Usability and Aesthetics
- is beautiful more usable?
Abstract
When discussing matters of usability, focus is usually kept on functionality whilst other aspects, such as aesthetics, are neglected. Discussions of aesthetics are on the other hand traditionally kept within the area of fine arts. Considering that both usability and aesthetics are of big importance in people’s lives, it is astonishing to find that their relationship has not been fully explored. Therefore, the purpose of this study was to, with interfaces of a Volvo Logistics environmental calculation tool, explore whether aesthetics (in the form of visual beauty) would affect the perceived usability of a system. Hence, the question of research has been whether a visually attractive user interface will be perceived as more usable than a less attractive one when usability/functionality is kept constant? (Or in more general terms; is beautiful more usable?)

To achieve this, two interfaces with the same functionality but with different levels of visual beauty were designed and used in an experiment where participants rated perceived usability and appearance. The results of the experiment were expected; participants perceived the better looking interface as more usable whereas actual usability appears to have been constant.
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Foreword
This study has been performed at Volvo Logistics Corporation (VLC), which is the lead logistics provider for the Volvo Group. VLC delivers complete supply chain solutions to customers worldwide and as the transport sector is responsible for a considerable amount of environmental damage, new environmental laws and regulations (such as emissions trading within the EU) put pressure on companies like VLC. This leads to stricter company policies and obviously also to increasing costumer demands. To keep up with these demands Volvo Logistics need an appropriate IT solution to support environmental calculations. Hence, the interfaces used in this study have been designed as an environmental calculation tool for Volvo Logistics Corporation.
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1 Introduction

Information technology is a big part of modern society. We interact with digital artefacts daily and opinions about the goodness and badness of technology greatly differ. On one side you find the opinion that technology itself is neutral when it comes to morals and ethics. Hence, only the use can make it good or bad. This point of view is called technological somnambulism (Pfaffenberger, 1989). The other extreme is technological determinism which holds that technology is an independent factor that influence society on its own. Thus great technological changes give rise to great social changes (ibid.). Even if one does not adopt one of these extremes, it is safe to say that whilst being surrounded by digital artefacts, these affect how we live our lives and go about daily routines. Being such a big part of society it is of great importance to design technology in a way that supports people. Thus, artefacts need to be easy and enjoyable to use. Usability is today a widely discussed concept in the area of HCI (Human Computer Interaction). The focus though, is typically on functionality and other aspects, such as aesthetics, are usually neglected. Aesthetics is, like usability, also widely discussed but these discussions are traditionally kept within the area of fine arts (Berleant, 2005). Considering that both usability and aesthetics are of big importance in people’s lives, it is astonishing to find that the relationship between them has only begun to be explored.

1.1 Purpose

Digital information technology has quickly become the largest group of cultural artefacts of our time. When considering this, it is remarkable that so many digital artefacts have shortcomings when it comes to their ease of use. Being such a big part of our everyday life, improving these artefacts is obviously of great importance for the individual user, for businesses and for society as a whole. A common understanding of what factors affect usability is however not yet to be found and the purpose of this study is to, explore whether aesthetics (in the form of visual beauty) can affect the perceived usability of a system. To achieve this, two interfaces with the same functionality but with different levels of visual beauty was designed and used in an experiment where participants rated perceived usability and appearance (see chapter 4).

1.2 Question of research

- Whilst keeping usability/functionality constant, will a visually attractive user interface be perceived as more usable than a less attractive one? (Or in more general terms; is beautiful more usable?)

1.3 Thesis outline

Chapter 2 will give the reader a theoretical framework for this study, in which concepts like usability, aesthetics and beauty are discussed. The following chapter provides the reader with an understanding for environmental issues of the transport sector and the functionality needed for an environmental calculation tool. In chapter 4, methods used for designing the experiment interfaces are explained. In the same chapter information about the design, participants and procedure of the experiment can be found. In chapter 5, results of the experiment are presented and the final chapter offers a discussion regarding these results.
2 Theoretical framework
The aim with the following chapters is to give the reader an understanding of the concepts usability, aesthetics and the relationships found between them so far. The chapters regarding aesthetics will provide the reader with both modern and historic perspectives of the phenomenon. Finally, design guidelines, which have been used in the study, are presented.

2.1 Usability

"Usability is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified use of context" 

The ISO 9241:11 standard for usability

Usability can be described as the quality in use of interactive products. This quality reveals itself in the interaction between the product and the user over time, that is in use. To design a product with high usability one has to consider a number of things. First the human system with general qualities such as perception, information handling and problem solving but also specific qualities such as values, knowledge, attitudes and expectations (Ottersten & Berndtsson, 2002). Second, one has to consider the context in which the product will be used, that is the physical context (lights, noise, etc.) as well as the psychological context (stress, workload, etc.).

2.1.1 Usability goals
Preece, Rogers and Sharp (2002) describe how usability can be broken down to a set of usability goals, which are: effectiveness, efficiency, safety, utility, learnability and memorability. Each of these can be described by providing them with a set of key questions. Asking questions of how well a system does what it is supposed to do can ensure effectiveness. Can the users get the information they need and so on? When it comes to efficiency one has to look at how well a system supports users in their tasks. Safety refers to the way the system protects users from unwanted outcomes. This involves physical safety as well as avoiding accidental actions. If an error occurs the system should also allow corrections. Utility refers to the functionality of the system, and if it allows users to go about their tasks in a way they want to. Learnability is simply about how easy a system is to learn. The level of learnability can differ greatly depending on when and who will use the system. Finally memorability involves how easily the functions of a system can be remembered once learned.

Public interactive products, which the users actively decide to and want to use, are normally more user-orientated then products that have to be used. A common mistake is thinking that usability isn’t important since the users will learn when forced to use a system. This is of course true, humans have an amazing ability to adapt, but the cost of this type of thinking can be great. With high usability one can avoid errors, have lower costs for training, less support needed, happier users and a stronger brand (Ottersten & Berndtsson, 2002). There is however no simple way, and certainly no one way to accomplish usability. One approach to usability is however interaction design, which will be discussed in the following chapter.
2.2 Interaction design

According to Ottersten and Berndtsson (2002) a common mistake when developing interactive products is to neglect interaction design. The consequence of not viewing interaction design as an important and controlled process is usually that user interfaces become a reflection of the underlying technological architecture, hence forcing the user to understand how the system works. Interaction design is sometimes confused with graphic design. Whereas graphic design involves the graphic part of interfaces, the interaction designer works mainly with the behaviour of a system, which is the part that is not visible. In fact, the best interaction design is one that is not noticed at all (ibid.).

2.2.1 User experience goals

The purpose of interaction design is to describe the interaction between the product and the user. This involves designing the user interface content, behaviour and presentation in a way that pleases the customer as well as the user (ibid.). Usability goals (see chapter 3.1) are central for interaction design. The great diversity of application areas for interactive products (e.g. home, entertainment, education) is however a reason to concern a wider range of goals. These goals called user experience goals refers to what interacting with a product feels like (Preece et al. 2002). The relationship between user experience goals and usability goals are illustrated in figure 1. User experience goals differ from usability goals in that they are of a more subjective nature. Often there is a trade-off between the two types of goals and all of them are obviously not applicable to every interactive product.

![Diagram showing the relationship between usability goals and user experience goals](image)

Figure 1 – The relationship between usability goals and user experience goals (Preece et al. 2002).

2.2.2 The design process

Every interaction design project is unique and hence, so is every design process. Löwgren and Stolterman (2004) divide the design process into five not fully...
separable phases to make it more understandable. These phases are *investigation, exploration, composition, evaluation* and *coordination*. The investigating phase involves collecting as much information about the design context as possible, in other words to explore and understand the current situation. In this phase the designer needs to maintain balance between the *existing* and the *potential*, what is and what can be. The risk of suggesting a computer-based version of an already existing manual solution is evident. Another risk is to introduce daring innovations where existing good practices are ignored. When engaging in an investigation one must have a clear purpose to avoid a random study of the current situation.

One method to achieve proper understanding of the design situation is *contextual inquiry*, which is a participatory method for system design. With this technique users are offered a way to articulate work and system practices and the associated experiences. Contextual inquiry has its roots in field research of psychology, sociology and anthropology and was developed to better understand users work flow and activities. Every computer system involves an underlying model of what users need and how they work. When using contextual inquiry, the aim is to achieve such a model based on existing work intentions. Hence, a contextual inquiry should result in knowledge about:

- What users do?
- What users say?
- What disrupts workflow?
- What supports users work?

To achieve this, users are observed, preferably during work, or interviewed. Interviews are however not always informative since users may not be aware of their own work situation. Important is to keep a dialogue, ask questions and knowing that the user is the expert (Holtblatt & Jones, 1993).

Separating the phases investigation and exploration is sometimes difficult. Löwgren and Stolterman (2004) describe investigation as being mainly about understanding what already exists whereas exploration is about what is possible. This phase is for creativity and for exploring different design solutions. The risk of being narrow-minded is greatly reduced if one actively tries to use divergent thinking. *Brainstorming* is a well-known method for achieving this. During a brainstorming session, a group of people is gathered to generate ideas without critique. The result of the idea generating is then analysed and systematised. The next phase, composition, involves creating a gestalt of a design solution (ibid.). The designer must create a whole of the existing and the new into a final composition. A function analysis can be a helpful tool in this phase. Such an analysis is performed by structuring available information and describing possible functions, which are valued as necessary, desirable or unnecessary. Scenarios, GUI sketches or storyboards can later help to illustrate and communicate a design concept. The last two phases, evaluation and coordination, involves testing a solution for usability and check for compliance with design guidelines (see 3.6). It also involves organising the design process on a meta level.
2.3 Mental phenomena

Usability can be better understood with knowledge of certain mental phenomena. One of these phenomena is mental models. Mental models are structures of knowledge that people develop to make sense of the world and explain experiences (Sternberg, 1999; see Johnson-Laird, 1989). The implicit assumptions that individuals hold about experiences constrain these models and the assumptions can be of varying accuracy. Mental models can be thought of as conceptual spaces where sensory information is structured and functions as a basis for ideas and concepts (Gärdenfors, 2000). Norman (2002) discusses how a designer must provide a conceptual model that can be understood by the user and three aspects of mental models are distinguished:

- The design model
- The user’s model
- The system image

The first aspect is the concept of the designer and the second is the model developed by the user to understand the system functions. The design model and the user’s model should preferably be equivalent. This can be difficult to achieve since the communication between user and designer usually goes through the system. Hence, the system image (e.g. appearance, functions, manuals) is vital (ibid.). When initially approaching a system, the user has intentions and goals. Even when executing simple tasks, goals are interrupted and the forming of new goals takes place (Hutchins, Hollan & Norman, 1986). Since a system can only be presented as physical states and for successful interaction the gap between user and system must be bridged. This process may start from either end: by designing an interface that meets the needs of the user or by the user’s adaptation of intentions. The forming of a new mental model has however proven to be mentally challenging for the user (Heimler, 2003, referring to Ericsson (2001)).

