Cognitive aspects in HCI

From the theory to the practice

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Abstract

In our world we are surrounded by technology and it involves all aspects of our lives. Along the last decades big efforts have been put to create lighter, faster, more reliable and safer systems. Following the Moore's law we can in fact now use devices which double their performance every 18 months [12]. Even though we often do not perceive any improvement in terms of user experience so that our job does not really seem easier compared to the one of few years ago. We are supposed to live in a better world, a world improved by technology, where the heating can set up itself getting meteorological information from the Internet or through sensors placed outside and our cars are so intelligent that they could be soon drive us home safety [7]. Still we often go back to a freezing house and we almost cause accidents trying to set the navigation system of our car using vocal instructions. The reason is often no attention has paid to the usability aspects of the system: while it is considered normal for programmers to know every important technical detail, such as how the memory is handled by the operating system in order to write an efficient code, it is not required to them to have any knowledge at all about how the system should be developed in terms of usability. After briefly discussing why human computer interaction is underrated today and explaining why this trend is so dangerous, it will be presented and discussed the keys concepts of the human cognitive psychology which are strongly relevant in the HCI studies: knowing how the user *works* is crucial to help whoever is developing a system to derive useful guidelines which can be successfull applied for the development of well-designed systems. Finally a practical example is shown: principles and guidelines explained in the first part are used to evaluate two pages of the Swansea University Website.

Contents

1 Introduction

In the article, "*Don't call them digital native*[1]" [1] the Italian journalist Paolo Attivissimo tells the story about an ordinary day at the elementary school where he gave a lecture to the last year class. At the question "who doesn't use Internet?" a boy raises his hand asserting "I don't" and after few seconds he continues "but I use YouTube". Other children apparently have nothing to retort. Therefore the journalist infers that the world we are living in is making us stupid, because we do not know how it works anymore. However, a positive way to look at the story would be to see the victory of the HCI: finally technology became transparent and users do not need to learn how to deal with it, they can just use it. Unfortunately it is not always true and when technology is involved we often find ourselves struggling to accomplish even the simplest job. How often parents ask for their children's help, because they cannot change the mobile phone's ringtone, or they cannot even read an SMS? It is not the functionality is not present, or the device is broken, they are simply unable to use it: it is an usability issue. The problem is very critical because if it is true that, as the journalist points out, we do not know how technology works, we could find ourself in a nightmare when it does not work in the way we expect it to do, as today it permeates each aspect of our life.

The aim of this paper is explaining why the cognitive psychology, within the HCI field, is so important and how it can be exploited to develop better new systems or to improve the existing ones. The paper is divided in four sections: in the first section it will be summarized the HCI state of art; in the second section it will be introduced the role of the cognitive psychology within the HCI field, with a particular focus on those aspects which are mainly relevant in HCI studies: perception, memory, attention, learning, and mental models. For each aspect it is given a definition, several practical examples and finally some guidelines will be derived. In the third section it will be presented a practical example about how the derived guidelines can be used to evaluate or develop a system in terms of usability. Finally, in the last section, it will presented the conclusion.

2 HCI state of art

First electronic digital computers were enormous: for example the ENIAC occupied about 1800 square feed, used about 18000 vacuum tubes and weighted almost 50 tons [9]. The system complexity was so high that it would have been unimaginable for the user to handle it without a proper training. However, these days, it would not have been acceptable any more: technology is everywhere, and it needs to be transparent to us. There are several consequences aroused by the underestimate of the usability importance. Firstly it causes unhappiness when related to normal users: it happens for example when we loose the document we have been working all day just because we pressed the wrong button. Secondly it is business critical when related to companies since they can loose profits: software companies, for example, need to keep their customer satisfied, otherwise they will simply switch to another software; therefore any

[1]The original title has been translated.

company needs to keep their employee efficient, and this implies giving them proper tools. Last but not least it is safety critical: most of the the famous accidents related to critical system (nuclear plants, airplanes, railways) always end up to the same conclusion *human error*. However, since the error is the in human nature, systems should be developed in order to be tolerant, or event better, to prevent errors.

2.1 Understanding the H(uman) in the HCI equation

The importance of designing a good interface is underrated by companies which often refuse to hire specialists: usability requirements seem to live in a limbo between the *programming world*, where everything needs to be efficient, fast, reliable and secure, and the *graphical design world* where everything needs to "look pretty". Unfortunately neither programmers nor graphic designers are skilled enough to carry out the job properly. There are obviously models and rules that should be applied to make a system usable. And this is what HCI discipline is about, studying humans and how they interact with the system, in order to develop well-designed devices. However, applying the rules without any awareness of the theory behind can be deceiving, since the human being is a very complex system: a deep knowledge of its operation is needed in order not to fall in trap. As Dix et alt. highlight "if a designer do not understand the assumptions underlying a design rule, it is quite possible that early application can prevent the best design choice" [4]. A well known example is the *7±2 principle* [11]: as Miller pointed out in his experiments, a normal individual can store in the short memory from 5 to 9 different *chunks*[2] of information. Some designers started to think that they should not design menus with more than 9 items. However this approach is fundamentally wrong since when menus are involved, humans rely on *recognition* instead of *recalling*[3], and the process is significantly different. This explain why understanding the cognitive aspects of the human nature is so important: in fact as Preece says [15] "cognitive psychology can help to improve the design of a computer system by providing knowledge about what user can do and cannot be expected to do, identifying and explaining the nature and causes of the problem users encounter supplying modelling tools to the build more compatible interfaces."

3 Cognitive key concepts in HCI

According to Preece [15] there are five key concepts of cognitive psychology that are closely related to the HCI: *perception*, *attention*, *memory*, *learning*, and *mental models*. In the following section for each aspect it is given a definition, examples and finally some usefull design guidelines are derived.

