Using Psychology to Improve the Usability of Computer Interfaces

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Abstract

Can psychology help to improve the usability of computer systems? This was investigated by applying psychological theories and research, mostly from cognitive psychology, to try to improve the learnability and user satisfaction of a renting system. The renting system was redesigned in order to make it easier to learn and to use. A usability test was conducted where 16 participants were randomly divided into two groups. Group one first performed tasks on the old system and then the new one, and vice versa for group two. The results showed that the redesigned system is easier to learn and to use and the users were more satisfied. This indicates that having a background in psychology and understanding how people think and behave can be valuable for designing usable computer systems.

Keywords: computer interfaces, usability, psychology
Foreword

I have been working on designing user interfaces for a couple of years in conjunction with my studies in psychology. I want to know more about how I can use my education in psychology to make interfaces better and more usable. The goal of this project is to use the theoretical knowledge I have gained in psychology for something practical and be able to make a simple and good interface using that knowledge. I want to apply the theory in practice. I hope this thesis can give some information to the readers about how knowledge in psychology can help with making more usable systems and applications.
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1. Introduction

Computers today are used by humans for countless different tasks, both privately and in business. Many tasks can be done more easily with computers. However, computer systems can cause a lot of frustration for the user. This is often because the user interface, the part of the system that the user interacts with, is not well designed. A poorly designed user interface can lead to several problems, such as:

- **Decreased efficiency and productivity.** Systems are often introduced to get more work done in less time. With a bad user interface, the users might waste time struggling with the interface, making them work less efficient and less productively (Ceaparu, Lazar, Bessiere, Robinson, & Shneiderman, 2004).

- **Errors and decreased safety.** A bad design induces unnecessary human errors (Thimbleby, Oladimeji & Cairns, 2015). In some cases, these errors may cause dangerous situations for both humans and the environment (see for instance Department of Transport, 1987).

- **Decreased acceptance.** Users are less likely to accept and use a system that is poorly designed (Thong, Hong & Tam, 2002).

- **High development costs.** A business might have to spend a lot of money on redesigning the system. Software specialists spend about 50% of their time on avoidable rework rather than on work that is done right the first time (Weinschenk, 2005).

- **Decreased sales.** E-commerce sites can loose customers if it is difficult to figure out how to place orders. Souza (2001) reported that 65% of online shopping attempts end in failure because users cannot find what they are looking for. Most of these users will not try to purchase from the site after the failure experience.

1.1 Introducing usability

Human-computer interaction (HCI) is a multidisciplinary field in which psychology and other social sciences unite with computer sciences and related technical fields with the goal of improving the usability of computer interfaces (Olson & Olson, 2003). Usability is “the measure of a product's potential to accomplish the goals of the user” (Rouse, 2005). According to Nielsen (2012), usability has five components: Learnability.
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efficiency, memorability, errors, and subjective satisfaction.

1.2 Project Description
The objective of this thesis is to use psychological knowledge to improve the usability of a renting system. First usability and different ways to measure usability will be described. Then, some psychological theory and research will be presented. Third, the thesis will explain how we can use this knowledge to make interfaces easier to learn. Fourth, a renting system will be presented and evaluated using the psychological knowledge presented in chapter three. Fifth, the redesign will be presented. Sixth, a usability testing will be conducted and finally conclusions will be drawn.

The assumption is that if we have knowledge about how people think and behave then this can be used to make systems more usable. Without this knowledge, we are simply left guessing how to design a good user interface. This is how interfaces are usually designed. The interface is designed first and then tested and changed in order to make it more usable. If we have knowledge about how people use computers, then this knowledge can be used in the designing process so that we do not need to guess what will make the interface more usable.
2. Usability
As already mentioned, according to Nielsen (2012) usability has five components: Learnability, efficiency, memorability, errors, and subjective satisfaction. In this chapter these components and different ways to measure and evaluate usability will be described.

2.1 Learnability
Learnability concerns how easily the user can start using the system or whether or not the user can learn to use the system by observing the interface (Nielsen, 2012). Systems that are difficult to learn might require the users to receive training or to take courses before they can start performing their tasks. It can become both expensive and time consuming for businesses if they have to provide courses for their employees in how to use the system. However, if the system is easy to learn, the users should need less training.

The learnability of a system can be measured by giving first time users (users that have never used the system before) tasks to perform on the system and then record the completion rates. If these users can complete the tasks on the system, this indicates that it is easy to learn how to use the system. If they cannot complete the tasks, it indicates that it is hard to learn how to use it (Sauro, 2013).

Learnability can also be measured by tracking the time it takes for people to perform some tasks on the system over repeated trials (Sauro, 2013). If users can complete the tasks faster each time, this indicates that they are learning. The results typically produce a learning curve which shows how fast the users are learning. This curve can then be compared to other systems' learning curves in order to compare the learnability of the systems.

2.2 Efficiency
Efficiency refers to how quickly users can complete their tasks after they have learned how to use an interface (Nielsen, 2012). An efficient system allows its users to complete their tasks quickly. An example of what systems can do to be more efficient, is to provide shortcuts such as holding the keys “Ctrl” and “c” to copy something instead of having to move the mouse to the navigation bar and click on the “edit” button and then on the
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“copy” button. Efficiency can be measured by recording how long it takes users to complete a task after learning how to use the interface (Sauro, 2011).

2.3 Memorability
Memorability refers to whether, after using an interface, a user can remember enough to use it effectively in the future (Nielsen, 2012). This is important for systems that are not used regularly. If a system is used only occasionally, it can confuse the users if they do not remember how to do the tasks on it. Memorability can be measured by teaching a user how to perform a task on a system, then after a few days, test whether the user remembers how to complete the task (Sauro, 2011).