Another important phenomenon to discuss is perception and more specifically visual perception. Perception can be described as the processes that help us make sense of sensations received from the environment (Sternberg, 1999). Visual perception helps us organize and recognize visual stimuli, for instance to maintain size and shape constancy. It also involves organising elements into coherent groups. The Gestalt approaches to form perception aim to explore the holistic processes involved with perceiving structure. This school adopts the notion that the whole differs from the sum of its individual components. The basic Gestalt principles are important when designing visual interfaces and these are:

- Figure and Ground – certain elements (figures) appear more prominent that others (ground)
- Proximity – we tend to view objects that are close together as a group
- Similarity – grouping of objects is based on similarity
- Continuity – forms are perceived as continuous rather than discontinuous
- Closure – uncompleted objects are perceptionally completed
- Symmetry – mirror images around the centre of objects are perceived

Techniques for designing visual interfaces based on the Gestalt principles are discussed in chapter 2.6.2.
2.4 Aesthetics

The name aesthetics originates from the Greek word *aisthetikos*, meaning sensation or perception. Berleant (2005) discusses how the original field of aesthetics dealt with the perception of what pleases the senses, as opposed to the structure, utility or content of an object. Discussed qualities were (and still are) beauty and ugliness, sublimity and dissonance. Yet the connection to the senses has often been overlooked since Alexander Gottlieb Baumgarten introduced the field as an independent part of philosophy in 1735. Over the last two and a half centuries aesthetics has tended to limit itself to the philosophy of art.

Ancient Greek philosophers like Plato and Aristotle and Enlightenment thoughts have been the major influences on western aesthetics. The two major concerns have been the theory of art and the theory of beauty. Thoughts of beauty have changed drastically over the years (see 3.4.1), whereas the theory of art has been kept rather constant (Dickie, 1997). Art is considered a self sufficient and autonomous cultural institution, which demands a certain attention mode called *disinterested contemplation* (Berleant, 2005). The notion of disinterest can be understood as perceiving an object for it’s own sake and completely separate it from cultural context. This experience is considered the aesthetic experience, which differs from moral, cognitive, religious and instrumental experiences. Peter Lanemark (2000) discusses how aesthetics traditionally has focused on concrete objects such as paintings, sculpture and architecture. An exception is dancing and in recently also film. Yet, the boundaries of what is considered art and what can be subject of aesthetic studies is slowly shifting, much due to the advent of computers and information technology. The aesthetics most applicable to information technology is the visual aesthetics, which involves what pleases the eye, in other words beauty. Whether there is a definition of beauty will be discussed in the following chapter.

2.4.1 What is beauty?

Beauty is not an easy concept to explain. Yet, the ponderings of beauty is certainly not a modern phenomenon, on the contrary it started with the great philosophers of ancient Greek. Plato kept his thoughts of beauty on an abstract level. According to Plato the meanings of general terms like beauty, justice or goodness are their abstract entities called *forms*. Hence an observed object or action is beautiful if being a participant of the abstract form beauty (Dickie, 1997). Plato thought of beautiful things that we see, hear or touch as existing in the world of sense, which he considered an illusion. Instead Plato took more interest in beauty itself, which was in the intelligible world that existed apart from our senses. The prevailing view of beauty, as expressed by Webster’s online dictionary below, is however credited to Aristotle:

**Beauty** – The qualities that give pleasure to the senses.

Aristotle rejected Plato’s thoughts of forms existing in a world beyond the world of experience. For Aristotle there was only one world, in which experiences of the senses were in no way illusory (Katsenelinboigen, 2003). The main difference from the Platonic view of beauty was however the introduction of subjectivity. For something to be pleasing there must be a person who is experiencing pleasure and not only an object with objective qualities. Thus, in the 18th century there was a shift of focus from beauty to *taste*. Prior to the 18th century philosophers had mainly tried to establish what the objective quality of beauty was and when a satisfying definition could not be worked out the concept of taste was brought to light (ibid.).
2.4.2 Beauty and truth

The truth and universality of beauty has been widely discussed and the works of Kant is among the more influential ones. According to Matthews (1997), Kant believed that perception of beauty was both a subjective and a universally valid phenomenon. This might seem rather contradictory, how can something universal be subjective at the same time? Here the notion of taste comes into the picture. Kant argued that taste was based on disinterested pleasure and common sense. The pleasure was grounded in subjective cognitive states, and since cognition is universally communicable, the basis for taste was intersubjectively valid. Further, Kant claimed that human values and rational nature makes the experience of beauty subjective. If we could only put our values aside and take a more disinterested pleasure in objects, we would all find the same things beautiful and aesthetically pleasing. Hence, beauty was both universal and subjective.

When it comes to beauty and truth in science there are several books written on the subject. Mathematics is usually considered the truth of the world and theorems, proofs and theories are often considered beautiful or ugly. Beautiful mathematics is normally characterized by shortness, simplicity and self-containment. Mathematics also has a connection to arts. When composition is concerned, every school of art seems to have a mathematical base. This becomes especially clear when considering architectural beauty, which depends on mathematical relationships such as symmetry, proportions, geometrical figures, rotation, equilibrium, the golden mean and the school of Pythagoras. Since the experience of art is considered a highly emotional one, aestheticians sometimes hold that the relationship between mathematics and aesthetics is limited due to the lack of emotion in mathematics. Yet, plenty of art is directed to the intellect rather than emotion, which supports a relationship between mathematics and aesthetics. For instance did the theory of proportions play an important role in classical art as well as during the Renaissance period. Some mathematicians even suggest that one, through mathematics, could come up with an exact, universal and scientific theory of the arts, which would result in a recipe for creating beautiful objects. (Emmer, 2005)

When it comes to guidelines for designing visual interfaces one can also find a clear connection to mathematical as well as physical rules. When Mullet and Darrell (1995) concern the organizing of visual structure in interface design, they emphasize (among other things) balance, symmetry and optical adjustments to ensure a pleasing visual experience (see chapter 2.6.2).

2.4.3 Beauty and information technology

When speaking of aesthetics and information technology it is usually about the "look and feel" of GUI’s (Graphical User Interfaces). Karvonen (2000) discusses how literature of interface design rarely has any reference at all to traditional aesthetics. Instead of mentioning aesthetics and beauty, concepts like pleasantness or design quality are discussed. Lanemark (2000) suggests that dynamic art, such as web interfaces, shouldn’t be evaluated with the same aesthetics normally applied to static objects. Instead Lanemark sees a need for a new form of aesthetics, namely hyperaesthetics. In literature on interface design there is however an indirect reference to traditional visual aesthetics and beauty. For example is elegance and simplicity the first two design rules discussed by Mullet and Darrell in Designing visual interfaces (1995). Elegance and beauty are obviously closely related and the notion of simplicity dates long back in traditional aesthetics. The German aesthetician Johann Joachim Winckelmann declared in the 18th century that he considered beauty to be plurality in
simplicity and that the most difficult way to create beauty was through simplicity (Karvonen, 2000). Simplicity can also be found in other sets of design rules as well as in programming and mathematics (Preece et al. 2002).

The connection between aesthetics, beauty and interaction design is by far fully explored. David Heller (2005) discusses how the aesthetics of interaction design is hard to critique as it lacks aspects of line, colour, weight, volume, etc. as opposed to other design disciplines. This is an aspect also noticed by Löwgren and Stolterman (2004) stating that the material used in interaction design is without properties. Further Heller means that the complex role of interaction makes it difficult to separate the presentation of a system from the behaviour. Yet, Heller believes that the youth of the discipline creates a need for depth or, as he calls it, a ”philosophy + critique” practice. Though Heller does not fully investigate the aesthetics of interaction design he makes a comparison to dancing in which several elements meet through choreography. Interaction design, like dancing, consists of many elements that need to be identified and defined to create the aesthetics of the discipline.

2.4.4 Beauty and good

“When I’m working on a problem, I never think about beauty. I think only how to solve the problem. But when I have finished, if the solution is not beautiful, I know it is wrong”

- R. Buckminster Fuller

Katsenelinboigen (2003) has distinguished two ways in which the relationship between beauty and good are expressed in literature. One is a general comparison and the other is related to morals and ethics. In the first case beauty and good are considered distinct; beauty can only be an attribute of an object with an aesthetic value and good is an attribute to an object of moral value. The other approach is that beauty and good are interchangeable, a view typical for the ancient Greeks. In the social sciences there is a well-documented phenomenon known as the ”beautiful is good”-stereotype. This phenomenon was first established in a classic study conducted by Karen Dion in which she examined whether physical attractiveness influenced believes about personality and assumed success in other areas such as occupation and happiness (Dion et al., 1972). The result of the study indicated that stereotyping based on physical attractiveness does occur. Attractive people were assumed to have better personalities and better jobs than unattractive people. It has also been shown that attractive people are liked more than others, all other things being equal (Hatfield & Spencer, 1986). This can perhaps be explained by the halo effect, which is the tendency to impute consistency. When making an evaluation about a person being good (or bad) in a certain area, one is likely to assume this evaluation holds in other areas as well (Taylor, Peplau & Sears, 2003).

Though a ”beautiful is good” stereotype has been proven to exist, a positive relationship between beauty and good is not always assumed. In fact it has often implicitly been implied that if a product is efficient and functional it doesn’t need to be beautiful. With this view beauty becomes a poor substitute for function. One might even say that beauty is only needed when functionality is poor. Hence beauty can be considered the opposite of function. Donald Norman suggests, in his highly influential book The psychology of everyday things (1988), that designers often make the mistake of putting aesthetics first and forgetting functionality. Norman claims that beautiful things are often difficult to use and gives us examples of chairs that can’t be
sat on and teapots that can’t pour tea. In these cases focus on beauty offers a way to disguise bad design and poor usability. Norman keeps focus entirely on usability and fully neglects the importance of aesthetic qualities in design, a view that in recent days has been highly criticised.