[2] *Chunks* are basic piece of information, they are discussed in section 3.2

[3] Recognition and recall processes are explained in details in section 3.2

3.1 Perception

The human perception is strictly related to our senses: sight, hearing, touch, taste and smell. When dealing with the system design, the attention is paid mainly on the first three, since taste and smell are not usually involved in any interaction. Hearing is important and should not be underrated and, as the haptic technology is increasing, even the touch is becoming more relevant. However, for the average individual, the sight surely dominates our perception and it appears to even influence the way we think (an example is the sentence "I see" to underling we have understood) [10]. For this reason only the sight will be discussed. The act of seeing is an active process and according to Dix can be divided in two different stages [4]: "the physical reception of the stimulus from the outside world and the processing and interpretation of that stimulus" .

3.1.1 The physical reception

The physical reception happens when light, in form of photons, go through the lenses of our eye and focuses on a membrane situated on the back the the eye, called *retina* [10]. The retina is made of millions of two different type of cells, which contain a photopigment that is sensible to the light; those cells go under the name of *rods* and *cones* or generically *photoreceptors*. Rodes are mainly situated in the periphery, are high sensible to the light so that they are responsible for the night vision; they are subject to saturation and this explains why we are temporary blind when we go from a bright to a dark place[4]. However rodes cannot resolve fine details or distinguish between colours: this is why we see in black and white in poor illumination conditions or when objects are in the periphery of our visual filed. Cones can be of three different types, each one is sensible to a different wavelength[5]: from the combination of the three different types of information we are able to see colours, and this mechanism is known as *thricotomy* [17].

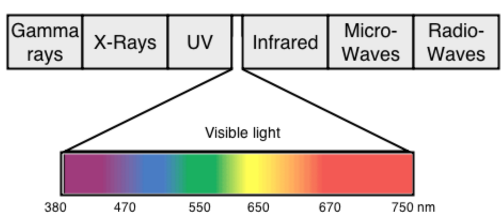


Figure 1: The wavelengths which are visible by human consist in a very small subset of the entire spectrum

However the human vision is limited to a small part of the electromagnetic spectrum, in fact we can see wavelength of light in the range of 400 to 700 manometers [10] as

[4]Photoreceptors produce a pigment that is sensitive to the light: this pigment is not endless and it takes time to regenerate. Since cone's pigment is very sensible to the light, they need a bit of time to recover from being bleached by the light.

[5]There are three kind of cones depending on their sensibility to wavelengths: short have a peak between 564–580 nm (perceived as blue), medium have a peak between 534–545 nm (perceived as green) and long have a peak between 420–440 nm (perceived as red).

shown in figure 1. Finally the *fovea* is a small area of the retina, of approximately 1.5 mm, which is the highest populated area by cones and it is responsible for the sharp central vision: however in this area the are only few cones sensible to the blue wavelength.

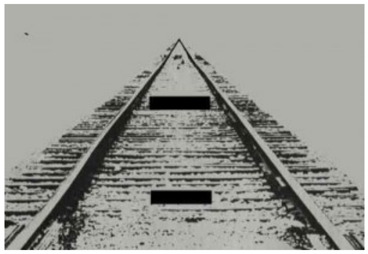
Examples. The figure 2 shows an example of the human vision's limit from a physical point of view: on the retina there is a small area, called *optic disk*, where there is the connection with the optical nerve. This area is lacking of cones and rods, hence we are completely blind in that point. To find the blind spot we need to close one eye, focus the other eye on the cross in the figure 2 and get closer to the image until the dot disappears: we cannot see it anymore because its image on our retina falls exactly on the blind spot.

Figure 2: The blind spot

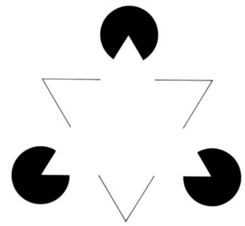
3.1.2 Processing the information

As said, the vision process does not end with the physical reception: in fact we do not see an objective version of the world but what our perception and our processing mechanism construct for us. This idea is perfectly expressed by the fundamental principle of information design which says that "1 + 1 = 3 or more"[18]. The stimulus is perceived from the brain, processed, elaborated and then interpreted using our knowledge of the world in order to give a sense to the physical representation. One of the process which take place is the use of the so called *pictorical cues*: basically to interpreter the world outside and to find a meaning we rely "on certain assumptions about how the world is organized" [17]. *Occlusion,* for example, says that in the real world if an object is behind another, it will occlude some part of it. Alternatively, according to the *prospective,* we know that small objects result in a small projection in our retina so that if we know prior (*familiarity*) the size of the object we can estimate how far it is. Finally, the *closure* principle [6] affirms that when we look at complex arrangement of individual elements, we tend to first look for a single and recognizable pattern.

Examples. Those simple principles explain some of the most famous optical illusions: in the Ponzo illusion in figure 3a the upper line seems longer than the lower because of the prospective cue but they are actually the same size; moreover in the Kanizsa's triangle in figure 3b we perceive a triangle even if it is not drawn because of the closure principle.



(a) The Ponzo illusion



(b) The Kanizsa's Triangle

Figure 3: Examples of famous optical illusions

3.1.3 Design implications for visual perception

The interactive designer should be aware of the physical limitation of the human sight such as the fact it is not possible to perceive colours in low level of illumination or through the peripheral vision, or that it is not possible to discern too fine details. Therefore information should not be only coded into colours, and objects of the interface should always have proper size: buttons, text and menus need to be clearly visible. The interactive designer has also to be aware of mechanisms that are involved during the elaboration and processing of the physical stimulus to take advantage of it or to prevent error. For example, the same colour can be used to show different areas which are semantically connected, since thanks to the *similarity principle* we create a semantic and logical connection between areas with similar characteristics (such as the same colour). Tabs and windows are an example of good interaction design: the user can interact with different layer of information since the hierarchy is made clear by the occlusion principle.

3.2 Memory

Memory is "the mechanism whereby past experiences influences present behavior" [10]. Researchers usually distinguish between *memory stores*, where the information is hold, and *memory processes,* mechanisms which operate on the hold information.

3.2.1 Type of memory

There are three types of memory: *sensory memory*, *short term* or *working memory* and *long term memory*. The sensory memory is like a buffer where stimulus are constantly overwritten [4]. Stimuli can be ignored by our system, so they do not go further the sensory memory, or they can arrive to the short memory, being perceived. The short memory has a small capacity and it is subject to a rapid decay, but it very fast to access. However, continually refreshing the information thought *rehearsal* , the information can be kept in the short memory longer [10]. Finally long term memory has huge if not unlimited capacity, it is hardly subject to decay but has a relatively slow access. Memory can be also classified as *episodic* or *semantic*. The first refers to the memory related to events, for example what we had for lunch last Friday; the second refers to the knowledge about the world, for example what a lunch is.