2.4 Errors
Errors refer to how many errors users make while accomplishing a task, the severity of errors and how easily they recover from these errors. A system can have errors and additional errors can be made by users. If errors happen, the system should notify the user of them so the user will be aware of these errors and can fix them or at least not make more errors. What is even better than notifying users of an error is to prevent that error from happening in the first place. Errors can be measured by recording any unintended action, slip, mistake or omission a user makes while trying to accomplish a task (Sauro, 2011).

2.5 Subjective Satisfaction
Subjective satisfaction refers to how pleasant usage of a system can be, for example, how users enjoy the user interface. The Single Ease Question (SEQ) can be used to evaluate the user satisfaction. SEQ is a 7-point rating scale that is administrated immediately after a user attempts a task in a usability test. After the user attempts a task, the user is asked this single question: Overall, how difficult or easy was the task to complete? The participant evaluates the rate of easiness he/she felt performing the task by circling a number from 1 to 7 where 1 is hardest and 7 is easiest. The SEQ has been shown to be
reliable, sensitive and valid as well as short, easy to respond to, easy to administer and easy to score (Sauro, 2010; Sauro & Dumas, 2009).

2.6 Usability Testing

As we have seen, there are several ways of testing the usability of a system. What these testing methods have in common is that a set of tasks is given to users to perform on the system and an observer observes the users as they perform these tasks.

Before deciding the tasks to administer in the usability testing, some main goals that the users should be able to accomplish on the system should be set up (Nielsen Norman Group, 2014). These main goals should include the most important things that every user must be able to accomplish on the system. This might include some routine tasks that users typically perform. The tasks given to the participants should be as realistic as possible. Users should be given some task scenario so they have a context in which to do the tasks. For example: “you want to buy a recipe book. Go to Amazon and find one to buy”. The tasks should make the participant actually use the system and not just ask: “where would you click to find a book to buy?”. The participant should use the site or application and not just describe how she would do it. The task description should not give clues or describe the steps that need to be taken in order to accomplish the task. For example, a user should not be told where to click or what to look for. A bad example would be: “go to Amazon.com and go to the book department and select a cookbook to buy” (Nielsen Norman Group, 2014).

To summarize, when considering which tasks to give to the users, one should make sure that each task scenario:

1) is realistic and typical for how people actually use the system, when they are on their own time, doing their own activities
2) encourages users to interact with the interface; and
3) doesn't give away the answer.”

(Nielsen Norman Group, 2014)
2.7 Heuristic Evaluation

Another way to measure the usability of a system is doing a heuristic evaluation. Heuristics are rules of thumb that provide a best-guess solution to a problem. Heuristic evaluation is fast and easy to conduct, but it is not a very powerful evaluation technique (Jeffries & Desurvire, 1992). Like with usability testing, a heuristic evaluation can be made after the system has been designed or such an evaluation can be used to help the designer improve the usability while designing.

Heuristic evaluation was developed by Nielsen and Molich in 1990. Many sets of heuristic guidelines have since been formulated. In this chapter Don Norman's guidelines (Norman, 2013) will be presented and explained. Don Norman was a professor, researcher and writer of cognitive science and psychology before he began writing about human-computer interaction (Norman, n.d.). His guidelines are based on “psychology, on the nature of human cognition, emotion, action, and interaction with the world” (Norman, 2013, p. xiv). Here are his seven guidelines:

1) **Discoverability** – Refers to whether the users can figure out what actions are possible and where and how to perform them. For users to know what to do, the functions must be perceivable. On the screen this would mean that the functions must be visible.

2) **Feedback** - Refers to giving the users information about the results of an action. Examples are, showing a message confirming that a file has been saved or a progress indicator showing that the action is being processed. If feedback is not provided the user might give up using the system.

3) **Conceptual model** – Refers to the explanation of how something works. When people encounter a computer system, they try to understand how it works and create a conceptual model or an explanation of how it works. The interface needs to project all the information needed to create a good conceptual model of the system. The icons of folders on the computer for example, help people create an explanation of how the folders work. The folders on the computer work in a similar way as folders in real life where you can sort different files into different folders. The conceptual models that people create do not necessarily have to be correct. People just need to understand enough to be able to use the system correctly.

4) **Affordance**. The term affordance was originally introduced by psychologist James J. Gibson (1977). He defined it as an “action possibility” available in the environment,
independent of an individual's ability to perceive it, but always in relation to agents (people or animals) and therefore dependent on their capabilities. For example, a big chair might afford sitting for a strong person and a child and the same chair might afford lifting for the strong person but not for the child.

In his book *The Design of Everyday Objects* (2013), Norman defines an affordance as “... the relationship between the properties of an object and the capabilities of the agents that determine just how the object could possibly be used” (p. 11). He states that affordances define what actions are possible; what you can do with an object. However, in a good design, the options must be visible for people to know what to do. They need some signifiers or visual cues. For example, a button on a computer system might afford clicking but for users to know that they can click on it it needs to provide some signifier or clue.

5) **Signifier** - Signifiers communicate where the action should take place. If people do not use a design as the designer intended, this might indicate bad signifiers or a lack of signifiers. For example, to show that a link is clickable, the cursor should change to a pointing hand and the link should change color when hovered over. This is the conventional way of showing that a link is clickable on the web ("Mouse and pointers”, 2016).

6) **Mapping** – Refers to the relationship between controls and their effects in the world. When the mapping uses spatial correspondence between the layout of the controls and the devices being controlled, it is easy to understand how to use them. In other words, the mapping is natural.

Simon and his associates (e.g., Craft and Simon, 1970; Simon, 1969; Simon, 1970; Simon and Rudell, 1967) found that reactions are usually faster and more accurate when a stimulus occurs in the same relative location as the response, even if the stimulus location is irrelevant to the task. For example, if a subject is required to press the “a” key on a computer keyboard when the word “left” occurs on the screen and the “l” key when the word “right” occurs, the reaction is faster and more accurate if the word “left” occurs on the left side of the screen and the word “right” occurs on the right side. Simon's explanation for the effect was that there is a natural tendency to respond toward the source of stimulation (Simon, 1969).