2.5 Usability and Aesthetics

Though other qualities than functionality traditionally has been neglected within the area of HCI, there has in recent years been an increasing recognition of other factors affecting usability. A common understanding of which factors affect the overall perceived usability is however not yet to be found (Hartmann, 2006). In modernism, one of the most fundamental axioms has been that *form follows function*. Engineers have been praised for their tendency to subordinate form to function and raw materials, hence creating useful objects. Useful is here thought of as the ultimate form of beauty (Palmer & Dodson, 1996). This axiom is obviously very difficult to apply to arts but when it comes to design its application is obvious. As discussed earlier, the view of Norman (1988), that aesthetics has no place when it comes to usability has been the subject of criticism for designers as well as Norman himself. In later work by Norman he discusses *emotional design*. Objects, people, actions, etc. causes emotions either positive or negative and these emotions affect how the mind works. The human mind has got three levels of processing: the visceral level which is automatic, the behavioural level that controls everyday behaviour and the reflective level which is the contemplative part of the brain. Each of these levels can be affected with three corresponding forms of design, and different ways of designing leads to different emotions and states of the processing levels. Positive emotions cause mental processes that are more open and tolerant. Hence, a person in a positive state is more likely to be creative and seeing the big picture instead of concentrating on minor difficulties. This helps to explain the findings of certain studies on usability and aesthetics, which are discussed in the following chapters. (Norman, 2004)

2.5.1 State of the Art

Empirical research of the correlation between aesthetics and usability is just on its beginnings, but there have been a few important studies. The focus in these studies has mainly been on the subjective side of usability, such as user experience/perception (Hassenzahl, 2004).

Kurosu and Kashimura (1995) conducted an experiment in which the inherent usability of an automatic teller machine (ATM) was compared to the *a priori* perceived usability, which they termed *apparent usability*, and aesthetics. The inherent usability of the ATM was determined by seven independent variables, all reflecting common design guidelines. These were (1) location of main display, (2) type of numeric keypad, (3) grouping of keys according to function, (4) sequence of special numeric keys, (5) location of numeric keypad, (6) location of confirm key and (7) location of cancel key. Two dependent variables were *apparent usability* (how easy is it to use?) and *aesthetics* (how beautiful is it?) rated on a scale from 1 to 10. Different interfaces were shown to people who rated usability and aesthetics. The experiment resulted in a high relationship between aesthetics and apparent usability ($r = 0.59$). This result was highly surprising and due to the unexpected findings Noam Tractinsky replicated the experiment in Israel with some design adjustments. The original experiment was held in Japan, a culture where aesthetics is highly valued, and Tractinsky (1997) thought there might be a cultural dependency to explain the correlation. The study supported the original result and the correlation between apparent usability and aesthetics was even higher than in the original experiment.
Marc Hassenzahl (2004) carried out a study based on the Hassenzahl model. The model assumes that users combine the features of a product (e.g. content, interaction, function) with personal standards and expectations, to create product attributes. These attributes can be either pragmatic, which refers to utility and function, or hedonic which involves the user self. Hassenzahl tested how these attributes correlates with beauty assessments. Four MP3-player skins were picked based on a prior rating of their beauty/ugliness. The two most beautiful skins and the two most ugly skins were used in the study. The skins were shown to users who were asked to rate the skins pragmatic qualities (e.g. technical-human, complicated-simple), hedonic identification qualities (e.g. isolating-integrating, cheap-valuable) and the hedonic stimulation qualities (e.g. typical-original, lame-exciting). In this study only the hedonic identification ratings mirrored the beauty ratings. The pragmatic qualities, which are highly associated with usability, did not. Thus, the results of the study did not support a correlation between usability and aesthetics. There was though a strong correlation between beauty and overall impression of the skins.

User satisfaction is a concept often mentioned in usability discussions and an attempt to find out what constitutes this satisfaction was made by Lindegaard and Dudek (2003). Three experiments were conducted in which users interacted with web sites, followed by interviews and completion of a WAMMI (a standardized tool with 20 questions and 5-point response scales for measuring perceived usability). In the first experiment users browsed two web sites with no special task to complete, one with high usability and one with low. In the second experiment users browsed one web site that was aesthetically pleasing as well as usable. In the third and last experiment users browsed a highly aesthetic but not so useful website. Responses from the interviews were divided into aesthetics, emotion, likeability, expectation and usability. The results of the study were that all of these affect the overall user satisfaction but vary in prominence due to the task. In the first experiment most comments landed under aesthetics. In the second experiment, comments on usability were more frequent. In the third experiment usability as well as aesthetics were highly commented. Hence, the study suggests that aesthetics is a strong determinant when it comes to user satisfaction. (Lindegaard & Dudek, 2003)

Since it’s only recently the question of aesthetics has found a place in HCI there has not been any tools for measuring aesthetics. Lavie and Tractinsky (2004) saw the need for such a tool and hence started a process for developing a measure of HCI aesthetics for interactive products in general and for web sites in particular. The aim was to identify the constructs of web site aesthetics and also to investigate the relationship between them. Lavie and Tractinsky explored the users subjective, aesthetic perceptions of web sites and found these to consist of two dimensions. These dimensions were termed classical aesthetics and expressive aesthetics. The classical aesthetics carries notions from antiquity to the 18th century, such as clean and orderly design, pleasantness and symmetry. The other dimension holds notions of creativity, originality and fascination. A high correlation between the dimensions was found which indicates that good design balances these dimensions.

### 2.5.2 Why aesthetics matter in IT

As discussed earlier, studies have found aesthetics to be of some importance when it comes to interface design. Noam Tractinsky (2004) argues that there, apart from experiments, is enough theoretical and practical evidence to support aesthetics as an important part of interactive systems. Tractinsky considers the main evidence to be (a) the advances of technology have exceeded many users and organisations needs,
(b) our evaluation of surroundings are mainly visual and information technology is a growing part of our environment and (c) aesthetics is a basic human need.

Tractinsky suggests, with a growing body of literature supporting him, that the technical advances of information technology have exceeded both individual and organisational needs. When functionality is more than sufficient and prices of IT-products decrease, the area of competition move toward making the user experience better rather than to improve functionality. Thus, when the technology and functionality of products are equal, to make an IT-product stand out it must be made an object of emotion, fashion or visual pleasure. Tractinsky also makes a reference to the previously discussed “beautiful is good” stereotype (see 3.4.1) which holds that aesthetic perceptions of an object affect how other aspects of the object is perceived. A consequence of this may be that the visual appearance of a product influences how interaction is performed. Further Tractinsky means that when functional needs are satisfied the need for emotion, fun and visual pleasure grows stronger. Since functional needs are often in focus they are likely to be fulfilled whereas aesthetic needs are often overlooked.

2.6 Design guidelines
Knowledge of human cognitive and perceptual capabilities has provided a solid ground for formulating principles and guidelines for designing usable and aesthetically pleasing systems.

2.6.1 Usability design principles
Norman (2002) describes the most common design guidelines. These are visibility, feedback, constraints, mapping, consistency and affordances

Visibility
Important and frequently used functions should always be easy to find. In fact, with visible functions the user is more likely to understand what to do next when interacting with an object or a system. Norman (2002) uses the controls of a car to explain the concept of visibility. Indicators, warning lights and headlights are normally easy to find and hence supporting the driver in knowing how to operate the car.

Feedback
After an action, the user wants to know the effect of this action. Informing the user of this effect is feedback. Without feedback in our daily life, it would be almost impossible to carry out the simplest of tasks. Playing the piano without hearing the sound of it or drawing without seeing the lines would be most awkward. Hence, providing feedback is most essential whether it’s tactile, visual or auditive.

Constraints
Taking advantage of constraints in design means restricting the actions that can be executed by the user. An example is a jigsaw puzzle where only one piece fits a certain spot, hence restricting the actions of the user. Imagine the trouble one would have if every piece fit every spot. Constraints can be of different kinds: physical (as with the jigsaw puzzle), semantic (where the context restrict actions), cultural (as in conventions) and logical (relying on the logical layout of space or functions).
Mapping
Mapping refers to a relationship between a control and the effects of using that control. Norman (2002) discusses natural mapping which means using physical analogies and cultural standards in design. An example of natural mapping is moving a control left with the result of moving an object left. Preece et. al. (2002) uses controls of musical playing devices as an example of the difference between natural mapping and arbitrary mapping. Figure 2 illustrates this.

![Mapping](image)

*Figure 2 – Mapping (a) Natural and (b) arbitrary (Preece et. al. 2002)*

Consistency
Consistency refers to keeping related operations for achieving related tasks. This means following external conventions as for example the ones in figure 2 and also following specific internal design principles.

Affordances
Affordances are the properties of an object that give an indication of its operations. For example should a handle afford grasping and a chair afford sitting. The affordance properties decide the possible areas of use. Hence, when a design is successful the user knows how to operate an object simply by its appearance. On the other hand, when labels, instructions or pictures are necessary for simple everyday objects, the design must be considered a failure.

2.6.2 Visual design principles
Whereas the design principles described by Norman keep focus on usability, Mullet and Sano (1995) discuss communication oriented visual principles and techniques. These techniques are based on psychological phenomena and functional aesthetics found in graphic design, industrial design and architecture. In the following chapters the visual principles relevant for this project are discussed.

Elegance and simplicity
The meaning of elegance is to carefully select elements in a design with conscious decision. Simplicity involves solving a design problem in a clear and economical manner (see 2.4.2). Being strongly related it is no coincidence that both elegance and simplicity are evident in practically every timeless design. In fact, the simplicity of an elegant solution is usually striking. Simplicity is also a design principle that many other principles depend on. Thus, to increase quality of design, conceptual and formal components must be reduced to a minimum. Simplicity itself depends on the principles of unity, refinement and fitness. Unity involves ensuring that elements are perceived as a coherent whole. Refinement means keeping the users attention on vital properties of the design. Fitness involves assessing the appropriateness of a specific design. Elegance cannot, as simplicity, be reduced to a set of principles, as it often involves taste (see 2.4.2). Reducing design to its essence however usually
enhances elegance, regularizing elements (keeping a predictable a regular pattern) and letting elements have multiple roles.

**Scale, contrast and proportion**
To create harmonious designs a good relationship between scale, contrast and proportion must be accomplished. These aspects are some of the subtlest in design and they require practice. The design will always suffer if elements are too big or small, too light or dark, too prominent or indistinct. Scale refers to the size of an element relative the whole composition and other elements. Contrast is the provider of visual distinctions in the form of position, shape, texture, size, colour, orientation and movement. Both scale and contrast can be used to emphasize and differentiate elements from each other. Proportion involves balance and harmony of relations between elements. Techniques for accomplishing harmonious designs are establishing perceptual layers, sharpening visual distinctions and integrating figure and ground.