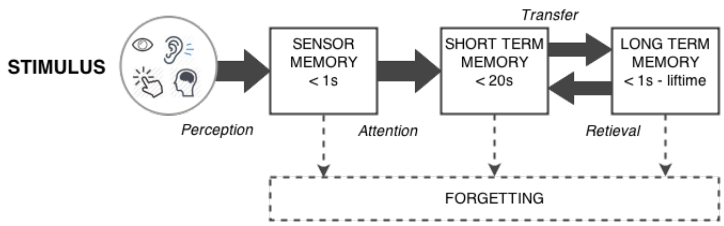


Figure 4: Memory workflow

Examples. To understand what the sensory memory is we can think to the case when we ask someone to repeat what she/he had just said to realize one second after we do not need it any more. What happens is the information passes from our *echoic memory* to the short memory through a selection process handled by our *attention*; since it requires some time, we have the time to say that we did not hear even if actually we did.

3.2.2 Recognition and recall

According to the *associative theory* the memory "is organized on the basis of semantic relatedness or semantic distance" [2]. It involves the concept of chunks: chunks are elementary piece of information stored in our brain and connected one to each other through *association*. "Each chunk is characterized by its *activation*: a measure of how easily it can be retrieved from memory" [3]. The activation of a chunk is influenced by *practice*, *recency* and *context*. Practice concerns how often we use that chunk: in fact each time we access the chuck its activation increases; a typical example would be our name. Recency is about how recently the chunk has been used: obviously we can access easier to chunks related to events which have just happened. Finally, context is related to what is focused by attention: as said each chunk is associated to another, when something in the current context is strongly related with a chunk, it can therefore increase the activation of its neighbor.

Examples. A clear example of this mechanism happens when we loose something, such as car keys, and we try to retrace our steps in order to find out where we lost them. We can access our memory through *recognition* or *recall* and they differ by the number of *cues* they use: recognition is usually easier because has more cues which spread activation to related chunks in memory, making it more possible to catch the missing information.

3.2.3 Design implications for memory

The interactive designer should never, when possible, rely only on the recall mechanism because as seen it is hard for the user to the retrieve the right information without any cue. Recognition should always be encouraged instead. Therefore user's memory should not be overloaded with complicated procedures for carrying out task [16]. Log-in and menus are a typical example which involves respectively recall and recognition. However both mechanisms can be used successfully together: for example, when we use a web search engine, we normally rely on recall first: with nothing or only few cues we try to remember the word we are looking for. Once the search gives us the first results, the recognition mechanism starts: scanning through the list of links, all different cues begin to spread activation to different chunks. The *command line* interface is insthead an example of a bad paradigm of interaction, in fact it relies only on recall: to invoke a specific program its name has to be written, furthermore followed often by options that must respect a specific order.

3.3 Attention

As briefly hint when discussing how information goes from the sensory memory to the short term memory, attention is the mechanism we use to limit and filter between all the stimuli we are expose to [15]. We can of course focus our attention to more than one job at the time, capability known as *multitasking*, however research shows that in that case we then tend to make more mistakes or we are slower [8].

Examples. A typical example of how we use our attention is when we are in a busy place, such as a bar or a party, and we can decide to listen to our neighbor rather then the discussion at the table behind. What happens is that we focus our attention to specific stimuli ignoring everything else.

3.3.1 Design implications for attention

The interactive designer should be aware of the limited capabilities of the user in terms of attention which can be paid. The designer should use proper cues to get the user's attention, such as colours and animations. However it is needed to avoid "cluttering the interface with too much information: this especially applies to the use of colour, sound and graphics. There is a temptation to use lots of them, resulting in a mishmash of media that is distracting and annoying rather then helping the use attend to relevant information" [16]. Finally since the user can be easily distracted, a good interface should also give cues about how to resume an unfinished job. Examples of good design are text boxes in websites form which change colour or characteristic when we click on them: in this way we can easily know which element of the page is active and at what point of our task we arrived so far.

3.4 Learning

Learning is defined as "the processes by which experience acts on neural circuity to generate memories" [10]. According to Preece [15] users approach the problem using different strategies. Usually they prefer to start using the system, performing actions and evaluating the results, rather than just reading the manual (*learning by doing*).

They need to construct a model of what the system can do, how it works, and they try to deduct logical explanation to what they observe (*learning by active thinking*). It is the way *mental model*[6] are usually constructed. Sometimes they have a specific goal or task in mind, and they look for operations made available by the system to accomplish their task (*leaning through goal*). Users often adopts analogies, trying to match the unfamiliar system with familiar concepts, so that they can apply their past experience to understand the system (*learning through analogy*). Finally, users learn through mistakes (*learning from errors*).

Examples. Suppose the user buys a new phone: she/he would unlikely spend time reading some boring manual (which probably will never see the light outside the box) and she/he is rather playing with it navigating randomly the system (learning by doing). The user could fall in mistakes which give extra information (learning from errors) and allow to slowly constructs the model of how the device works (learning by active thinking). At some point the user may want to accomplish a specific task, rather than just exploring the system, such as for example setting an alarm; so she/he looks for the functionalities of the system which allow to set the alarm (learning through goal). Maybe the user does not know yet where the alarm application is, but it can be guessed making analogies with previous phone owned (learning by analogy).

3.4.1 Design implications for learning

The interactive designer should develop the system in order to support the listed learning strategies. Ideally, using the system without any need of a manual should be possible, therefore it has to be *self explaining*. Furthermore it should be transparent enough to allow the user to derive the proper mental model: it is challenging because a complete transparency is not desirable since the user does not want to know everything about system; after all she/he just needs to use it correctly. All the possible actions the user can perform on the system should be made visible or easily reachable, so that she/he can always know how to accomplish a specific task. Error messages should always be informative as much as possible. Finally the interface should encourage the exploration [16]. The WIMP, which is a acronyms for Windows, Icons, Menus and Pointer, is an example of a good design paradigm for learning. The WIMP is a paradigm of interaction developed by Xerox PARC in the 1973 and currently in use. It teaches the user how to use a computer in a different way, much more friendly than the old command line interface. Through metaphors and using familiar objects the user can apply known strategies from the real world to the digital one, making the reuse of knowledge possible.