An example of good mapping in interface design is an arrow to the right meaning
“next” and an arrow to the left meaning “back”. This is natural mapping for people that are used to reading books and newspapers from left to right. However, this might not be natural mapping for people costumed to reading from right to left.

7) **Constraints** - Refers to restricting the type of actions that the users can do at a given moment in order to prevent errors. For example, invalid data can be prevented from being entered and prevent invalid actions from being performed.
3. Psychological Theories and Research Used in HCI

Psychology is often used in Human Computer Interaction (HCI) design. As we have already seen, Don Norman's heuristic guidelines are based on psychology. This chapter will present more psychological theories and research that is commonly cited in HCI design. Most of this research has been done within a branch of psychology called cognitive psychology. Cognitive psychology is a branch of psychology that is concerned with the scientific study of the mind (Goldstein, 2011, p. 19). This includes different mental processes such as perception, attention, memory, emotions, language, decision making, thinking, and reasoning.

3.1 Working Memory

Atkinson and Shiffrin (1968) argued that human memory consists of three separate stores: the sensory register, the short-term store, and the long-term store. According to Atkinson and Shiffrin, the short-term store is also a working memory. Baddeley and Hitch (1974) are often considered the predominant instigator of the work in the field of working memory (Cowan, 2014). Working memory allows for “thinking”, such as problem solving and hypothesis testing. Working-memory receives information both from the sensory register and from the long-term store. Attended information stays in working-memory and all the other information decays.

3.2 Attention

It is debated how many things we can pay attention to at the same time. Miller (1956) famously suggested 7+/−2, Cowan (2000) suggested 4 items and some even suggest that the focus of attention consists of a single item (Garavan, 1998; McElree, 2001; Verhaeghen & Basak, 2007). According to Oberauer (2002), we can only focus on one item at the time and thus, in tasks that serially require attention on several items, the attention mechanisms switch the focus of attention among the different items. Because of these limitations, interfaces should not require users to pay attention to several tasks at the same time. Instead, users should be able to focus on one task at a time.
3.3 Cognitive Load
Cognitive load refers to the total amount of mental effort being used in working memory (Sweller, 1988). According to Sweller there are three types of cognitive load. Intrinsic cognitive load is the amount of mental effort that is required by the task. Extraneous cognitive load is imposed by information that is not important to accomplishing a task, such as distractors. Distractors add to the cognitive load and this slows down the attention mechanisms (Weast & Neiman, 2010). Distractors that are semantically unrelated to the task are more distracting than those that are related (Weast & Neiman, 2010). The third type of cognitive load is called germane. This is the effort that is needed to construct schemas – “conceptual frameworks or clusters of knowledge regarding objects, people, and situations” (Gerrig & Zimbardo, 2002, p.132).

A heavy cognitive load typically creates error or some kind of interference in the task at hand and makes it harder to learn how to perform the task (Paas, 1992; Moreno & Mayer, 1999; Mousavi, Low, & Sweller, 1995; Chandler & Sweller, 1992). The intrinsic cognitive load cannot be changed, but extraneous and germane cognitive load can be manipulated by designers. Extraneous cognitive load should be minimized in the interface. This can for example be done by removing any irrelevant information that act as distractors.

3.4 Automated Cognitive Processes
Because we cannot devote attention to many things at the same time, we need some way of performing several task simultaneously without focusing our attention to all of them. To achieve this, many of our actions become automatic (Schneider & Shiffrin, 1977). When we have done something multiple times, the behavior becomes habitual and is guided by automated cognitive processes, instead of being preceded by complex decision processes (Aarts, Verplanken, & van Knippenberg, 1998). For instance, walking becomes habitual and we can walk and consciously think of something else at the same time instead of having to consciously think about how to walk.

Computer interfaces should be consistent so that the behavior becomes habitual fast. The same actions should always lead to the same effect. By performing the same behavior multiple times, the behavior should become habitual and automated.
3.5 Recall and Recognition
This section will describe two methods for accessing stored information from the long-term store, recall and recognition.

**Recall.** Recall involves reproducing information previously presented” (Gerrig & Zimbardo, 2002, p.129). There are three types of recall: free recall, cued recall and serial recall. In the free recall method, a subject is for example, given a list of words to remember and is then tested by being asked to reproduce them in any order (Bower, 2000). In serial recall, the subject must reproduce them in the correct order (Henson, 1996). In cued recall, the subject can be given a list of paired words to study. Then the experimenter gives the subject one of these words as a cue to recall the word that it was paired with. When given cues, people can remember words that they did not remember in free recall (Tulving & Pearlstone, 1966). The context in which information was learned can work as a cue to recall the information. For example, when asked to memorize a list of words under water, people recalled more words when they went under water again than on dry land (Godden & Baddeley, 1975).

**Recognition.** Recognition is to identify stimuli as having been experienced before (Gerrig & Zimbardo, 2002, p.129). One of the simplest forms of testing for recognition is done by giving subjects an item and having them indicate whether they have previously encountered the item or not (Finnigan, Humphreys, Dennis, & Geffen, 2002).

It is generally thought that recognition is easier than recall (see for example Gillund & Shiffrin, 1984; Dix, Finlay, Abowd & Beale, 2004, pp. 38; Johnson, 2010, pp.109), although this is not always so (Tulving & Thomson, 1973). According to Gillund and Shiffrin (1984), recognition is easier than recall because recall involves two phases, a search for the information in long-term memory and then checking if the information retrieved is correct, while recognition only requires the later phase.

This assumption that recognition is easier than recall is the basis of the graphical user interface (Johnson, Roberts, Verplank, Smith, Irby, Beard, & Mackey, 1989). In graphical user interfaces the user uses a menu or clicks on icons to navigate and to perform tasks. In command-line interfaces on the other hand, the user must type in commands to perform tasks and these commands must be memorized and recalled. Menu-based and
graphical user interfaces are easier to learn and to remember than command-line ones (Chen & Zhang, 2007) presumably because it is easier to see, recognize and choose rather than having to recall and type. However, command-based ones can be more efficient for proficient users (Chen & Zhang, 2007). Some systems support both ease of learning and efficiency by providing both rich menus and dialogues and short-cuts for expert users.