**Organisation and visual structure**
Keeping elements in a design organised and structured help the user in finding guidance to interaction. The perception of structure happens automatically and is usually one of the first impressions of a product. Hence, the structure can either support or disrupt interaction. Without good organisation the content may very well be difficult to interpret and understand. Users will however always try to find structure even where it’s not obvious. The basic principles behind perceptual organisation are discussed in chapter 2.3. Organisation and structure in interfaces can be accomplished by grouping related elements followed by the establishing of a hierarchy based on importance. The composition must also be kept balanced and revealing the relationships between elements.

**Image and representation**
Being essential for communication, images are often an obvious element of GUI design. Despite this fact, imagery is one of the least understood aspects of interfaces. First, images must follow the same principles as the whole composition and second, they must be perceptually immediate to be recognized at once. Images must also be sensitive to the conceptual, physical and cultural context in which they will be displayed. Representation is used to give a GUI meaning. The analysis of representations depends on the relationship between the representamen and its object. Three forms of this relationship can be identified; an icon, which relates to the object by resemblance, an index, which is an association not based on resemblance and a symbol, which relates to the object by convention.
3 Environmental data handling

The interfaces used in this study were created within the Volvo Logistics Pilot Project Environmental Database. To give the reader an understanding of the context in which the interfaces were designed, the following sections will provide information regarding Volvo Logistics Corporation and environmental calculations in general and the Pilot Project Environmental Database in particular.

3.1 Volvo Logistics Corporation

Volvo Logistics Corporation deliver complete supply chain solutions to customers worldwide and is the lead logistics provider for the Volvo Group. A supply chain can formally be described as a process where raw materials are manufactured into products and delivered to customers. Thus, a typical supply chain contains four parts; supply, manufacturing, distribution and consumers (Beamon, 1999). By running all parts of the logistic flow, including *inbound* (material supply), *outbound* (distribution) and packaging, VLC can offer supply chain solutions as illustrated in figure 3. (Volvo AB, 2006)

![Figure 3 – The logistic flow (Ibid.)](attachment:image.png)

3.2 Transports and environmental issues

The role of transports can hardly be overestimated. The continuous of the world depends on satisfying flows of goods and intense contact between people. Hence, without transports, welfare would be reduced to local culture and natural resources (Ingenjörsvetenskapsskolan, 1991). Good transports support economic development but the demand of transports has an obvious disadvantage: environmental damage. The main environmental issues caused by the transport sector are *air pollution* and *climate changes*. These are directly related to the burning of fuel and the transport sector is responsible for approximately 25% of the world’s total consumption of fossil fuel. Hence, it is also responsible for discharging a proportionate amount of fossil carbon dioxide, which is the main contributor to global warming. Large emissions of green house gases can have serious consequences such as drought, floods, disease and lost ecosystems. Despite technological advances, emissions of carbon dioxide are increasing with the constantly growing demand of transports. When it comes to air pollution, problems are mainly regional and law in most countries regulates harmful elements from exhaust fumes. (AB Volvo, 2002)

3.2.2 Transport work

When analysing a supply chain system an appropriate *performance measure* must be selected. A performance measure is a quantifier for *efficiency* and/or *effectiveness*. Effectiveness refers to what extent a system performs a required task and efficiency refers to the economical manner of the task performance (Beamon, 1998). Thus, it is
possible for a system to be effective but not efficient and vice versa. When analyzing and optimizing transport systems it is vital to describe the actual material flow. Duma (1999) describes the main characteristics of material flow:

- Quantity (Q)
- Distance (d)
- Time (t)

The distance (e.g. route, length) depends on the start/end point of the transhipment and the quantity is expressed in mass or volume units (e.g. kg, m$^3$). The performance of transports is usually described as work per time unit ($P = W/t$). Transport work ($W$) is an average characteristic defined by multiplying a material quantity ($Q$) with the distance ($d$) of a transportation: $W = Q \times d$. The notion of transport work is used in research on transports and infrastructure, to describe the moving of people or goods executed by a transport service (ibid.). Transport work is expressed in tonne-km per time unit (e.g. tonne-km/year, tonne-km/hour) and the notion of tonne-km is internationally accepted and used for all modes of transport (sea, road, train and air). Usually tonne-km is considered synonymous to transport work.

### 3.2.3 Emission data

Emissions refer to the discharge of harmful gases from engines via the exhaust pipe. (Swedish Road Administration, 2004). To follow up on objectives, check on compliance with requirements and to perform environmental calculations of transport alternatives, VLC perform an annual survey of suppliers. The survey includes questions regarding fuels, emissions, load factors, environmental management systems, quality management systems and Euro classes. The term Euro class refers to EU directives set to regulate exhaust emission rates. The classification starts at Euro 0 and the environmental requirements gradually sharpen with higher classifications. (Posten AB, 2005).

The format of the Environmental Survey of Carriers is a web-based questionnaire, which is sent to suppliers who provide the requested information and then submit answers. Each supplier provides information on emissions from their fleet of air, sea and train carriers. Emissions from road transports are calculated manually by the environmental co-ordinator. If needed, the answers can be modified, changed or complemented by re-entering the survey. Once the emission data is collected, it is used as a base for decision making on routes and suppliers. For this, VLC uses the EnvCalc software, which is an internally developed tool for environmental calculations.

### 3.2.4 Problems with environmental data handling

The handling of transport work and emission data at Volvo Logistics is highly inefficient and time consuming, mainly due to the lack of a supporting IT-solution. The manner in which calculations of transport work is performed involves several problems for the environmental co-ordinator, these are:

- Manual calculations of transport work
  - The environmental co-ordinator has to multiply payload (weight of goods) with distance manually on each individual shipment
- Handling of distances
  - Distances are not stored in each concerned system
  - Manual retrieval of lacking distances
Distances vary in level of accuracy
- Distances are occasionally unreliable
- Distances based on diverse principles in different databases
- Unreliable number of tonne-km due to unreliable distances

Data collection
- Several people are involved before product is finished
- Diverse appearance, vocabulary and content in statistics sent from the databases
- Unnecessary data is sent to the environmental co-ordinator
- Difficulties in over-viewing statistics

Interaction
- The environmental co-ordinator is unable to interact with relevant databases
- Numerous time consuming cut and paste operations

Exclusion
- Region North America is excluded
- The packaging process is excluded

The problems of emission data handling are not as great as the ones associated with transport work. Spotted problems are the following:

- Response frequency not as high as wanted
- Manual calculations of road emissions
- Time consuming to create new questionnaire each year
- Unnecessary involvement from external consultancy firm. A different solution might have less financial impact

3.3 Pilot Project Environmental Database

When considering the inefficiency of the current VLC environmental data handling and the fact that VLC is a global company with growing demands of environmental statistics, the need for a satisfying IT-solution is evident. To keep up with demands, from customers and authorities, uniform and effective data handling is necessary. To investigate the possibilities of a solution the environmental co-ordinator at VLC initiated the Pilot Project Environmental Database, which can be viewed as a prestudy for this thesis. The aim with the Pilot Project Environmental Database was to:

- Investigate how data on transport work could be collected, stored and retrieved from different databases within the company, in a more efficient manner than today. This included investigating the possibility of automatic (rather than manual) calculations of transport work and the inclusion of all processed and regions.
- Investigating how transporter emission data could be handled more efficiently than today. This included comparing the method of Volvo Logistics to other logistics companies.

3.3.1 FuturCalc

One of the proposed solutions of the Pilot Project Environmental Database was the creation of a new environmental database with an application program specifically designed for the environmental co-ordinator of VLC. The interfaces of this study have been designed as a suggestion for this solution, named FuturCalc. The main functions of FuturCalc are (a) the creation of environmental reports including transport emissions and transport work, (b) separate calculations of transport work
and emissions and (c) to get information on subcontractors’ vehicles and environmental activities.
4 Method
The aim with this project was to, with interfaces of a VLC environmental calculation tool, investigate the relationship between perceived usability and visual beauty. To achieve this, studies of literature was followed by the design of two user interfaces of different levels of beauty but with the same general functionality. An experiment was then performed to investigate the perceived usability of the interfaces, depending on the level of aesthetic pleasure. As opposed to previous studies of such a relationship (in which perceived usability has been investigated \textit{a priori} use), perceived usability was here tested after \textit{actual} use. In the following chapters the design process and the experiment is described in more detail.

4.1 The design process
As mentioned in previous chapters a design process is a complex and iterative procedure. Therefore, descriptions of all iterations and motivations of minor design decisions have in this description been left out. Focus are here kept on the main activities and to simplify the reading, the design process has been divided into one section regarding usability/functionality and one regarding aesthetics. In reality these processes were obviously intertwined.

4.1.1 Achieving usability
When designing the functionality and usability of the interfaces, the design process followed Löwgren and Stolterman’s (2004) five phases, as described in chapter 2.2.2. More effort was put into some phases whereas others, as for example the coordination phase, were considered less important for this particular study.

Investigation
To get a vision of the functions needed for an environmental calculation tool, it was necessary to understand the work situation of the users at Volvo Logistics Corporation. The main method used to achieve such an understanding was contextual inquiry (see 2.2.2). During the period February – April 2006, several unstructured interviews, observations, email conversations and demonstrations of current systems were held. Participants in the contextual inquiry were the environmental co-ordinator, IT-consultants and project leaders of Volvo Logistics and the Head of Corporate Citizenship at DHL Express. A summary of the information collected from the contextual inquiry can be found in appendix 1. Some information can also be found in chapter 3.

The purpose of the contextual inquiry was, apart from achieving a general understanding of the users work, to set user experience and usability goals.

Exploration
The exploration phase was not considered one of the more important phases. This was due to the fact that finding the best and most creative GUI wasn’t the purpose of the project. Hence, the usability rather than innovative creativity was put in focus. Some effort was though put into exploring user interfaces of other environmental software tools. To name a few, Volvo Logistics own emission calculation tool \textit{EnvCalc} was explored and also \textit{ACCEPT} owned by Deutsche Post and used by DHL Express (see appendix 2 and 3). To create a connection to VLC’s EnvCalc the name FuturCalc was used for the assumed new environmental calculation tool.
In the exploration phase divergence was of particular importance. The aim was to come up with as many conceptual ideas as possible (without valuing these as good or bad).

**Composition**

After the phase of divergence, the phase of convergence followed. Out of all initial ideas and concepts a final design had to be chosen. To make this choice easier and to simplify making a whole of different parts, a function analysis (as described in chapter 2.2.2) was performed. The result of the function analysis can be viewed in appendix 4. After the function analysis, the design concept considered most suitable from the previous phase was chosen to build the final interfaces.