3.5 Mental model

While interacting with a system the user forms a internal representation about how it works; this representation, known as mental model, is used to explain the system's

[6] Mental model are discussed in detail in the 3.5 subsection.

behavior and more important to make predictions. It differs from the *conceptual model* which is the representation of the system provided by designers, scientist or engineers. As Norman observes [5] mental models come with several problems. Firstly they are incomplete and unstable since the user cannot have a complete and truthful understanding of the system, and she/he will change therefore the model over the time to adhere to new intuitions about its logical operation. Secondly mental models are *unscientific* and are often based on superstition. Last, they are *parsimonious*: the user is ready to "do extra physical operations rather than mental planning that would allow him to avoid those actions" [5]: the user usually prefer to to do extra job in favor of reducing the mental complexity.

Examples. A famous example of how mental models can be deceiving comes from the Norman's book *The Design of Everyday Things* [14]. In the book Norman asks the reader to image what she/he would do if asked to cook some food in the oven when subject to a rush, knowing the temperature requested to cook the food is 200 degrees. Most readers, according to Norman, would be lead to the wrong assumption that setting a higher temperature will make the food ready earlier. This happens because they are applying the right principle of '*more is more*' to the wrong circumstance.

3.5.1 Design implications for mental models

The designer can help the user to derive the correct mental model using transparency. According to Norman [5] to achieve that purpose the conceptual model needs to be easy to learn, to map all the functionalities of the system and to be usable according to the human capabilities and limitation of interacting with a system. In fact a mental model which does not fit learnability criteria, even if it is a good model, cannot be explored by the user; a mental model which fails in showing its functionality does not allow the user understand in which way she/he can perform her/his intention; finally, a mental model which is not usable cannot be used by the user in a easy way.

4 Applying the rules, a case study: the Swansea University Website

We have seen how users perceive the real world outside them, how they use cognition to achieve tasks, how they learn interacting with a system, making errors and gaining experience, and how they internalize that experience in their memory. In the following section it will be explained how the knowledge we have acquired so far is useful to understand and evaluate existing design choices: we are now able to find out what is hard to use in a specific interface, but more important we can understand and explain why. A small subset of the Swansea University website will be analyzed, referring to the design implications suggested trough the previous paragraphs.

4.1 The methodology

For the scope of the analysis only two pages have been analyzed: the *MyUni* page and the *pop-up* page which allows the log-in to the myUni section. Each page is analyzed taking account of all the problems the user can face because of the lack of attention to those principles and rules illustrated in the previous paragraphs. The found design issues have been divided by *category*:

- *appearance*: when they affect the efficacy of the website: for example the content is not shown in the correct size so that the user struggle to read it;
- *interaction*: when they affect the way the user uses the system: for example a link which does not appear as linkable can preclude the user to reach its content.

Each error is then associated with the *cognitive area* (perception, memory, mental model, learning and attention) which it belongs to and a grade of severity between 0 and 2 (where 0 is low and 2 is high) is given to the issue.

4.2 MyUni Page

As shown in figure 5, according to the HTML DOM logical division, the web page is divided in:

Figure 5: MyUni web page

- the *header*, composed by the MyUni logo, a Google search box and a link to switch between English and Welsh;
- the *menu*, which leads to five different sections: “MyUni Login”,” Student Support”, “Library”, “Printing” and “Student Union”;
- the *main content,* grouped in three different sections:
  - a featured gallery: showing some pictures which dynamically change;
  - a list of articles: containing the actual information of the current section;
  - a right sidebar: containing links to other sections could be relevant;
- the *footer* which display only legal information about registration.

4.2.1 Header

As said the header contains three elements: the MyUni logo, a Google search box and a link to switch between English and Welsh (figure 6). Traditionally websites have used their logo on the top left of the page as an anchor to the home page: this is a good convection as it allows the user to return to the home easily [13]. It is hence useful for the user to have the MyUni logo available: it helps user’s learning through the reuse of a past and well consolidate experience.

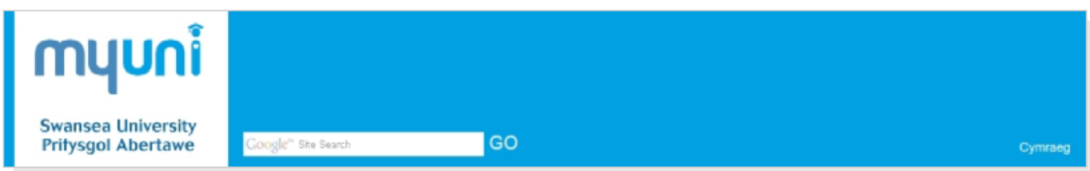


Figure 6: Header

However the use of convention is not respected for the Google search box that should be located on the top right. This is not the only problem related to the Google search box: the text size is not sufficiently wide, nor the explanation of its functionality is sufficiently exhaustive. Even if it could appear obvious that a user knows what a Google search box is, and how it works, no implicit assumption should be made: it is the designer’s job to consider all kind of users, from experts to novices. A better choice would have been, for example, the ones shown in the figure 7.

Figure 7: Alternative design for the search box

In the proposed solution the text is bigger, and it takes account for the human sight limitation. Therefore the learning process is improved, since more useful and meaningful information is given to the user. Despite the ineffective implementation the Google search box is a good tool: it helps the user to find information without overwhelming her/him with an excessive load of data to process: the user has not to navigate the entire system to find the needed information as the explored mechanism of recall and recognition can be proficiently used. Unfortunately the Google search box does not work: no matter of which keyword is used, no result will be found as shown in figure 8.