3.6 Prototypicality

Prototypicality is defined as “the amount to which an object is representative of a class of objects” (Leder, Belke, Oeberst & Augustin, 2004, p. 496). A prototype is a typical member of a category. It is not an actual member of the category, but an “average” representation of the category (Rosch, 1973). For example, the prototype for the category “cars” might resemble some of the cars you typically see but doesn't necessarily look like a specific car model.

Prototypicality appears to affect human-computer interaction. Over time, when people use the Internet, they learn what websites have in common and they create mental prototypes for what to expect from web pages such as where the navigation bar and the search is located (Roth, Schmutz, Pauwels, Bargas-Avila & Opwis, 2010). This might be the same as Norman's “conceptual model” (Norman, 2013). Different mental models seem to exist for different web page types such as online shops, news portals and company web pages (Roth et al., 2010). Highly prototypical web sites are similar to this mental prototype that people have created and they include the elements that people are used to and have become familiar with - the norm.

The prototype people have of a website typically include the following elements (The HTC team, 2013).

- Logo on the upper left of the page. This helps users know on which site they are on.
- Main navigation in a bar across the top of the site or on the left side.
- Links are underlined or appear in a different color from the rest of the text.
- Clicking on a button causes something to happen.
- Standard icons. An envelope icon signifies email; a shopping cart or bag icon signifies the checkout page.
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- Visual hierarchy. For example, with the page name appearing at the top of the page with bigger writing than the rest of the text and more important parts appearing at the top and less important lower down.

People do not like it when the prototypicality is violated (Hekkert et al., 2003). People can become confused when norms are violated (Holbrook, Krosnick, Carson, & Mitchell, 2000). For example, if there is a button on the page but clicking on it does not cause any visible changes, the users might think it is broken. The same goes with text that is underlined but does not bring the users anywhere when clicked on.

3.7 Information Scent

Cognitive psychologists have found that people search for information online in a very similar way to how animals search for food. This theory is called information foraging theory (Chi, Pirolli, Chen, & Pitkow, 2001). According to this theory, animals follow a physical scent to look for food. Humans, in a similar way, follow an information “scent” online that is made up of key words, images and other cues. When those words and images resemble what they are looking for, the information scent is strong and they continue looking on that path. If the words and images do not resemble what they are looking for then they go look somewhere else. The users try to predict what they will find if they click on the different links based on these cues. For example, when people want to do a specific task such as buy an airline ticket, they search for words that are specific to that task such as “buy”, “flight”, “tickets”, and “cheap” if they are looking for cheap tickets. They will ignore anything else that is not relevant to what they are looking for such as hotels or rental cars. This is so because they think it is more likely that they will find a cheap airline ticket if they click on links containing these words than if they click on links that contain other words. For this reason, it is important that menus and links provide clear names that are descriptive of what they link to, and the names should not be ambiguous. This will give strong information scent. If the names are not clear enough, the users will go looking somewhere else.

Links can have a deceiving scent if the cues are similar to what people are searching for but do not lead them to the right information. If the information scent is strong enough, people can be convinced that they are looking in the right place. If that place
does not contain what they are looking for, they can conclude that the site does not provide that information (Nielsen, 2004).

### 3.8 Gestalt Psychology

Gestalt psychology is a family of theories, which are generally formulated as laws, that try to explain how we simplify the world in order to perceive it (Koffka, 1935; Wertheimer, 1944). The different Gestalt psychologists have formulated many variants of Gestalt laws. Many of them are very closely related or overlap, and it is often very hard to distinguish between them. Many of the Gestalt laws have been identified as having significant implications for computer screen design (Chang, Dooley & Tuovinen, 2002). These laws can help with organizing information on the screen so that we can perceive it faster (Palmer & Beck, 2007). In this section I shall describe six of the laws that Chang, Dooley & Tuovinen (2002) identified as being most relevant to computer screen design.

**Similarity.** Similar things appear to be grouped together. In Figure 1, the white circles appear grouped together and the black ones appear to be grouped together.

![Figure 1. “Gestalt similarity”, 2008. Retrieved from https://commons.wikimedia.org/wiki/File:Gestalt_similarity.svg. In the public domain](https://commons.wikimedia.org/wiki/File:Gestalt_similarity.svg)

**Continuation.** The human mind tends to see continuous forms rather than disconnected segments. In Figure 2, we perceive two crossing lines from A to D and from B to C instead of four lines meeting in the center O. This perception is also more likely than perceiving two lines drawn in a non-smooth path from A to C and from B to D.
Closure. The human brain tends to close contours that have gaps in them. In Figure 3 for instance, we see a circle and a square.

Proximity. Elements that are placed close to each other are perceived as a group of objects related to each other.

For example, in Figure 4 we perceive one group of 36 circles and three groups of 12 circles.
Symmetry. Symmetrical figures are seen as closed figures. In Figure 5 we perceive three pairs of brackets rather than six individual brackets.

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[ ] { } [ ]
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Figure and ground. This law was first discovered by Edgar Rubin in 1915. Rubin did not consider himself a Gestalt psychologist and was skeptical of their theories (Pind, 2012). The figure-ground perception was nevertheless embraced by the Gestalt psychologist and featured in Kurt Koffka’s *Principles of Gestalt Psychology* (1935).

According to this law, the human mind separates the visual field into the figure (the foreground) and ground (the background). The foreground consists of those elements of a scene that we are paying attention to, and the background is everything else. For example, Figure 6 can be perceived as either two faces or a vase.