**Evaluation**

To end the design process a lofi-prototype was created and the design was checked for compliance with the design guidelines mentioned in chapter 2.6. After this evaluation the prototype was tested on two people (one woman and one man who were both friends of the experiment leader) to discover major usability problems. As the level of actual usability was not of great importance for the study, it was considered unnecessary to find additional and random test participants. No major design changes were performed as a result of the lofi evaluation. The final designs of the interfaces can be viewed in appendix 5 and 6.

### 4.1.2 Achieving different levels of beauty

After having made decisions on the functionality of the environmental calculation tool, two interfaces with different levels of beauty were created. The main elements used in the designs were; a FuturCalc logotype, a Volvo Logistics logotype, boxes, text fields, dropdown menus, buttons and checkboxes. A comparison of some of the elements in the two interfaces can be viewed in figure 4.

![Figure 4 – Elements of interfaces](image-url)
The interface with the higher level of beauty was designed first, with help from the visual guidelines described in chapter 2.6.2 and intuition. The colour scheme (grey and blue) was chosen to fit the graphic profile of Volvo Logistics and also for a clean look, which was assumed to suit the environmental purpose of FuturCalc. When designing the first interface, balance, colour coordination and simplicity was put in focus, as was the gestalt principles of proximity, similarity and symmetry (described in chapter 2.3). Figure 5 is an example of the applied gestalt rules in the first interface. The look of the final version of the first interface can be viewed in figure 6.

**Figure 5** – Example of proximity and similarity. Objects are grouped based on similarity and closeness.

**Figure 6** – The look of final interface, Version 1.
The second interface (as can be viewed in figure 7) was created by, to a certain extent, ignoring rules of symmetry and elegance whilst maintaining the overall functionality of the system. To avoid creating a provotype, the aim with the design was to maintain some aspects of symmetry whilst ignoring others; an example of this can be viewed in figure 8 and 9. The same font, font colour and elements (with different looks) were used in both designs, to keep the usability at an assumed constant level (see the final chapter for a discussion regarding this issue). The colour scheme (orange, blue and green) of the second interface was chosen to disharmonize with the graphic profile of Volvo Logistics.

Figure 7 – The look of final interface, Version 2.
**Figure 8** – Comparison of interface versions. Version 2 (upper) and Version 1 (lower). Differences are marked with red squares.
Prior to the main experiment a test was performed to ensure that one of the interfaces was visually more attractive than the other. A total of 20 people, 9 women and 11 men with the age range of 21-29, were randomly picked at the IT-University in Gothenburg to take part in this test. They viewed the two design suggestions on a laptop and then gave their verbal opinion on which was more beautiful. To avoid ordering effects, half of the test group viewed interface version 1 first whereas the other half viewed version 2 first. As expected, version 1 was considered more attractive with 16 votes out of 20.

4.2 The experiment
To ensure that the experiment would run smoothly a pilot was held with two participants (both friends of the experiment leader) prior to the main experiment. The pilot was followed by minor changes in the tasks provided for the following participants.

4.2.1 Design
The design of the experiment was similar to the one executed by Kurosu and Kashimura in 1995 and later repeated by Tractinsky (see chapter 2.5.1). One important difference was however that the participants in this experiment were actually interacting with the systems, after which perceived usability and beauty was measured. This as opposed to the previously mentioned studies where perceived usability and beauty was tested a priori use.
The experiment was of a between-subject design. This experimental design was preferred to a within-subject design as the perceived usability of an interface may be affected by the impression of the first interface.

The participants were given 8 tasks to complete, whilst being observed and timed by the experiment leader. After finishing the tasks, participants were given a questionnaire with questions regarding the usability and look of the interface (for more information see chapter 4.2.3 on procedure). The experiment was designed so that three independent groups t-tests could be performed on the gathered data. The variables in the experiment design were:

- **Independent variables**
  - Actual usability
  - Looks of the interfaces (aesthetic conditions)

- **Dependent variables**
  - Perceived usability, measured with a rating from 1-5 in the questionnaire
  - Perceived beauty, measured with a rating from 1-5 in the questionnaire
  - Time in minutes

The reason for the inclusion of the time variable in the experiment was to detect a possible difference in actual usability, since the usability in this test was assumed to be constant.

**4.2.2 Participants**

40 students at the IT-University in Gothenburg took part in the experiment. 20 of the participants were women and 20 were men. The ages ranged from 20 to 39 years and the average age was 24.6. The participants were randomly picked from an area outside the university library. These people were chosen as it would have been too difficult finding a satisfying number of real users, meaning environmental coordinators or similar. By choosing these participants there was obviously a risk that the interface would be perceived as less usable than it would have been with real users. This risk was however not of great importance for this study as the purpose was not to assess the actual usability of the interfaces. The two groups of participants were assumed to be equally familiar with logistics, environmental calculations and handling computers.

**4.2.3 Procedure**

The experiment was performed in a quiet and secluded area at the IT-University in Gothenburg, where interruptions were unlikely to occur. The participants were first given an introduction of the experiment leader and the purpose of the experiment. Further, an explanation of relevant terms such as transport work, emissions and usability were given to the participants, which were followed by instructions on how the test would be performed. All the information was given both verbally and written (see appendix 8 to view the instructions given to participants). The participants were after the introduction allowed asking questions regarding the experiment.

After giving participants the introduction and making sure there were no questions, the participants were given a paper with 8 tasks to complete (see appendix 9 for these tasks). After having notified the experiment leader that they were ready, the participants started performing the tasks whilst being timed and observed. The interfaces were interacted with, using a 12-inch Macintosh iBook G4. The same
laptop was used for all participants. The experiment leader took notes on the participants’ mistakes during the interaction with the interfaces.

After having finished the tasks, the experiment leader noted the time of completion and the participants were given a questionnaire to fill in. The questionnaire, which can be viewed in appendix 10, included ratings of the usability, visual pleasure and general impression of the interface.

As a thank you for taking part in the experiment, participants were given apple-pie with custard.
5 Results

Three independent group t-tests have been performed on the experiment data to compare the means of variables from the two groups. The analysed dependent variables are perceived usability, aesthetic ratings and time. The t-test for perceived usability is the main test, whereas the tests for time and aesthetic ratings have been performed to make sure that the interfaces did not differ in actual usability and did differ in levels of beauty.

5.1 T-test for perceived usability

The following is an undirected t-test for the perceived usability ratings of the two independent experiment groups. The aesthetic conditions of the groups are here called high (visually pleasing) and low (less visually pleasing). Data needed for the computations can be viewed in table 1.

Table 1 – Data for perceived usability t-test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Aesthetic condition</th>
<th>Population</th>
<th>Mean</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived usability</td>
<td>high $X_1$</td>
<td>$n_1 = 20$</td>
<td>$x_1 = 4.05$</td>
<td>$s_1^2 = 0.26$</td>
</tr>
<tr>
<td>Perceived usability</td>
<td>low $X_2$</td>
<td>$n_2 = 20$</td>
<td>$x_2 = 3.3$</td>
<td>$s_2^2 = 0.33$</td>
</tr>
</tbody>
</table>

The null hypothesis $H_0$: $\mu_1 = \mu_2$ is tested against the alternative hypothesis $H_a$: $\mu_1 \neq \mu_2$. In table 2 further data for the t-test is gathered. The level of significance is set to 0.05.

Table 2 – Further data for perceived usability t-test

<table>
<thead>
<tr>
<th>Level of significance</th>
<th>$\alpha = 0.05$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees of freedom</td>
<td>$df = 38$</td>
</tr>
<tr>
<td>Critical t-value</td>
<td>$t_{cv} = \pm 2.021$</td>
</tr>
<tr>
<td>Standard error</td>
<td>$S \bar{x}_1 - \bar{x}_2 = 0.172$</td>
</tr>
<tr>
<td>Computed t-value</td>
<td>$t = 4.36$</td>
</tr>
</tbody>
</table>

Conclusion

Since the computed t-value (4.36) exceeded the critical t-value ($\pm 2.021$) the null hypothesis is rejected. Hence, there appears to be a difference in perceived usability.
depending on the level of visual beauty for the two test groups. The interface with the aesthetic condition high was perceived as more usable than the other version.

5.2 T-test for perceived beauty
The following is an undirected t-test for the perceived beauty ratings of the two independent experiment groups. The aesthetic conditions of the groups are, as in the previous test, called high (visually pleasing) and low (less visually pleasing). Data needed for the computations can be viewed in table 3.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Aesthetic condition</th>
<th>Population</th>
<th>Mean</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived beauty</td>
<td>high $X_1$</td>
<td>$n_1 = 20$</td>
<td>$\bar{x}_1 = 4.10$</td>
<td>$s_1^2 = 0.41$</td>
</tr>
<tr>
<td>Perceived beauty</td>
<td>low $X_2$</td>
<td>$n_2 = 20$</td>
<td>$\bar{x}_2 = 2.40$</td>
<td>$s_2^2 = 0.46$</td>
</tr>
</tbody>
</table>

The null hypothesis $H_0$: $\mu_1 = \mu_2$ is tested against the alternative hypothesis $H_a$: $\mu_1 \neq \mu_2$. In table 4 further data for the t-test is gathered.

<table>
<thead>
<tr>
<th>Level of significance</th>
<th>$\alpha = 0.05$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees of freedom</td>
<td>df = 38</td>
</tr>
<tr>
<td>Critical t-value</td>
<td>$t_{cv} = \pm 2.021$</td>
</tr>
<tr>
<td>Standard error</td>
<td>$S \bar{x}_1 - \bar{x}_2 = 0.21$</td>
</tr>
<tr>
<td>Computed t-value</td>
<td>$t = 8.10$</td>
</tr>
</tbody>
</table>

Conclusion
Since the computed t-value (8.10) exceeded the critical t-value ($\pm 2.021$), the null hypothesis is rejected. Hence, there appears to have been a statistically significant difference in perceived beauty for the two test groups. The first interface version was perceived as more beautiful than the second version.

5.3 T-test for actual usability (time)
The following is an undirected t-test for the measured times (in minutes) of the two independent experiment groups. The aesthetic conditions of the groups are, as in the previous two tests, called high (visually pleasing) and low (less visually pleasing). Data needed for the computations can be viewed in table 5.
Table 5 – Data for actual usability t-test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Aesthetic condition</th>
<th>Population</th>
<th>Mean</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>high ( X_1 )</td>
<td>( n_1 = 20 )</td>
<td>( \bar{x}_1 = 10.72 )</td>
<td>( s_1^2 = 5.05 )</td>
</tr>
<tr>
<td>Time</td>
<td>low ( X_2 )</td>
<td>( n_2 = 20 )</td>
<td>( \bar{x}_2 = 10.85 )</td>
<td>( s_2^2 = 3.20 )</td>
</tr>
</tbody>
</table>

The null hypothesis \( H_0: \mu_1 = \mu_2 \) is tested against the alternative hypothesis \( H_a: \mu_1 \neq \mu_2 \). In table 6 further data for the t-test is gathered.