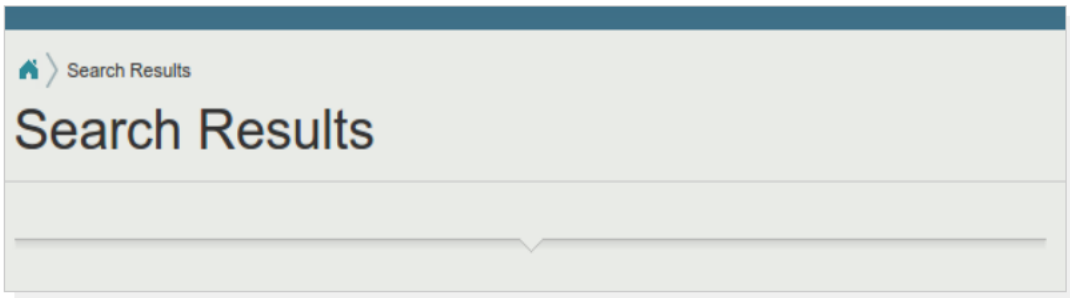


Figure 8: Google search box results for the keyword “Student”

To make matters worse no meaningful message such as “no result found” is given to the user: hence she/he could infer, for example, that no result for the given keyword is actually present. Finally the link to switch between languages is too small and not easy to reach: suppose the user scrolls the entire page, then she/he could not see it anymore. Therefore there are more effective way to get the user attention or being self explaining such as using icons that are more familiar: it would help the user's learning allowing to apply knowledge from the real world to the virtual one.

Here is the recap table for the header section's issues:

MyUni: header				
Element	**Issue**	**Category**	**Cognitive area**	**Severity**
Google Search box	Text is small and not informative	Appearance	Perception	1
Google Search box	The search does not work	Interaction	Memory	2
Google Search box	Does not follow conventions	Appearance	Learning	0

Table 1: Issues for the header section divided by category, cognitive area and severity

4.2.2 Menu

The menu is the element of a website that usually allows the navigation trough different sections of the website.

Appearance The menu is made from four colored element: MyUniLogin on blue, Student Support on lilac, Library on green, Printing on red and Student Union on blue again.

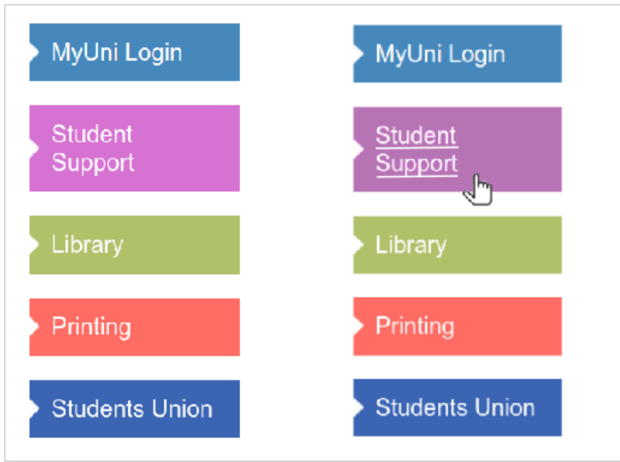


Figure 9: Menu with mouse over

When the cursor goes over an element of the menu, three different things happen: the cursor style changes from pointer to hand, the colour becomes darker and the font style changes from normal to underlined. These cues are very useful as they suggest the user how to interact with the system using a way that should be already obvious to her/him. Also the fact that the element changes its appearance is a good way to get the user attention itself. However the colours choice is not appropriate as the blue colour has been chosen for both the MyUni Login and the Student Union element. Even if the colours are slightly different, there it has to be kept in mind that we are less sensible to the blue than to other colours, hence noticing the difference could not be obvious. This could be an issue: because of the similarity principle, the user could infer some relationship between the two areas when in fact there is none.

Interaction As said to each menu voice a possible action is associated, as links usually take the navigation somewhere else. The menu interaction suffers from a general lack of coherence and consistence that might make the navigation logic unclear: in fact while clicking on the myUni Login voice opens a pop-up, for any other choice a new tab is opened: this behavior represents an issue for several reasons. Firstly it does not let the user to control the interaction since opening a new tab is not her/his choice; therefore she/he could be disoriented by the focus on a new window. Moreover this behavior does not helps attention: we know that the user's attention is limited and that the user can be easily distracted: now suppose the user does not pay attention to the screen in the few seconds she/he click on the menu voice, she/he will not probably notice that the navigation has been redirected to a new tab; again this mechanism could be disorienting and should be avoided. Another problem related to the menu is how it responds to a strategy of interaction that could be implemented by the expert user. When clicking with the right button on the MyUni Login element, and selecting "Open in a new tab"/"Open in a new Window" the navigation is in fact redirected on a different URL (https://myhub.swan.ac.uk/) than the one the user would have been accessed through the direct left click (https://myuni.swan.ac.uk/#). In particular the navigation is redirected to the accessible version of the website, but no information about it is given. The mistakes in the designer implementation are particularly severe as they could get the user in trouble: suppose the user right clicks on the MyUni Login element, a new tab is opened; she/he logs-in in the system, then as soon as she/he finishes the task, she/he closes the tab: she/he is still on the MyUni website but in the first tab opened. Now she/he tries to log-in again: what happens is she/he receives an error message (figure 10) because the page has not been refreshed and the log-in made in the previous tab is still valid. The user can find himself facing the consequences of an error she/he did not make, a designer error.

Figure 10: A log-in error message

To make it worst the error message is clearly not enough informative: in fact it is not clear what "another link" nor "a different URL" should mean. Even the graphic of the message, with the "broken" Outlook Webapp window is not helpful. As a result, because the interaction is no coherent, since for the same action the user gets different feedbacks, the learning process is made difficult. The user in fact tries to create the right mental model of the website, but this job is made complicated by the fact the result of the interaction changes each time: without a proper mental model the user cannot even predict what the result of her/his action will be.