*Figure 6.* “Cup or faces paradox” by Derksen, B., 2007. Retrieved from https://commons.wikimedia.org/wiki/File:Cup_or_faces_paradox.svg. Available under a Creative Commons Attribution-Share Alike 3.0 Unported license.

The Gestalt laws operate together most of the time. For example, we understand that data in the same column of a spreadsheet are related because they are similar (the law of
similarity) and close (the law of proximity) to each other.

3.9 Visual Hierarchy
Hierarchies are an organization of items into levels of relative importance. A visual hierarchy is created by making the more important items more noticeable than the less important items. Wolfe and Horowitz (2004) provided a list of attributes that guide the deployment of visual attention. These attributes include:

- Color (Treisman & Souther, 1985; Treisman & Gormican, 1988)
- Motion (Rosenholtz, 2001)
- Orientation (Foster & Ward, 1991)
- Size (including length and spatial frequency) (Treisman & Gormican, 1988)

Some examples of how visual hierarchies are created are making headings bigger than the paragraph or writing important words in a bold typeface.
4. Using Psychology to Improve Learnability

This chapter will explain how we can use the knowledge we have gained from reading the previous chapter to improve the learnability of computer systems.

If the system is highly prototypical, i.e. resembles the mental prototype that people have created of this type of systems, then it should be relatively easy to learn. This is because people have already learned how to use similar systems and can generalize their knowledge to the new system. The learning in one context is transferred to a related performance in another context (Perkins & Salomon, 1992). The users simply need to recognize features of the mental prototype such as a navigation bar at the top of the page and this enhances the learning of the new system.

The system should be consistent so that the behavior becomes habitual fast. By performing the same behavior multiple times, the behavior should become habitual and automated and not need to be preceded by complex decision processes (Aarts, Verplanken, & van Knippenberg, 1998). The navigation bar should for example be the same on all the pages. Things that look the same should work in the same way. For example, all buttons that look the same and have the same label should cause the same action to happen.

Strong information scent should guide the users on the right path. The labels should be clear and resemble what people are looking for, otherwise, they will continue searching somewhere else (Chi, Pirolli, Chen, & Pitkow, 2001). Users might get confused if they cannot find the option they are looking for.

The system should not require the users to hold several things in working memory since the working memory has a limited capacity (Miller, 1956; Cowan, 2000; Garavan, 1998; McElree, 2001; Verhaegen & Basak, 2007). The interface should be kept simple and avoid extraneous cognitive load or distractors. The users should be able to focus on the task they are doing. Too much extraneous cognitive load slows down the learning process (Paas, 1992; Moreno & Mayer, 1999; Mousavi, Low, & Sweller, 1995; Chandler & Sweller, 1992).

According to the Gestalt psychologists, we use the Gestalt laws to simplify the world in order to perceive it (Wertheimer, 1944). These laws can be used to simplify the content on the screen. They can be used to design the screen so that the content is clearer and
guides the users (Fisher & Smith-Gratto, 1999). An example can be grouping related functions together by using the laws of proximity and similarity.

Visual hierarchy can also be used to improve the screen presentation. Visual hierarchy tells the users what is most important. The top of the hierarchy (the most dominant element) should communicate to the users what the page is about and what they can do on it. The deployment of attention is guided by certain attributes. These attributes include color, motion, orientation and size (Wolfe & Horowitz, 2004). The page name, which tells the users where they are, should for example have a larger font. Buttons that tell what actions can be done, could for example have a distinct color so that the users will notice them.

Don Norman's design principles (Norman, 2013), which were derived from psychology, can also be used to make the system more learnable. Here I will explain how five of them, discoverability, feedback, signifiers, mapping, and constraints can be used.

- **Discoverability.** Users can discover the functions more easily and start using them if they are visible. If the functions are not visible, then the users need to search for them before they can start using them.

- **Feedback.** The system needs to provide the users with feedback when they do some action on the system. If the system communicates with the users, the users can learn it more easily. The learning process is a function of communication (Ndongko & Agu, 1985). For example, if there is some error the system should notify the users of this error and tell the users what they need to do in order to fix it.

- **Signifiers.** The design must provide signifiers of the actions available so that the users can see what actions are possible.

- **Mapping.** The mapping should be natural. There is a natural tendency to respond toward the source of stimulation (Simon, 1969). This way the users do not need to learn how the controls work but can use their intuition.

- **Constraints.** The system should have constraints so that users cannot perform actions they should not. For example, they cannot enter wrong data into a form or they should be warned if they are doing something that cannot be undone such as deleting an entry.
5. The Old Interface

In this chapter, I will introduce the interface redesigned in this thesis. I will then evaluate it according to the psychological knowledge presented in chapter 3.

5.1 Introducing the Old Interface

The interface redesigned in this thesis is a web-based renting system. The administration part of the system will be analyzed here. The system is an intranet which means that it can only be accessed by people within a specific company. This system is used only by specific users in a company who went to courses to learn how to use it. The reason for redesigning the system and making it easier to learn is to reduce the time and money that the company spends on training their employees.

I will only analyze and redesign some of the main functions of the system. The system does have many other functions as well such as checking who is currently residing in the properties, adding images of the properties and adding contracts. Analyzing and redesigning the whole interface is beyond the scope of this thesis.

I planned to conduct a usability test after the redesign. I therefore, decided on some main goals that the users should be able to accomplish on the system and wrote down some tasks (see appendix II) that they should perform in the testing according to the recommendations of the Nielsen Norman Group (2014). The parts of the system that relate to these tasks will then be analyzed and redesigned. In the old system these tasks required the user to go through several steps that were on different pages. The steps had to be done in a specific order. These steps will be described here.

Task 1: Add a new property. To add a new property, the user needs to go to the page “property registration”. This is accomplished by clicking on a button labeled “cottage” in the navigation bar at the top of the page and then on the link named “property registration”. On the “property registration” page the user needs to click on the button “add “. Then a form appears where the user fills in some basic information. Only one of the fields, the name, is marked with an asterisk. When the user clicks save, an alert window pops up and tells the user that some information is missing and is marked in red. The caretaker field (where the user selects who is responsible for taking care of the
property) is then marked with red and must be filled out. This field is mandatory but is not marked with an asterisk. After the basic information has been filled out, the property is added to the list of properties on the “property registration” page.