Table 6 – Further data for actual usability t-test

<table>
<thead>
<tr>
<th>Level of significance</th>
<th>( \alpha = 0.05 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees of freedom</td>
<td>( df = 38 )</td>
</tr>
<tr>
<td>Critical t-value</td>
<td>( t_c = \pm 2.021 )</td>
</tr>
<tr>
<td>Standard error</td>
<td>( S \bar{x}_1 - \bar{x}_2 = 0.64 )</td>
</tr>
<tr>
<td>Computed t-value</td>
<td>( t = -0.20 )</td>
</tr>
</tbody>
</table>

Conclusion
Since the computed t-value (-0.20) did not exceed the critical t-value (± 2.021), the null hypothesis is not rejected. Hence, there appears to have been no difference in actual usability for the two test groups.

5.4 General impression of the interfaces
The last question of the questionnaire given to experiment participants regarded general impression of the interface. Even though the experiment groups ratings of beauty and usability differed (as shown by the statistical tests) the comments regarding general impression of the interfaces were similar in both groups. In the following two sections a summary of the comments given on usability and appearance of the interfaces is presented.

5.4.1 Comments on usability and aesthetics
The following are comments about the functionality and usability of the interfaces. Generally the comments on usability were positive but some problems were identified and these are listed below.
Environmental knowledge
Several comments regarded difficulties in understanding the environmental terms such as transport work and emission data. Many participants assumed that if they had been familiar with the terminology they would have rated usability higher.

Language
The information given to participants prior to the experiment, text in the interfaces, tasks to perform and the questionnaire were all written in English (except the verbal introduction). The reason for this was the corporate language of Volvo Logistics, which is English. Instead of translating the material it was easier to use English from the start and it was assumed that the participants would have equal knowledge of the English language. However, some participants admitted to have language difficulties and when the experiment was performed it became clear that the English skills of the participants varied and that this affected how long it took them to complete the tasks.

Create new report
Almost all participants had problems with creating a new environmental report. Only 1 participant interacted with the system without making a mistake on this task. As can be seen in figure 10, the interfaces had drop-down menus for selecting common environmental reports and dates. The correct interaction was here to make a selection from the drop-down menus and press Choose if one wanted to choose a common report. If one wanted to create a new report, only the Create new button had to be clicked (without selecting anything in the menus). 39 participants made an unnecessary choice in the menus before clicking Create new. Hence, the Create new button should be placed differently and be made more prominent.

![Figure 10 – The create new button](image)

Cancel and ok buttons
Two participants commented that they’d almost pressed a Cancel-button (to the left) instead of an Ok-button (to the right) since these are placed oppositely in a Microsoft Windows environment (see figure 9).

Utility
Several participants commented the general utility of the environmental calculation tool; “it seems like a good thing to have a tool for calculating emissions instead of manually calculating them”.

Navigation
When it came to the general navigation of the system most comments were positive but a few difficulties were encountered. For example did the system lack a way to navigate backwards if one made a mistake. Further, the main tabs were unclickable once entered.

Appearance
The most frequent comment on appearance regarded simplicity. Most participants appreciated the simple design of both the interfaces. Further, the colours (blue and white) of the first interface were perceived as suitable for an environmental calculation tool as they were associated with concepts like freshness, air and clean. Nobody commented on the colour scheme of the second interface.

5.5 Factors affecting the results
As it seems, once having executed a study it’s easy to point out “obvious” mistakes and hence, become a victim of hindsight bias. Anyhow, in the following sections factors that may have affected the results are discussed.

5.5.2 Participants
The actual level of usability was not an issue in this study but it is still interesting to consider whether the results would have been affected by having real users as participants (real referring to employees working with environmental issues at Volvo Logistics Corporation). Since the participants were unfamiliar with the functions and concepts of FuturCalc their general impression of the interfaces may have been more affected by appearance than real users impressions would have been.

5.5.3 Conceptual confusion
Even though the concept of usability was explained to participants in the information given prior to the experiment (see appendix 8), it seems this explanation was not clear enough. When being asked about usability a few participants appeared to mistake this concept with general utility of the environmental calculation tool. Hence, they rated usability as high since “it seemed like a good thing to have a tool to calculate emissions instead of manually calculating them”. Obviously this confusion may have affected the results of the study.
6 Discussion

The results of the experiment were expected; participants perceived the better looking interface as more usable whereas actual usability appears to have been constant. Previously mentioned phenomena such as the “beautiful is good”-stereotype (see chapter 2.4.4) can help to explain these results. Further, the halo effect (which is the tendency to impute consistency) may be part of the explanation. If this is the case, experiment participants assumed that the evaluation of one characteristic (in this case visual attractiveness) would hold in other areas (in this case usability) as well. The halo effect has mainly been used in social psychology to explain for example why good-looking people are assumed to have other good qualities but one can assume that this effect is valid for objects as well.

Besides these possible explanations for the results of the study, there are certain other relevant issues to discuss. Hence, the following chapters will offer discussions regarding the beauty and usability of the experiment interfaces as well as suggestions for further research and experiment critique.

6.1 Aesthetics

In chapter 2.4, the notion of disinterest was introduced and described as the perception of an object for it’s own sake. This also includes separating an object from its cultural context and by doing so, engaging in an aesthetic experience. It is interesting to discuss whether an interface of an environmental calculation tool can evoke an aesthetic experience? Since such a tool has a purpose beyond being visually pleasing it may be difficult to, as a user, separate a possible aesthetic experience from cognitive experiences. As opposed to art, which usually have no purpose other than affecting senses and emotions, it may be impossible to separate the experience of visual attractiveness of software interfaces from its context. Hence, it is reasonable to believe that the visual assessment of an interface has more to do with appropriateness and expectations rather than attractiveness and beauty. For example may the expectations of a computer game differ greatly from the expectations of an environmental calculation tool, which could lead to different aesthetic evaluations of the same visual content.

6.1.1 Beauty

The aim with this study was to answer whether visual beauty would affect perceived usability in a positive direction. The statistical analysis of the gathered data resulted in a rejected null hypothesis; hence the conclusion was that visual beauty does affect perceived usability. The question is however whether beauty was ever in the picture since it remains unclear whether any of the interfaces were actually perceived as beautiful. When designing something, the only judgement to rely on for beauty assessments is your own, which may be based on intuition and/or experience and be correct or incorrect. There is however no guarantee that the design will be perceived as beautiful by others.

In this study a pre-test was performed to determine which one of the two interfaces looked better but a question regarding beauty was never asked. Hence, it’s not necessarily so that any of the interfaces was perceived as beautiful. As discussed in chapter 2.4.1, beauty can be described as the qualities that give pleasure to the senses, and a spontaneous thought is that the two interfaces did probably not offer much pleasure for the senses of the experiment participants.
The general idea of what is considered beautiful is not culture independent and has changed many times during the history of human kind. Hence, as one cannot know beforehand what others will perceive as beautiful, one has to rely on guidelines. In this study, knowledge of visual perception and guidelines of visual structure were used in the design process. In chapter 2.3 the Gestalt principles are described, and as mentioned previously, this approach aims to explore holistic processes involved with perceiving structure and do not claim to deal with beauty and visual pleasure. However, there seems to be a strong connection between visual structure and beauty. It may be so that something beautiful is always visually structured whilst something visually structured is not necessarily beautiful.

6.2 Usability

The results of the experiment showed that the two interfaces differed when it came to perceived usability. This result was in one way expected (due to knowledge of for example the halo effect) and in another way not expected. The reason for expecting a different result was the lack of complexity in the environmental calculation tool functions. When designing the interfaces some thought was put into whether the functionality of the tool was too simple for detecting a difference in perceived usability. Fortunately this proved not to be the case. It is however interesting to discuss whether complexity can affect the results of an experiment like the one performed. If one imagines a system that contains only one button (and only one function), would there still be a difference in perceived usability depending on the beauty of the button? It’s hard to imagine that would be the case. Hence, it may be so that beauty affects perceived usability only if the complexity reaches a certain level. Another interesting aspect to consider is whether different levels of actual usability are equally sensitive to beauty when it comes to measurements of perceived usability?

6.2.1 Can beauty affect usability?

In the performed experiment, actual usability was assumed to remain constant for the two interfaces and the statistical analysis of the time variable showed that this was the case. The question is however whether beauty can affect usability? There seems to be no doubt that beauty affects the first and general impression of for example an object or a person. Also, beauty will affect further assumptions about this object or person. However, it may be that actual usability (as opposed to perceived usability) is affected by matters of visual structure, colour combinations and simplicity rather than beauty.

In chapter 2.5 Donald Norman’s (2004) ideas of emotional design were discussed. Norman meant that objects, people, actions, etc. causes emotions which affect how the mind works. This theory supports a hypothesis stating that beauty may affect actual usability. Hence, if something was beautiful enough to cause a positive emotion, usability might be affected. As discussed earlier, beauty may not have been present in this study and the interfaces probably did not cause any specific emotions, which can explain why usability was not affected in this particular case.

6.3 Further research

As already discussed, it is questionable whether the participants perceived any of the experiment interfaces as beautiful. It would however be interesting to further investigate whether it is meaningful to talk about beauty when it comes to interfaces
of the kind used in this study. Further, it would be of interest to investigate and compare visual structure and perceptual rules to what is considered beautiful.

**Gender**
In the pre-test of this study, men and women were asked which one of the interfaces they preferred visually. 4 participants out of 20 preferred the second interface version and 3 of these were men. In the main experiment the average aesthetic ratings of women were 3.45 and 3.05 for men. In this study no statistical analysis have been performed to compare the results of men and women but it may be of interest to further investigate this aspect. There may be a difference between men and women when it comes to aesthetic preferences and also in how much appearance will affect perceived usability and general impression.