In the following page is the recap table for the menu section's issues:

MyUni: menu				
Element	**Issue**	**Category**	**Cognitive area**	**Severity**
MyUni Login and Student Union menu voices	Both used co lours are too similar and they could seem semantically related	Appearance	Perception	1
Menu links	The behavior is not coherent: sometimes the click opens a new page, sometimes does not	Interaction	Mental model, Learning	2
Menu Links	The click opens a new tab or window	Interaction	Attention	2
MyUni Login link	Left click opens a pop-up whereas right click opening a new tab takes to a different URL	Interaction	Mental model, Learning	2

Table 2: Issues for the menu section divided by category, cognitive area and severity

4.2.3 Main content

As seen the main content is made by three different sections: a gallery, a list of articles and a right sidebar with related items.

Appearance In this sections there are several examples of good design. The section recalls the voice of the menu (figure 11): this is a good way to apply the similarity principle, since the user can easily understand where she/he is. The attention is helped through the use of bold text to display salient information, and the use of the blue colour to get the user attention over the available links (even if, as said, the blue colour is not the best choice).

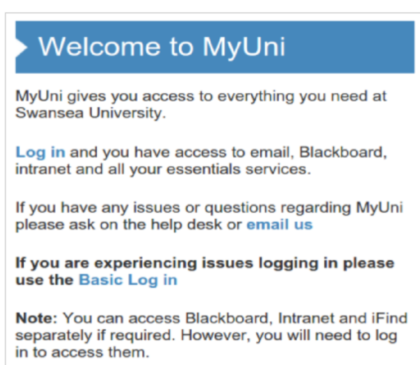
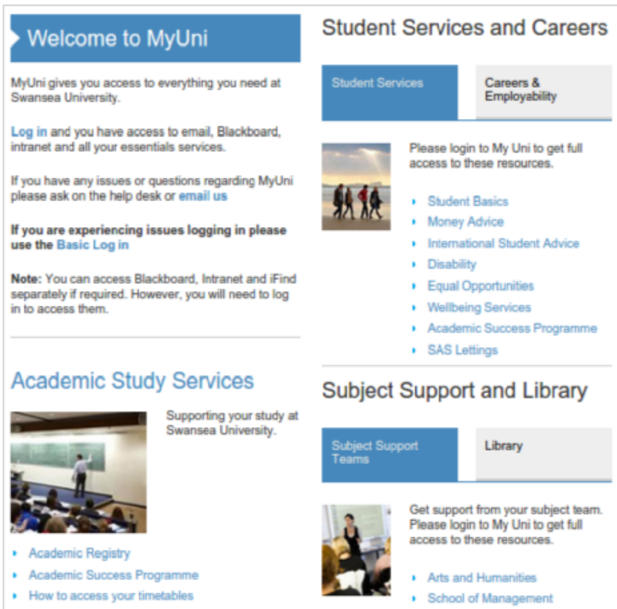
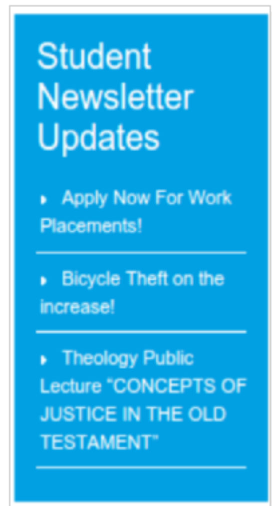


Figure 11: An example of a good design choice: bold to get attention, blue font to show links, blue color of the head to create a semantic connection

The content is structured in different areas which thanks to the closure principle we perceive as boxes, while the use of the overlapping principle allows to perceive tabs, which are a useful way to organize information logically and hierarchically. However the boxes edges are sometimes not immediately recognizable, since the horizontal lines would suggest a way to complete the area, while the title would suggest another (figure 12a). The closure principle is a good way to help the user to perceive information grouped in a correct way, however it should have been applied more carefully.



(a) Which are the boxes?



(b) The sidebar boxes content is properly displayed thanks to the closure principle

Figure 12: A bad and a good example of applying the closure principle

On the contrary, an example where the closure principle has been used in a correct way, is in one of the sidebar box, where lines are adopted to divide logically different information (figure 12b).

Interaction More often the interaction is not consistent nor coherent: in fact clicking on links randomly takes to a new tab, or change the content of the current one. Looking at the URL would appear that the *system models* is: same domain same tab, different domain new tab. However the user is not required to know the concept of domain and the navigation should be transparent since she/he should have the impression to visit always the same website. The designer has not developed the proper conceptual model that allows the user to construct the right mental model. In fact, it should be coherent or at least notice the user when the main tab has been left. Another problem is related to the way the switch between different languages is managed: when the user clicks on the "Cymraeg" link, the entire webpage is translated in Welsh, however when the user clicks on a link, the new page is English again. Perhaps some mechanism to allow the user to now if the link takes to a Welsh or an English page in advance should be adopted (for example English name links for English pages, Welsh name links for Welsh pages). The closure and similarity principles are wrongly applied again in the sidebar boxes design: when over with the mouse each section of the box ("Need a PC?", "Find a free PC now" and the image) changes independently one from another (figure 13). This would suggest each link to take to a different page, even thought it is wrong. Appling principle in the right way would have been meant designing the box in such way that, when the cursor is over, the entire content would change together.

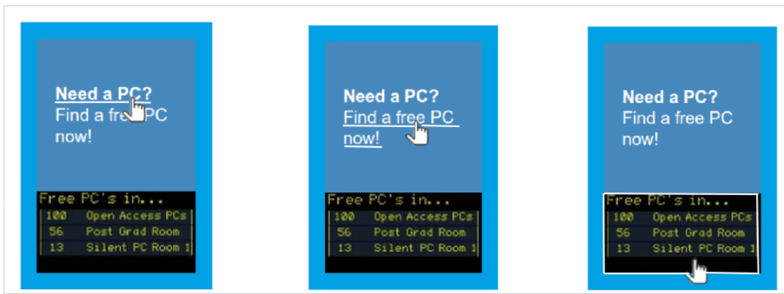


Figure 13: Box from sidebar: the cursor changes styles independently for each part for the box

Here is the recap table for the main section's issues:

MyUni: main content				
Element	**Issue**	**Category**	**Cognitive area**	**Severity**
Content boxes	The content is not always properly displayed	Appearance	Perception	0
Links	The behavior is not coherent: sometimes the click opens a new page, sometimes does not	Interaction	Mental model, Learning	2
Cymraeg link	The translation is not consistent	Interaction	Learning	1
Need a PC sidebar box	There are different links for the same purpose	Appearance	Perception	1

Table 3: Issues for the main section divided by category, cognitive area and severity

4.3 MyUni Login Pop-up

When the MyUni Login element is clicked a pop-up appears on the screen as shown in the following figure 14.