**Task 2: Add features to a property.** More information can be added to a property by clicking on different icons as shown in Figure 7. To add features of the property such as number of rooms and sleeping spaces, the user must click on the third icon from the left on Figure 8. Clicking on this icon brings up a page where the information that can be added appears in long lists as shown in Figure 8 and the user can select what is in the property.

![Figure 8](image)
*Figure 8. Old design: Links to adding more information to property.*

![List of Features](image)
*Figure 7. Old design: Selecting features of property.*
Task 3: Set rental days. To set rental days for a property, the user must go through several steps that will be described below.

Step 1: Create an application period. The user must go to a page named “application periods”. There she can either select a period that has already been created or she can create a new period. Whichever is chosen, the user must click on an icon of tools that says “rule setting” (see Figure 9).

![Rule setting](image)

Figure 9. Old design: Link to selecting properties available for renting.

Step 2: Rule setting. This link brings the user to another page where she selects on a checklist which properties should be available for renting in this period.

Step 3: Period management. The third step is to go back to “property registration” page and click on each individual property to select the days in the created period that the property can be booked on and set a price before the property can be rented.

5.2 Evaluation of the Old Interface According to Psychological Knowledge

Users of the old system had several complaints about how they were to accomplish these tasks. I spoke with a couple of the users and wrote down the problems that they had faced when trying to learn the old system. In this section I will present these problems and describe why these tasks are difficult to accomplish from a psychological perspective using the psychological knowledge from chapter 3 about memory, attention, cognitive load, automated processes, prototypicality, information scent, Gestalt psychology, and visual hierarchy.

Task 1: The users thought that finding where to add a new property was difficult. A psychological explanation for this might be that the information scents of the links in the menu are deceivingly strong. According to the information foraging theory (Chi, Pirolli, Chen, & Pitkow, 2001), when users are looking for where to add a new property, they will look for words that might be semantically related to this task, such as “property”, “add”, “register”
or they will look for pictures that might be semantically related, such as plus signs or buildings. The navigation bar on the old system has a button with the label “registration”. This gives a deceivingly strong information scent because clicking on this button will not bring the users closer to accomplishing task 1. There is another button that has an icon of a building. However, this button has the label “cottage”. This scent is not strong if the users want to add a property that is not a cottage. Nevertheless, this is the correct button.

When the users click on the cottage button, it brings up a list of seven links that all but one have an icon of buildings and all start with the word “property”. One of these links is the correct link. All the other are not important to accomplishing the task and therefore act as distractors that add to the cognitive load of the users and slows down their attention mechanisms (Weast & Neiman, 2010), making it harder for them to find the correct link.

Navigating around the page, the users found it difficult to know on which page they were on. This might be because the users had created a mental prototype for what to expect from a system like this one (Roth, Schmutz, Pauwels, Bargas-Avila & Opwis, 2010) and this mental prototype had the page names at the top of the page. This is where page names are usually located. However, in this system the page name is at the bottom. Also, the page name does not have any of the elements listed by Wolfe and Horowitz (2004) that guide the deployment of attention and hence, the users fail to see it.

Once the users find the correct page where they can add a new property, the “add new property” button is difficult to spot. It does not have any of the attributes that direct people’s attention (Wolfe & Horowitz, 2004). It appears in a tool bar under the navigation menu together with other options such as “delete” and “view all”. The label on the button is written in the same font and the button has the same color as the other options. All these buttons might act as distractors when searching for the right option since they are not important to accomplishing the task, and hence slow down the attention mechanisms (Weast & Neiman, 2010).

The asterisk is a conventional indicator for the field being mandatory. It might confuse the users when this convention is violated and not all the mandatory fields are marked (Holbrook, Krosnick, Carson, & Mitchell, 2000).

**Task 2:**
When trying to find where to add features such as number of sleeping spaces and oven, “attribute configuration” does not give a strong scent. The users thought it unlikely that
this was the correct link. They thought they could click on the “edit” button to add more features to the property. This might be because the links are not in accordance with the mental prototype that the users have of this type of website (Roth, Schmutz, Pauwels, Bargas-Avila & Opwis, 2010). They might be used to adding additional features to the property at the same place as they add the basic information.

Task 3:
On Figure 7, we could see that one of the icons on the newly added properties is a calendar. When this icon is hovered over, it shows the label “period management”. When the users are looking for where to set rental days for the property, this icon gives a strong information scent because a calendar often represents days. However, this scent is misleading because the users must first go to the “application periods” page and open up a rental period, assign the property to this period and then, they can finally click on the calendar icon on the “property registration” page. The users follow the scent and are led on the wrong path.

The system requires the users to navigate between several pages to accomplish a single task. This requires holding several items in short term memory and people can only hold a limited amount of items in the short-term memory (e.g. Miller, 1956; Cowan, 2000; Garavan, 1998; McElree, 2001).

The “rule setting” button on the “application periods” page gives a faint information scent if the users are looking for where to choose properties because the image and the label do not resemble what they are looking for (Chi, Pirolli, Chen, & Pitkow, 2001).

The steps that must be taken to accomplish task 3 must be memorized. The system should require the users to recognize what to do instead of recalling because recognition is easier (Chen and Zhang, 2007).
6. The New Interface

6.1 The Goal of the Redesign
This section will explain the goals of redesigning the system according to the analysis presented in the previous section.

Strategic goal. The strategic goal of the redesign was to improve the learnability of the system. The system should be self-explanatory. With the new design the users do not need any training or courses to start working on their tasks. The users should be able to start working on a task and finish it as intended without instructions. The users should learn how to use the system by actually using it. Users should also be more satisfied with the new system than the old one.