**6.4 Final thoughts**
The main result of this study was that whilst keeping actual usability of two interfaces constant, the visually more attractive interface was perceived as more usable. These results indicate that usability is subordinate to visual attractiveness in the human mind. When looking at these results from a business perspective, they suggest that usability can be neglected altogether. As long as the object in question is beautiful customers will be satisfied anyway? Maybe this is the case. The question is however whether the results from this study can be generalised to other areas where usability is more crucial, as in for example a car or cockpit. However, there is little or no doubt that beauty matter a great deal in peoples lives and it would be interesting to find out just how big a role it plays in the human mind.
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Statistiska Centralbyråns
http://www.scb.se

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www.volvo.com/logistics

Volvo på väg – Transportmagasinet från Volvo Lastvagnar i Sverige
http://www.volvopavag.com
8 Appendix

Appendix 1 - Environmental calculations at VLC

Transport work
Transport work data is collected quarterly by the environmental co-ordinator at Volvo Logistics on demand from Volvo Truck Corporation (VTC). Data on transport work is stored and retrieved from several different databases within the company, as illustrated in figure 11. For the inbound process, data is stored in three different databases depending on business region. Region Europe as well as Region Scandinavia and Overseas use the same system for the outbound process whereas Region North America uses various systems depending on current supplier. For the packaging process, one system is used for all business regions.

Figure 11 – Storage of transport work data

Necessary data and data flow
The data on transport work is not stored directly in the databases. That is, most of the data needed to make calculations on transport work possible is stored in the data systems, as opposed to actual transport work data. To perform the requested calculations, the following data on each individual shipment in a certain time span is needed:

• Supplier of goods
• Receiver of goods
• Location (from)
• Location (to)
• Payload (goods weight in kg)
• Transporter
• Mode of transport (sea, road, air or train)
• Date
• Market
• Distance (route in km)

The environmental co-ordinator does not have access to the databases needed to retrieve relevant data; hence he or she is not able to interact with the databases directly but has to order statistics from the systems as illustrated below. The environmental co-ordinator has to contact three different people to receive statistics (in the form of Excel documents) from the relevant systems TIR (Transport
Informations Rutiner), A4D (Application for Distribution) and FADS (Forwarding Administration System). Excluded from this process are Region North America and the packaging process (see figure 12).

Figure 12 – Transport work data flow

Data in current databases
As already mentioned, data on each individual shipment is necessary to calculate transport work. Most of the data needed for the calculations is available in the current databases and the format of the data is mainly the same in all systems. Table 7 illustrates the availability and format of relevant data in the systems currently included in the transport work calculations.

Table 7 – Data availability in current databases

<table>
<thead>
<tr>
<th>DATA</th>
<th>TIR</th>
<th>A4D</th>
<th>FADS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sender</td>
<td>Supplier name</td>
<td>Factory name</td>
<td>Supplier name</td>
</tr>
<tr>
<td>Receiver</td>
<td>Factory name</td>
<td>Customer name</td>
<td>Factory name</td>
</tr>
<tr>
<td>Location (from)</td>
<td>Name</td>
<td>Code</td>
<td>Name</td>
</tr>
<tr>
<td>Location (to)</td>
<td>Name</td>
<td>Code</td>
<td>Name</td>
</tr>
<tr>
<td>Payload</td>
<td>Weight in kg</td>
<td>Weight in kg</td>
<td>Weight in kg</td>
</tr>
<tr>
<td>Transporter</td>
<td>Name</td>
<td>Name</td>
<td>Name</td>
</tr>
<tr>
<td>Transport mode</td>
<td>Road, air, sea, train, CKD</td>
<td>Road, air, sea, train</td>
<td>Road, air, sea, train</td>
</tr>
<tr>
<td>Date</td>
<td>Date of shipment</td>
<td>Date of shipment</td>
<td>Date of shipment</td>
</tr>
<tr>
<td>Market</td>
<td>Country of trade</td>
<td>Country of trade</td>
<td>Country of trade</td>
</tr>
<tr>
<td>Distance</td>
<td>Not available</td>
<td>Available</td>
<td>Available</td>
</tr>
</tbody>
</table>

There is however no uniform and global standard for the format of the data which results in some irregularities. For instance is the data on locations (from/to) stored as location codes, names or postcodes. The main part of the location codes follow UN standard but the use of the codes within the company is not uniform. The codes can be divided into three levels of accuracy:

- **Country** - SE for Sweden
- **City** – GOT for Gothenburg
- **Location** – OOO1 for specific location
The use of these codes varies. The outbound process uses all nine characters in the system A4D, whereas others use only five or none at all.

Further there are irregularities when it comes to distances. Distance and payload are obviously essential for calculating transport work but the data on distances are somewhat unreliable and sometimes even nonexistent. Distances are stored in A4D as well as FADS but the accuracy of these is questionable. Distances stored for the outbound process (A4D) are based on a system of zones and the different modes of transport are fully ignored. RE - inbound keeps distances in a similar manner. The statistics ordered from FADS and A4D by the environmental co-ordinator usually lacks distances on certain routes, due to poor updating on new routes. In TIR distances are not stored at all. CKD is considered a transport mode for RSO inbound, that is in TIR. CKD (Completely Knocked Down) is a term used by VTC for trucks sold as parts, as opposed to CBU (Completely Built Up). In the statistics for RE inbound (FADS) CKD is not included. The lack of a common vocabulary is also evident in the different systems.

Statistics
The statistics ordered from FADS, TIR and A4D are sent to the environmental co-ordinator as excel documents. The look of these documents is however not uniform. Neither the column names nor the number of columns are equal. As mentioned earlier, data on ten different variables are required for the transport work calculations. Thus, the statistics include several variables of no use for the environmental co-ordinator. The RSO inbound excel document drawn from TIR consists of 40 columns filled with information since the environmental co-ordinator only requires 10 variables, 30 columns with irrelevant data could be discarded. Further, the retrieval of data from TIR is not so easily managed. To achieve the necessary excel document several inefficient and time consuming ”cut and paste” operations are required. Moreover, the variable payload cannot be retrieved without manual calculation.

Future system changes
A new global Supply Chain Management System for the inbound process at Volvo Logistics is currently being developed. The new system, ATLAS (Advanced Transport Logistics for Automotive Supply), will include approximately 4000 suppliers and 200 carriers within the inbound process. This new system will obviously change the way data on transport work is stored for the inbound process and the estimated time for full implementation in all regions is Q2 2007. The long term plan and hope of the environmental co-ordinator at VLC is to include all regions and processes in the transport work statistics. The inclusion of RNA inbound should not be a problem when ATLAS is fully up and running. Including RNA outbound is however somewhat more complicated since various systems are used within the region. The inclusion of RNA outbound is probably not realistic unless the system (A4D) used by the other regions is introduced here as well. As in the other systems, most of the required data is available in the systems. The only problem seems to be distances that are not stored in V-EMS. Work on a table of distances for ATLAS has begun (based on longitude/latitude co-ordinates). This table will however take 1-2 years to finish and it is still not sure whether how and if distances will be stored in ATLAS.

Emissions
Emissions refer to the discharge of harmful gases from engines via the exhaust pipe. In addition to these gases, particles from tires, brakes and roads are usually considered part of emissions as well (Swedish Road Administration, 2004). The emission rate and composition depend on a combination of fuel and engine type. The main part of vehicle fuels is today liquid and fossil. Yet, the environmental properties of these fuels can vary greatly depending on the area of use. Further, additives of different sorts also affect the environmental properties of fuels. One example is lead that until 1994 was added to petrol in Sweden. Another example is heavy engines (mainly in ships), for which oils with high sulphur content is still frequently used (Bilindustriföreningen, 1995).

Survey of suppliers
To follow up on objectives, check on compliance with requirements and to perform environmental calculations of transport alternatives, employees of the core values department perform a survey of suppliers each year. This annual survey includes questions regarding fuels, emissions, load factors, environmental management system, quality management system (the only approved quality management system is ISO 9001:2000) and Euro class. The term Euro class refers to the EU directives set to regulate exhaust emission rates. The classification starts at Euro 0 and the environmental requirements gradually sharpens with higher classifications. For example are less emissions allowed with Euro 4 than with Euro 0 (Posten AB, 2005). Euro 4 will be introduced in the autumn of 2006 and the next stage (Euro 5) in 2009 (AB Volvo, 2005).

When executing the survey of suppliers, the following data is needed for each supplier when it comes to emissions:

- Fleet sheet
- For road transports:
  - Fuel type
  - Fuel consumption
  - Goods weight
  - Euro class
  - Load factor
  - Standard values
- For train, air and sea transports:
  - Emissions of carbon dioxide, nitrogen oxides and particle matters
  - Energy
- For sea transports:
  - Emissions of sulphur

Each supplier provides information on emissions from their fleet of air, sea and train carriers. Emissions from road transports are however handled differently. These are calculated manually by the environmental co-ordinator, using information about vehicles provided by the suppliers and standard values from AB Svenska Shell. For a graphical overview of needed data, see figure 13.
Web questionnaire

The format of the Volvo Logistics Environmental Survey of Carriers is a web-based questionnaire, which is developed in cooperation with consultants from Infokus Business Intelligence AB. With this questionnaire, information on management systems as well as vehicles is collected. According to Sjöberg (2006) VLC is in this cooperation responsible for:

- Supplying addresses and questions
- Invitations of suppliers to the survey
- Reminders to non-responding suppliers
- Template for road emission calculations
- Participation at validation meeting
- Internal reporting
- Feedback for suppliers

Infokus Business Intelligence is on the other hand responsible for:

- Creating the web page and login for suppliers
- Listing responding suppliers
- Basis for validation meeting
- Continuously answering questions
- Final report

Once finished, the web-questionnaire is sent to suppliers who provide the requested information and then submit answers. Infokus Business Intelligence handles all technological difficulties. The suppliers can, if needed, view a list of approved environmental management systems, followed by the upload of either a copy of a certificate or an action plan. The same actions are taken when it comes to quality management systems. The answers are submitted (saved) when a “Save answers” – button is clicked. If needed, the answers can be modified, changed or
complemented by re-entering the survey and clicking the "Save answers" – button again. Further, non-electronic information can be submitted by post to Infokus Business Intelligence. Figure 14 shows the look of the 2004 questionnaire.

Figure 14 – Web-based supplier survey questionnaire
Appendix 2 - DHL Express and ACCEPT

DHL is the leading logistics and express provider in the world with services of air and road express as well as road, air, sea and rail freight. With a fleet of 75,000 vehicles and 160 million transports, 2 million customers are served yearly. DHL Express is owned by Deutsche Post World Net who views environmental protection as part of the corporate strategy. Deutsche Post also owns ACCEPT (Automatic Customer Calculation of Environmental Performance Tool) which is the environmental calculation tool used by DHL Express. The company has been testing a pilot version of the system since January 2006 and the aim is for ACCEPT to be fully implemented by January 2007. (Respect, 2004)

All the information in the following chapter, unless stated differently, has been provided by Ulf Hammarberg (Head of Corporate Citizenship) at DHL Express. All data in user interface screen dumps are fictional.