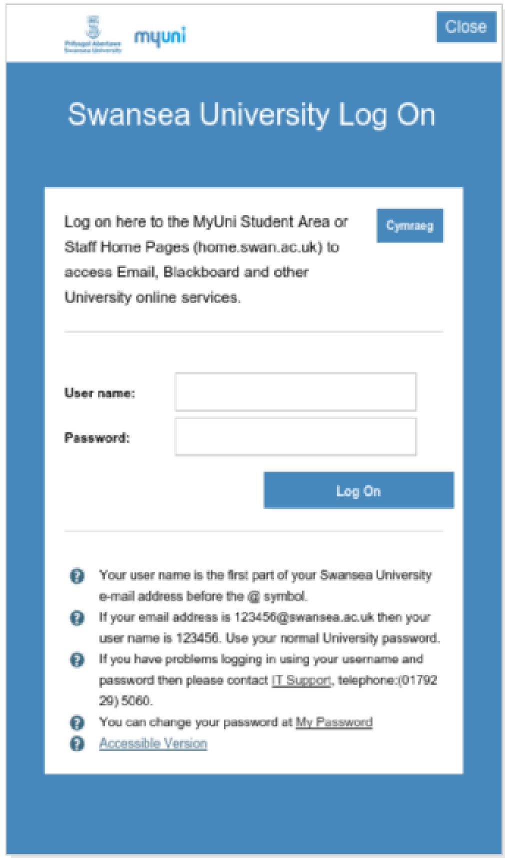


Figure 14: Log-in pop-up

Appearance The pop-up obscures the background and it is a good choice since it helps the user attention to focus on the right place. The overlapping principle is used to show that the pop-up is on the foreground. However the background should not be clickable while it is: it is an issue since it is in contrast with the fact the pop up is asking for attention. Another problem is related to the names choice: while the section is called "MyUni Login" on the pop-up the expression "Log-on" is used instead: one more time it affects the coherence of the system. Buttons are another problem: in fact while the 'close' button changes colour (light to darker), cursor (from point to hand), and text style (from normal to underlined), the 'language' and the 'logon' button do not. Therefore there are easier ways and conventions which should be used to help the user learning, such as a 'X' icon for the 'close' button. On the bottom of the pop-up there are some useful instructions. This is a good strategy to help the user through the learning process without overwhelming her/his attention: only few important key information are shown. However the information does not seem semantically well organized, and because of the similarity principle (empty shape are seen as buttons, so clickable) the '?' icon could appear clickable when instead it is not.

Interaction There are several issues related to the interaction within the pop-up. The MyUni logo that usually takes to the MyUni home page, takes to the Swansea

University homepage instead. Again, even if the 'change language' link changes the language of the pop-up, then all the links ('IT support', 'my passowrd') take to the English version. Finally when trying to log-in into the system no difference in the error messages is made between two cases: when the username is right but the password is wrong or when even the username is wrong. Furthermore the error message is in black so that it is hardly noticed by the user (figure 15): it is impossible for the way the attention works to catch it . Even worst if the pop-up is closed and then reopen, the

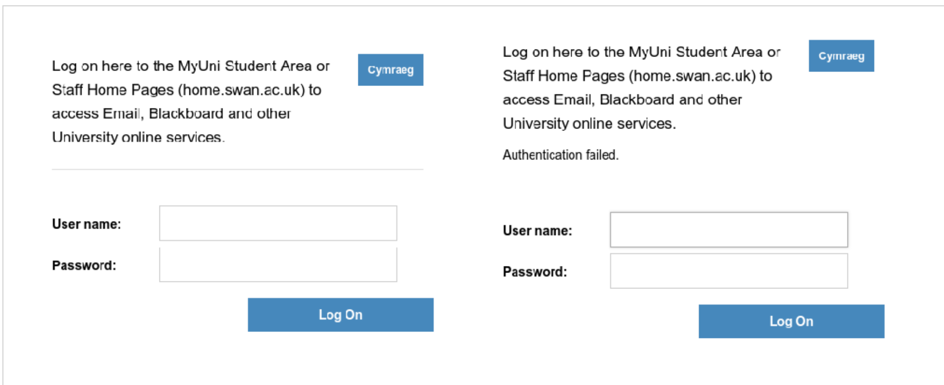


Figure 15: Can you easily see the error message?

error message is not deleted. Finally, when the user makes to many wrong attempts, the entire use of system instead of the user account is locked (perhaps in a very insecure way since cleaning the cache of the browser solve the problem). The message error, however, is not informative enough to the user to let her/him would solve what is going on (wrong user name? wrong password?)

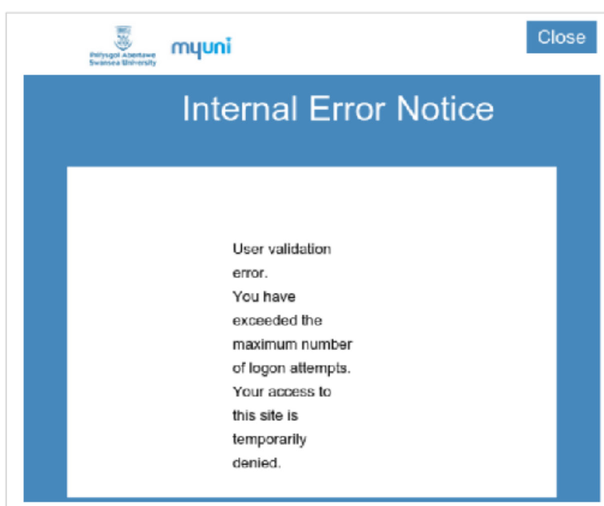


Figure 16

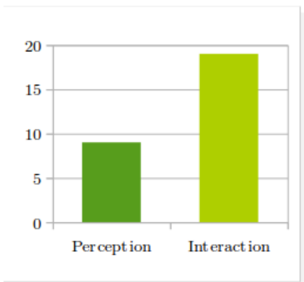
In the following page is the recap table for the pop-up section's issues:

