0.05
	C	N	4.0721	p<0.01	0.826	p<0.01
	C	O	3.5643	p<0.01	0.737	p<0.01
	N	O	-3.1846	p<0.01	0.642	p<0.05
Blood-Red	E	N	-3.1303	p<0.01	0.622	p<0.05
	A	N	-3.6735	p<0.01	0.740	p<0.01
	A	O	-3.7897	p<0.01	0.774	p<0.01
	C	N	-3.0814	p<0.01	0.616	p<0.05
	N	O	3.3013	p<0.01	0.665	p<0.01
Pink	E	A	-3.1366	p<0.01	0.627	p<0.01
	A	N	3.2557	p<0.01	0.646	p<0.01
	A	O	2.9877	p<0.01	0.598	p<0.05
	C	N	2.8606	p<0.01	0.582	p<0.05

Table A.8: Mascot-Tablet

Appendix B
Questionnaire for the user study

Questionnare

Please fill this form after the video watch to reflect your opinion

The scales mean that the statement which describes the behavior of the Mascot that you have just saw in the video is Very Inaccurate, Inaccurate, Neutral, Accurate and Very Accurate.

I can describe the behavior of a Mascot that I have seen in this video with the following words:

1. Friendly and warm:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
2. Gregarious and sociable:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
3. Assertive and forceful:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
4. Highly active and energetic:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
5. Seeks for excitement:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
6. Cheerful and Positive:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
7. Trusting and forgiving:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
8. Straightforward:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
9. Altruistic:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
10. Cooperative:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
11. Modest:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
12. Sympathetic:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
13. High sense of Self-efficacy:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
14. Orderly:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
15. Dutiful:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
16. Achievement-striving:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
17. Self-disciplined:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
18. Deliberating and Continuous:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
19. Anxious:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
20. Angry and hostile:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
21. High level of Depression:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
22. Self-conscious:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
23. Immoderate behavior:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
24. Vulnerable:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
25. Imaginative:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
26. Artistic interests:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
27. Emotional:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
28. Adventurous:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
29. Intellectual:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate
30. Liberal:	○ Very Inaccurate ○ Inaccurate ○ Neutral ○ Accurate ○ Very Accurate

Figure B.1: The questionnaires given for each video during the experiments.

Bibliography

[1] Mark Weiser. The computer for the 21st century. *IEEE pervasive computing*, 1(1):19–25, 2002.

[2] Felix Hupfeld and Michael Beigl. Spatially aware local communication in the raum system. In *International Workshop on Interactive Distributed Multimedia Systems and Telecommunication Services*, pages 285–296. Springer, 2000.

[3] Lu Tan and Neng Wang. Future internet: The internet of things. In *2010 3rd international conference on advanced computer theory and engineering (ICACTE)*, volume 5, pages V5–376. IEEE, 2010.

[4] Kevin Ashton et al. That 'internet of things' thing. *RFID journal*, 22(7):97–114, 2009.

[5] Somayya Madakam, R Ramaswamy, and Siddharth Tripathi. Internet of things (iot): A literature review. *Journal of Computer and Communications*, 3(05):164, 2015.

[6] David Chung, Mathias Funk, Rung-Huei Liang, and Lin-Lin Chen. Explorations on reciprocal interplay in things ecology. In *Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility*, pages 51–56. ACM, 2018.

[7] Luigi Atzori, Antonio Iera, and Giacomo Morabito. The internet of things: A survey. *Computer networks*, 54(15):2787–2805, 2010.

[8] Luigi Atzori, Antonio Iera, and Giacomo Morabito. Siot: Giving a social structure to the internet of things. *IEEE communications letters*, 15(11):1193–1195, 2011.

[9] Luigi Atzori, Antonio Iera, Giacomo Morabito, and Michele Nitti. The social internet of things (siot)–when social networks meet the internet of things: Concept, architecture and network characterization. *Computer networks*, 56(16):3594–3608, 2012.

[10] Miyo Okada, Atsuro Ueki, Niclas Jonasson, Masato Yamanouchi, Cristian Norlin, Hideki Sunahara, Joakim Formo, Mikael Anneroth, and Masa Inakage. Autonomous cooperation of social things: Designing a system for things with unique personalities in iot. In *Proceedings of the 6th International Conference on the Internet of Things*, pages 35–42. ACM, 2016.

[11] Edward T Hall. A system for the notation of proxemic behavior1. *American anthropologist*, 65(5):1003–1026, 1963.

[12] Edward Twitchell Hall. *The hidden dimension*, volume 609. Garden City, NY: Doubleday, 1910.

[13] Jo Vermeulen, Kris Luyten, Karin Coninx, Nicolai Marquardt, and Jon Bird. Proxemic flow: Dynamic peripheral floor visualizations for revealing and mediating large surface interactions. In *IFIP Conference on Human-Computer Interaction*, pages 264–281. Springer, 2015.

[14] David Ledo, Saul Greenberg, Nicolai Marquardt, and Sebastian Boring. Proxemic-aware controls: Designing remote controls for ubiquitous computing ecologies. In *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services*, pages 187–198. ACM, 2015.

[15] Till Ballendat, Nicolai Marquardt, and Saul Greenberg. Proxemic interaction: designing for a proximity and orientation-aware environment. In *ACM International Conference on Interactive Tabletops and Surfaces*, pages 121–130. ACM, 2010.

[16] Alan P Fiske. The four elementary forms of sociality: framework for a unified theory of social relations. *Psychological review*, 99(4):689, 1992.