The general principal behind ACCEPT is illustrated in figure 15. The input of the system is (a) data on shipments (locations, filling rate, payload, distance, supplier and receiver), (b) an environmental index given to each supplier and (c) the environmental standards of NTM. The output is an emission report.

![Diagram](image)

**Figure 15 – The principle of the ACCEPT Environmental Calculation tool (Demonstration by Ulf Hammarberg, DHL)**

Creating an emission report in ACCEPT can be done with little effort. As can be seen in figure 16, the user selects a customer from a drop down menu or searches for customers by name or number. The user may select and add as many customers as pleased to a list and the emission report will be created for these. A time period and type of report is then chosen. By clicking the "report"-button a report is created. The emission report includes:

- Customer and time period (as chosen)
• Number of shipments
• Total weight
• Total distance
• Energy consumption
  - Fossil
  - Renewable
  - Nuclear
  - Total
• Emissions from customers cargo
  - Fossil CO$_2$
  - Total CO$_2$
  - NO$_x$
  - HC
  - CH$_4$
  - CO
  - PM
  - SO$_2$
• Transport work, tonne-km

As with any environmental calculation tool, the output from ACCEPT will be of the same quality as the input data. Hence, if the input data is reliable so will the output data be and vice versa. For DHL Express the input data is very reliable in parts of the world and in others not so reliable. The shipment data is the problem and especially distances can vary in accuracy. The data used in ACCEPT is however not based on templates, as opposed to many other environmental calculation tools, which makes it somewhat more reliable.

An important part of the ACCEPT concept is the environmental index. This was established in Sweden for all regular subcontractors and the plan is for other Nordic
countries to implement it as well. The environmental index is based on a register of 130 road carriers providing services under the DHL brand. The register includes information of the environmental activities of the subcontractor, such as ecodriving, environmental certificates, projects, education, follow up on fuel consumption and recycling. The register also includes information regarding the vehicles of the subcontractors such as truck models, engines, tyres, heating/cooling, and relevant equipment (see figure 17). (Respect, 2004)

The subcontractors are given points on their environmental activities and vehicles. These points are then aggregated in an index which is used in ACCEPT to guide future environmental decisions. The demands on environmental index set by DHL Express are raised yearly. The subcontractors have to update the information on vehicles and environmental activities when needed.

When it comes to usability, the ACCEPT user interface measures up. The main functions are clearly visible and the concept behind the software is easily understood. Interaction is straightforward and no obvious disruptions are apparent. The interface is however not characterized by creative innovations. This is not necessarily a disadvantage considering the purpose of the software. One might consider making the interface somewhat more engaging though. With a more appealing interface, it could function as an incentive for using the software. The usability of the interface used by subcontractors to update their data has not been investigated.

At first glance, ACCEPT appears to be a good solution for Volvo Logistics Corporation. As already mentioned, the fundamental principle behind ACCEPT is
easily grasped, the user interface supports effective interaction and emission reports can be created effortlessly. However, when looking closer at ACCEPT the same problems encountered with VLC’s current systems, are also encountered with ACCEPT. The main problem is validating input data and especially shipment data. Hence, the use of ACCEPT would save time for the environmental co-ordinator but since the problem with distances remain, the main issue would not be resolved. However, if the problem with distances would be solved elsewhere, ACCEPT appears to be an excellent tool for the environmental co-ordinator.

Another advantage with ACCEPT is that both emission data and transport work data is included in reports. As I see it, it is preferable to keep one consistent and supportive IT-solution for all environmental calculations as opposed to different tools for different data. Since different customers may require different statistics and calculations, the aim with ACCEPT is to keep as much relevant information on vehicles and subcontractors as possible. This appears to be an advantage for VLC as there may be different needs and demands in the future. One can also imagine the environmental co-ordinator wanting/needing information on a certain subcontractor without wanting to create an emission report which is obviously possible with the ACCEPT solution. An option for VLC is obviously to create their own version of ACCEPT.
Appendix 3 - EnvCalc (tool for environmental calculations)

Emission data is collected from subcontractors and then used to perform environmental calculations on different transport alternatives. In 2005 a new tool for performing environmental calculations was launched at VLC (see figure 18). This tool, the EnvCalc software, was developed with the purpose to ensure an appropriate base for decision making on routes and suppliers. Further, another aim was to integrate environmental concern in the whole organisation.

![Diagram of EnvCalc tool](image)

**Figure 18 – Environmental calculations using EnvCalc (Sjöberg & Carlsson, 2005)**

The EnvCalc tool is used whenever there is a new logistics system or changes to an existing one have been executed. Data on transported goods in kg, distance in km and mode of transport is the input from the user. Once this data is processed the output is the level of carbon dioxide (CO₂), nitrogen oxides (NOx), sulphur dioxide (SO₂), particle matters (PM) and ELU (Environmental Load Unit). ELU is a theoretical value used to determine the environmental impact of a process or product (Volvo på väg, 2006). The principle behind this value is that each product or process is given an ELU based on an estimation of its impact in the following areas:

- Biological multitude
- Health
- Biological ability of reproduction
- Natural resources
- Aesthetic values

Included in the EnvCalc tool is a table of distances in which mode of transport is considered. This table was specially designed for the environmental calculations but does unfortunately not contain all relations needed.
## Appendix 4 - Function analysis

<table>
<thead>
<tr>
<th>Function</th>
<th>Classification</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic transport work calculations</td>
<td>N</td>
<td>The main function, basic concept of the system</td>
</tr>
<tr>
<td>Automatic emission calculations</td>
<td>N</td>
<td>The main function, basic concept of the system</td>
</tr>
<tr>
<td>Save common search alternatives</td>
<td>D</td>
<td>Save time by saving frequent search alternatives</td>
</tr>
<tr>
<td>Printable reports</td>
<td>N</td>
<td>Create layout for printer friendly reports of data and statistics</td>
</tr>
<tr>
<td>Different search alternatives</td>
<td>N</td>
<td>Possibility to search using codes, names and so on</td>
</tr>
<tr>
<td>Statistics and diagrams</td>
<td>D</td>
<td>Allow data to be presented as statistics and diagrams of choice</td>
</tr>
<tr>
<td>Retrieval of various data</td>
<td>N</td>
<td>Every type of stored data should be available for retrieval</td>
</tr>
<tr>
<td>Comparisons of data</td>
<td>D</td>
<td>Simple way of comparing data</td>
</tr>
<tr>
<td>Lists</td>
<td>U</td>
<td>Listing data</td>
</tr>
<tr>
<td>View original data</td>
<td>U</td>
<td>Allow the user to study original shipment data</td>
</tr>
<tr>
<td>Choice of different report layouts</td>
<td>D</td>
<td>Allow the user to choose layouts for saving and printing reports</td>
</tr>
<tr>
<td>Choice of different report formats</td>
<td>D</td>
<td>Allow the user to choose formats for saving and printing reports</td>
</tr>
<tr>
<td>Feature</td>
<td>N / D</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>-------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Update data</td>
<td>N</td>
<td>User or system administrator (?) must update stored data on a regular basis</td>
</tr>
<tr>
<td>Add comments</td>
<td>D</td>
<td>Allow the user to add comments to statistics, diagrams and reports</td>
</tr>
</tbody>
</table>

N = Necessary  
D = Desirable  
U = Unnecessary
Appendix 5 - Final design of first interface
Appendix 6 - Final design of second interface
Appendix 7 - Information to experiment participants

As part of a cognitive science masters project, you will be testing a prototype for an environmental calculation tool called FuturCalc, which is developed for Volvo Logistics Corporation. The main functions of FuturCalc are (a) the creation of environmental reports including transport emissions and transport work, (b) separate calculations of transport work and emissions and (c) to get information on subcontractors vehicles and environmental activities. Transport work is a performance measure used by the transport sector to describe the quality of the service and is calculated by multiplying distance and weight of the goods.

The purpose of this test is to evaluate the usability of the prototype interface. Usability is the extent to which a product can be used to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context. To evaluate the usability, you will be given 8 tasks to complete, which are followed by a questionnaire with questions regarding the usability of the interface. The experiment leader will observe you during your task performing and also time you. During the task execution, questions about the interface will not be answered unless any technological problems are encountered.

You will remain anonymous throughout the experiment.

Thank you for participating!
Appendix 8 - Tasks for participants

1. Find out whether the subcontractor Schenker engages in Ecodriving. Do they?
   Yes □   No □

2. Print the information on Schenker.

3. Cancel printing.

4. Find out the load factor of the Schenker vehicle Volvo V40, CBE 783.
   The load factor is: _________

5. Create a diagram where the following transport work data is compared:

   a. Subcontractor DanCargo
      All regions and suppliers
      The Inbound process
      Customer Ford
      Jan 1999 – Mar 2004

   b. Subcontractor GreenCargo
      All processes and customers
      Region RSO
      Supplier Nokian

6. Create a new report for DHL Express from Jan 1999 – Jan 2000, with transport work and all emissions included.

7. Create yet another report with the same content as in the previous task. This time you should however use the already saved common reports.

   The emissions of CO₂: _________
Appendix 9 - Questionnaire

This questionnaire is a tool to evaluate how usable you perceived the user interface you've just tested. Please answer the following questions.

Gender:

Male ☐ Female ☐

Age:

________ years

Usability:
On a scale from 1-5, how usable (e.g. effective, simple to use) did you find the user interface? 5 being the most usable.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
not usable highly usable

Appearance:
On a scale from 1-5, how visually pleasing did you find the user interface? 5 being the most pleasing.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
not pleasing highly pleasing

General impression:
Please describe your general impression of the interface (for example regarding looks, content and first impression).

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Your contribution is most appreciated.
Thank you!
**Publications title**
Usability and Aesthetics – is beautiful more usable?

**Author**
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**Abstract**
When discussing matters of usability, focus is usually kept on functionality whilst other aspects, such as aesthetics, are neglected. Discussions of aesthetics are on the other hand traditionally kept within the area of fine arts. Considering that both usability and aesthetics are of big importance in people’s lives, it is astonishing to find that their relationship has not been fully explored. Therefore, the purpose of this study was to, with interfaces of a Volvo Logistics environmental calculation tool, explore whether aesthetics (in the form of visual beauty) would affect the perceived usability of a system. Hence, the question of research has been whether a visually attractive user interface will be perceived as more usable than a less attractive one when usability/functionality is kept constant? (Or in more general terms; is beautiful more usable?)

To achieve this, two interfaces with the same functionality but with different levels of visual beauty were designed and used in an experiment where participants rated perceived usability and appearance. The results of the experiment were expected; participants perceived the better looking interface as more usable whereas actual usability appears to have been constant.

**Keywords**
Usability, Aesthetics, Beauty, Functionality.