Practical goals. In order to achieve the strategic goal, more specific goals were set. These goals directed the design decisions and were also used as measurement when evaluating the usability improvement. In order to narrow the scope of the usability testing, which will be presented in the next chapter, only three practical goals were set. These goals relate to two of the aspects of usability – learnability and subjective satisfaction.

1. The users should be able to complete their tasks without instructions. If users can complete their tasks without instructions, it indicates that the interface is self-explanatory and easy to learn. Since the system is an intranet, the users will not just leave the website and go to another competing website if they encounter problems. However, improving learnability by making the system self-explanatory might greatly reduce the training costs.

2. The users should be able to perform the tasks faster. If the users are able to perform the tasks faster on the new system than the old one, it would indicate that the new interface is easier to learn.

3. The users should find the tasks easy to perform. If the users find the tasks easier to perform on the new system, it would indicate that the users are more satisfied with the new interface design.

6.2 The New Design
In this chapter the redesign will be described. First in general and then task by task. In
general, the interface has been made prototypical by using Bootstrap - “the most popular HTML, CSS, and JS framework for developing responsive, mobile first projects on the web” (getbootstrap.com). Since Bootstrap is the most popular framework on the web, the users may have encountered Bootstrap elements before and possibly already know how to use them. The interface also includes many elements that other websites typically have such as a logo on the upper left of the page, navigation bars on the top of the site and on the left side and links change color when hovered over (The HTC Team, 2013).

The system is consistent. The menu and controls are the same on every page. The page name is consistently at the top of the page. Adding and editing a property looks the same. The user only needs to learn this once and then she can recognize the same thing on every page. This allows the behavior to become habitual and consequently, to be guided by automated cognitive processes, instead of being preceded by complex decision processes (Aarts, Verplanken, & van Knippenberg, 1998).

**Task 1: Add a new property.**

The information scent of the link that leads to the properties page has been made stronger by changing the label from “cottage” to “properties”. According to the information foraging theory (Pirolli & Card 1999), the information scent is strong if people can predict that they will find what they are searching for if they follow the scent. The scent of the link in the new system is stronger because the word “properties” resembles more what the users will be looking for (the properties page) than the word “cottages”. The other links do not have a deceivingly strong information scent. They do not have any words or images that relate to adding a new property. If the information scent is strong, novice users should be able to find the correct link quickly and should be guided on the right path.

On the properties page, the page name appears with a larger font at the top so that the users know they are on the correct page. The users’ attention is directed to the page name because it has a larger font than the rest of the page's content. Size directs the deployment of attention (Treisman & Gormican, 1988). The “add property” button has been given a distinct green color. Color is another feature that guides the deployment of attention (Treisman & Souther, 1985; Treisman & Gormican, 1988). Green has also come to signify “go” which might give an additional cue.

To add a new property, two mandatory fields must be filled in; the name of the
property and its caretaker. A new property cannot be added unless these two fields have been filled in. Since only two fields are obligatory and the remaining fields are optional, these two fields have been added to the top of the form and marked with an asterisk. A note tells the user that all fields marked with an asterisk are required. This communicates to the users what they should do.

**Task 2: Add features to the property.** Once the basic information has been added, the users can click on the “next” button which brings them to the next tab where they can add more information. More information can be added to the property such as images and amenities. All the options appear in tabs at the top of the page so the users have an overview of what can be added to the property. The tabs can be seen in Figure 10.. As Norman (2013, p. 11) states, users are more likely to know what to do next if the functions are clearly perceivable.

The attributes that can be added to the property have been sorted by using Gestalt principles and visual hierarchy (see Figure 11). This makes the content on the screen clearer and guides the users (Fisher & Smith-Gratto, 1999). The headings have features, such as a larger size and distinct color, that deploy the users' attention (Treisman & Souther, 1985; Treisman & Gormican, 1988). The first heading has a bigger font and the other headings are in bold. Information that is semantically related is grouped together according to the law of closure – we see shapes that are not explicitly drawn. We see columns where no enclosure exists. The check-boxes under each heading appear as one group.
**Task 3: Set rental days.** Rental days can be set for the property by clicking on the tab that says “rent out”. On this tab a calendar appears and rental days can be selected by dragging the mouse over the desired days. Then, a pop-up appears and guides the users through the information that can be added such as the price. This way the users will not be left wondering what they should do and where they should go. Everything is in a single page and the users do not need to memorize anything or navigate between several pages.

### 6.3 Heuristic Evaluation of the New Interface

Heuristic evaluation of the redesign was carried out according to five of Don Norman’s principles.

**Discoverability.** So that users can discover what to do, the options and functions must be visible. The page title is written in a large font at the top of the page so that the users can see where they are. People usually start scanning the top of each page (Djamasbi, Siegel, & Tullis, 2011). A larger font should attract the users’ visual attention since size is one of the attributes that guides the deployment of attention (Treisman & Gormican, 1988). The “add new property” button has been made more visible by making it green while keeping the rest of the page in gray tones. Color is one of the attributes that guide the deployment of visual attention (Treisman & Souther, 1985; Treisman & Gormican, 1988). When adding a new property, the tabs make all the options visible.

**Feedback.** The system gives feedback when actions are performed. For example, it...
shows a message that says “saved” when a user fills in a form or makes changes to it.

**Signifiers.** More prominent signifiers have been added to the objects by putting all the options in a single place. All the information is displayed in tabs. On the page that lists all properties there is only one single button on the property that says edit. The information scent has been made stronger. The user does not have to wonder what can be done and how to do it. There is only one way.

**Mapping.** The system has natural mappings for people used to reading from left to right. The “next” button is on the right side and the “previous” button is on the left side.

**Constraints.** Users can only add data in the right format. They can only type numbers where this is required etc.
7. Usability Testing
The purpose of the usability testing is to evaluate how much the website has achieved the goals described in chapter 3. The subjective satisfaction of the users will also be measured. Novice users should be more satisfied with a system that is easier to learn.