[17] Antonio Pintus, Davide Carboni, Alberto Serra, and Andrea Manchinu. Humanizing the internet of things-toward a human-centered internet-and-web of things. In *WEBIST*, pages 498–503, 2015.

[18] Alessandro Soro, Margot Brereton, and Paul Roe. *Social Internet of Things*. Springer, 2018.

[19] Marco Spadafora, Victor Chahuneau, Nikolas Martelaro, David Sirkin, and Wendy Ju. Designing the behavior of interactive objects. In *Proceedings of the TEI'16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction*, pages 70–77. ACM, 2016.

[20] Gerald Matthews, Ian J Deary, and Martha C Whiteman. *Personality traits*. Cambridge University Press, 2003.

[21] Lüscher, Max. *The Luscher color test*. Simon and Schuster, 1971.

[22] Cerrato, Herman. *The meaning of colors*. The Graphic Designer, 2012.

[23] Schaie, Klaus Warner and Heiss, Robert. *Color and personality.*. Grune & Stratton, 1964.

[24] Alschuler, Rose H and Hattwick, LaBerta A. *Easel painting as an index of personality in preschool children.* American Journal of Orthopsychiatry, 1943.

[25] Schaie, K Warner. *Scaling the association between colors and mood-tones* The american journal of psychology, 1961

[26] Bagherian, Mandana and Mojambari, Adis Kraskian. *The Relationship between BIG Five Personality Traits and Assertiveness*.

[27] Kirst, Laura K. *Investigating the relationship between assertiveness and personality characteristics*. 2011.

[28] Ramanaiah, Nerella V and Deniston, William M. *NEO personality inventory profiles of assertive and nonassertive persons*. Psychological reports, SAGE Publications Sage CA: Los Angeles, CA, 1993.

[29] Lefevre, Esther R and West, Malcolm L. *Assertiveness: Correlations with self-esteem locus of control, interpersonal anxiety, fear of disapproval, and depression*. Psychiatric Journal of the University of Ottawa, Canadian Medical Assn, 1981.

[30] Costa Jr, Paul T and McCrae, Robert R. *From catalog to classification: Murray's needs and the five-factor model.*. Journal of personality and social psychology, American Psychological Association, 1988.

[31] Costa Jr, Paul T and McCrae, Robert R. *The Revised NEO Personality Inventory (NEO-PI-R).*. Sage Publications, Inc, 2008.

[32] Paunonen, Sampo V and Ashton, Michael C. *Big five factors and facets and the prediction of behavior.*. Journal of personality and social psychology, American Psychological Association, 2001.

[33] Boer, Diana and Fischer, Ronald and Strack, Micha and Bond, Michael H and Lo, Eva and Lam, Jason. *How shared preferences in music create bonds between people: Values as the missing link* Personality and Social Psychology Bulletin, 2011

[34] Rentfrow, Peter J and Gosling, Samuel D. *The content and validity of music-genre stereotypes among college students* Psychology of music, 2007

[35] Rentfrow, Peter J and Gosling, Samuel D. *Message in a ballad: The role of music preferences in interpersonal perception* Psychological science, 2006

[36] Zweigenhaft, Richard L. *A do re mi encore: A closer look at the personality correlates of music preferences* Journal of individual differences, 2008

[37] Rentfrow, Peter J and Goldberg, Lewis R and Levitin, Daniel J. *The structure of musical preferences: a five-factor model.* Journal of personality and social psychology, 2011

[38] Rentfrow, Peter J and Gosling, Samuel D. *The do re mi's of everyday life: the structure and personality correlates of music preferences.* Journal of personality and social psychology, 2003

[39] George, Darren and Stickle, Kelly and Rachid, Faith and Wopnford, Alayne. *The association between types of music enjoyed and cognitive, behavioral, and personality factors of those who listen.* Psychomusicology: A Journal of Research in Music Cognition, 2007

[40] Schäfer, Thomas and Sedlmeier, Peter. *From the functions of music to music preference* Psychology of Music, 2009

[41] Dunn, Peter Gregory and de Ruyter, Boris and Bouwhuis, Don G. *Toward a better understanding of the relation between music preference, listening behavior, and personality* Sage Publications Sage UK: London, England, 2012

[42] Zuckerman, Marvin and Kuhlman, D Michael and Camac, Curt. *What lies beyond E and N? Factor analyses of scales believed to measure basic dimensions of personality.* American Psychological Association, 1988

[43] Furnham, Adrian and Avison, Margaret. *Personality and preference for surreal paintings* Elsevier, 1997

[44] Schäfer, Thomas and Mehlhorn, Claudia. *Can personality traits predict musical style preferences? A meta-analysis* Elsevier, 2017

[45] Bonneville-Roussy, Arielle and Rentfrow, Peter J and Xu, Man K and Potter, Jeff. *Music through the ages: Trends in musical engagement and preferences from adolescence through middle adulthood.* American Psychological Association, 2013

[46] Fricke, Kai R and Herzberg, Philipp Y. *Personality and self-reported preference for music genres and attributes in a German-speaking sample* Elsevier, 2017

[47] Greenberg, David M and Kosinski, Michal and Stillwell, David J and Monteiro, Brian L and Levitin, Daniel J and Rentfrow, Peter J. *The song is you: Preferences for musical attribute dimensions reflect personality* Sage Publications Sage CA: Los Angeles, CA, 2016

[48] Langmeyer, Alexandra and Guglhör-Rudan, Angelika and Tarnai, Christian. *What do music preferences reveal about personality?* Hogrefe Publishing, 2012