Login pop-up				
Category	**Issue**	**Category**	**Cognitive area**	**Severity**
Appearance	The pop-up obscures the foreground, which remains clickable	Appearance	Perception	1
Labels	Lack of coherence in the terminology: sometimes log-in is used, sometimes log-on	Appearance	Mental model, Learning	1
Buttons	Buttons react in a different way to the on-over event	Appearance	Mental model	1
Close button	Standard not followed (the 'x' symbol)	Appearance	Learning	0
MyUni Logo	Take to the University homepage instead of the MyUni homepage	Interaction	Mental model, Learning	2
Cymraeg link	The translation is not consistent	Interaction	Learning	1
Error message	Not informative	Interaction	Mental model, Learning	2
Error message	Same colors of the normal text	Interaction	Attention	2
Error message	The error message is not clean when the pop-up is closed and the reopened	Interaction	Mental model, Learning	2
Lock of the system	If the user try too many times in a wrong way, he will be locked	Interaction	Mental model, Learning	2

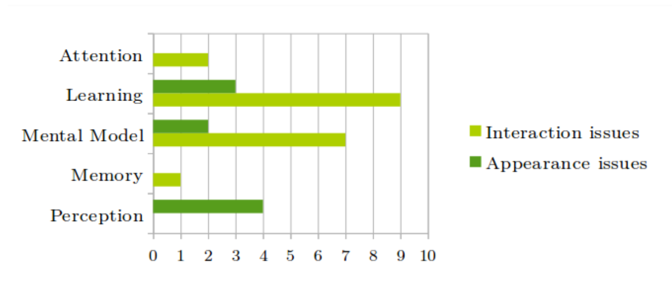
Table 4: Issues for the pop-up divided by category, cognitive area and severity

4.4 Analysis consideration

Almost the 30% of the total problems are in the perception area: it means that the user can experience problems because of limitation in terms of perception and this precludes the efficacy of the website. However most of the problems are in the interaction area: it is even worse since it means the way the user can interact with the website is often affected by bad design choices. In particular most of the problems are in the learning and mental model area. It happens because, as seen, the issues found affect mainly the coherence of the system: for the same action there are different system responces (clicking on links takes to external pages but not always); the system goes in an error state even if the user did not do anything wrong (such as when logged-in in a different tab); the system does not work but it is not possible for the user to notice it (such as the search box that is not working but the user could simply think that no result for the performed search has been found). Therefore the error is not managed in a proper way: error messages are not informative and sometimes they are not even visible: this is particularly bad because as seen, learning by making mistake, and in general by feedback, is an important learning strategy that could be implemented by the user.



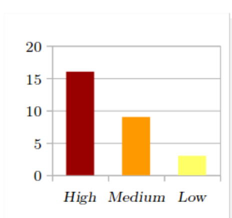
(a) Total number of issues for category



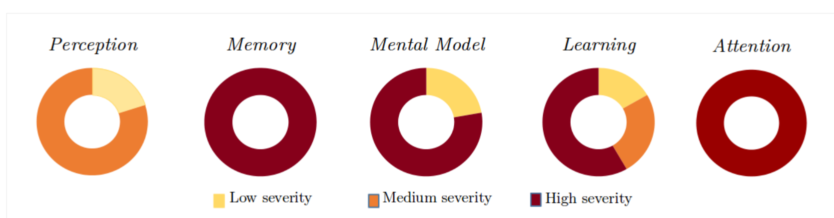
(b) Number of issues for cognitive area

Figure 17: Number of issues for cognitive area and category

To be noted that most of the error (16 out of 28) are characterized by high severity: when a user face one of them she/he can be stuck in a operation (such as during the log-in mechanism, or the lock of the system when too many attempts are done). Because of these reasons the user cannot construct the correct model of the system, hence its use cannot be learn easily. The user could loose confidence in himself, feel frustrated, and she/he could even abandon the task before its completion. From the analysis performed appears clear that the website has been not designed taking account of any good design practice and that a urgent revision is needed.



(a) Number of issues for severity



(b) Number of issues for severity and cognitive area

Figure 18: Severity of issues

5 Conclusion

The human being is a very complex system and in order to deeply understand it we need knowledge from several different fields, from cognitive psychology to social psychology, from industrial design to ergonomics [16]. In particular we have seen what is the contribute of the cognitive psychology, exploring the keys concepts of perception, memory, attention, learning and mental models. We should now have clear the meaning of the famous design principle “1 + 1 = 3 or more” [18]: the human being is something more than the sum of each singular component, and this aspect should be always kept in mind when considering the human factor aspect in the developing of new systems. In practical terms it means we should always develop new systems following interactive design guidelines, and above all, we need to understand the theory behind to not fall in trap when appling them. Therefore, if we really understand the theory behind, we will be able to develop our own guidelines. Through the analysis of the Swansea university website we have seen how the acquired knowledge can be applied to discern between good and wrong design choices: in particular the website has shown that most of the interactive design guidelines have been ignored, or applied without any particular awareness regrading the human cognition. This is particularly serious because the analysis has been performed on two crucial pages of the website, as they allow the access to the MyUni section, which is visited by thousands of students everyday. It means, for example, that students will probably require and ask for help from university staff to get information or services which are theoretically available on the website but not easily reachable: in other words the university looses efficiency, efficacy, time and profits. On the other hand students feel frustrated, loose time and confidence in the system: therefore if they get the idea the web site cannot help them they will probably stop using it, avoiding to use it even in situations where it could really be helpful. Unfortunately this trend is still followed by most of the companies: even if the awareness of the HCI importance increased during the past years [19], it is still too low. HCI today is crucial and must not be underrated: each designer, programmer, and everyone is involved in the process of the developing of the system should always investigate or at least be aware of the cognitive principles which are hidden underneath.

Darn those hooves!
I hit the wrong switch again!
Who designs these instrument
panels, raccoons?

Figure 19

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