Method

Participants
There were 16 participants, six males and ten females. The mean age was 42 and the age range was from 22 to 64. The participants were recruited through a personal request by the researcher in an office building. Participants had used neither of the systems before and had no experience with similar systems. All of the participants used computers and the Internet on a daily basis. Participation was voluntary and the participants did not receive any monetary compensation for their participation.

Test Design
A within-subject test design was used. The independent variables were interface design (old or new) and task. The dependent variables were success rate, time to complete the task, and easiness rating.

Instruments
The Single Ease Question (SEQ) was used to evaluate the user satisfaction (see chapter 2.5 about subjective satisfaction).

Materials
The materials used were a laptop computer, a stopwatch and a paper with a list of the tasks (see appendix II). The list of tasks included some typical tasks performed on the system. They included adding a new property (task 1), editing the property (task 2) and setting rental days (task 3).

Procedure
The participants were randomly divided into two groups where group 1 tested the old system first and the new system second, and group 2 did vice versa. This was to control
for within-subject effects.

One at a time, each participant sat in front of a laptop computer. The observer explained to the participant what he/she was supposed to do (see appendix I), then gave the list of tasks to the participant (see appendix II) and tracked the time it took the participant to perform the task. The tasks were given in a random order to control for order effects. The participant started the first task on the “Dashboard” page (the starting page on the system). When he/she had accomplished the first task, he/she could start on the second task and then the third.

The observer let the participant continue until he/she finished the task or he/she had reached the maximal time limit. The maximal time limit to complete each task was set at 10 minutes (600 seconds) so that the testing would not take too long.

After performing the task, the participant was asked to rate the level of difficulty he/she experienced performing the task.

Results

Task 1: Add a New Property
The data from one participant was removed from the analysis because the participant did not follow the instructions correctly. The results of a paired-samples t-test show that all the participants were able to perform task 1 successfully on both of the systems. Task 1 is easier to perform on the new system than on the old system, as revealed by a significant difference between the time spent on task one in the old system (M=234s, SD=76s) and the time spent on task one in the new system (M=53s, SD=18s); t(14)=-8.8, p < 0.001. Figure 12 shows the distribution of the time on the two versions.
Task 2: Add Features to the Property
Task 2 is easier to perform on the new system than the old system, as judged by the fact that the completion rate on the old system was 25% and 100% on the new one. A McNemar's test determined that there was a statistically significant difference in the completion rate of this task on the old and the new system, $p < 0.001$. Because most of the participants failed to perform this task on the old system, the time to complete the task could not be compared for the two systems.

Task 3: Set Rental Days
Task 3 is easier to perform on the new system than the old system. None of the participants could complete task 3 on the old system. All of them could complete it on the new system. A McNemar's test confirmed that the difference was statistically significant, $p < 0.001$. There were no time measurements to be compared.
Task Easiness Rate

A Wilcoxon signed-rank test showed that the participants rated the tasks as significantly easier to perform on the new design (task 1: $z = -3.35$, $p = 0.001$; task 2: $z = -3.57$, $p < 0.001$; task 3: $z = -3.58$, $p < 0.001$). Figure 13 shows the median easiness rate given by the participants for each task on each version of the system. As we can see, the tasks were rated as easier to perform on the new design. The participants found task 2 and 3 very difficult to perform on the old version.

![Figure 13. Rating of easiness of each task.](image)

7.1 Discussion About the Usability Testing

The redesigned version is easier to learn how to use than the old one. In other words, the new design has higher learnability. Novice users who had never used it before were able to complete all the tasks successfully on the new design but not on the old one. They were also able to perform one of the tasks faster on the redesigned version. This indicates that they can learn how to use the system faster. The new design does not require any training or courses to learn.

The users were more satisfied with the redesigned system than the old system. All participants found the new design easier to use than the old one.

In future research other aspects of usability could also be tested such as memorability,
errors and efficiency. It would be interesting to compare the time that proficient users spend doing each task on each of the systems. This would test the efficiency of the systems. Chen and Zhang (2007) tested which interface was better out of Graphic User Interface (GUI) and Text-based User Interface and concluded that GUI was easier to use for novice users but not necessarily better for an expert user. Comparably, the redesigned renting system might be better for novice users but not necessarily for proficient users.
8. Conclusions

The objective of this thesis was to find out more about how psychology could help improve the usability of computer systems. A renting system was redesigned using psychology. The results of the usability testing conducted showed that on the redesigned version of the system the users:

- Were able to complete all the tasks successfully without any instructions
- Completed one of the tasks faster
- Rated the tasks as easier to perform

The results of the usability testing indicate that understanding how people think and behave such as how they perceive the information on the screen, what attracts their attention, how they navigate through the system, what distracts them etc. can help with designing interfaces that are easier for people to use and to learn and that they are more satisfied with. We can guide users through the interface by using the elements that attract their attention, we can avoid overloading their working memory and much more. In other words, when we understand how people think and behave, we can design computer systems that are more usable for people.
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Appendix I

Usability test script

I am going to give you a list of tasks that I want you to perform on two different websites. We are testing the sites and not you. You can't do anything wrong.

Don't be scared of telling me what you think of the sites. Be honest, I won't get hurt.

If you have any questions, just ask. I may not be able to answer them right away, since I am interested in how people do when they don't have someone sitting next to them, but I will try to answer any questions you still have when we're done.

When you are ready you may start with task number one.

Thank you for participating.
Appendix II

The tasks

- Task 1: Add a new property. Name it Test 1. Fill in only the required fields and leave the other fields empty.
- Task 2: Find where to add these features to the property Example 1:
  - Oven, fridge and gas grill
  - 7 sleeping spaces
  - 4 rooms
  - Double bed, two single beds and a bunker.
- Task 3: Select days that the property, Example 1, can be rented. It should be one week in August and the price for this week should be 20,000 ISK.