TOOLS FOR BALANCING DESIGN:
ANALYSIS AND EVALUATION METHODS FOR RESTRICTED WORKSPACES

A Thesis

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the Degree Master of Fine Arts in the
Graduate School of The Ohio State University

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A balanced design bridges the barriers between the user, the task objectives and the environment, within the design itself and without. Such a design creates a connection between these elements rather than constructing artificial barriers that act as gates or walls between them.

This study begins by laying a groundwork with concerns and matters of design. These concerns must be addressed and incorporated into any design, and so, must be the foundation for any means or tools to analyze or evaluate design. But until now there has been no tool or scheme that evaluates the appropriateness of designs for their users, task objectives, and environments. In order to solve this problem, with reference to prior studies from other fields related to design and by incorporating research made in the psychology of perception, this thesis seeks to develop methods to aid in understanding and gauging designs. Using design semantics, perception, and ergonomics these methods may help in creating tools for analyzing and evaluating tight workspaces as the focus of this thesis.

Application of the developed tools within this study illustrates the relationships between user, task, and space, and in doing so, designs become more tangible, comprehensible, and easier to communicate. The emphasis of this work lies in examining non-physical factors influencing the user's workability, in order to enhance principles of design semantics by developing a natural approach to designing objects and spaces, thereby creating a balanced design.
DEDICATION

Für meine Ma.
(For my mother.)
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Above all, I wish to thank my friends and family who supported me throughout this time with unbreakable friendship and great trust.
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INTRODUCTION

Design is a discipline that is not easily measured or gauged. There are neither mathematical formulas nor dictionaries that may serve as guides. More often than not, design has been seen rather subjectively; it is either appreciated or not. But what makes a good design a good design?

In this study I suggest a good design is one that is balanced; that supports usability, workability, and productivity; a design that motivates, is safe, and appealing at the same time; a design that is intuitively understood; a design that is made with consideration to all circumstances and is adapted where necessary. A good design or a balanced design bridges the user, the task, and the environment and makes things work by being the balancing factor between the predictable and the unpredictable. A good design should strike a balance between stimulation and stress.

In his book, The Hidden Dimensions, Edward T. Hall made an interesting point:

"In America, the conventional idea of the space needed by office employees is restricted to the actual space required to do the job. Anything beyond the minimum requirement is usually regarded as 'frill'. The concept that there may be additional requirements is resisted, at least in part because of the American's mistrust of subjective feelings as a source of data."

Even though this book was published almost 40 years ago, in 1966, this statement that it makes is still applicable. Feelings, or sensory and emotional reactions, are still perceived as problematic source of data, though perhaps an important one, because
they are so difficult to quantify or measure. But this is where design may precisely be needed in connecting the measurable with the immeasurable.

Many studies have been developed in the fields of ergonomics, of human factors, and of human centered design. Notwithstanding these prior studies, the purpose of this project is to attempt to understand especially non-physical factors influencing the interaction and the design of spatially restricted work environments. The greatest challenges in designing these spaces lie in the ability to embed all afforded information and to provide required objects for the particular circumstances without stressing the user.

The analysis and evaluation of working processes, and therein the relationship between the user, the task, and the environment, will be of basic concern for this study, with emphasis lying in the environmental impact on the user's mental performance, that is the users' emotions and resulting psychological comfort. The aim is to uncover imbalances within the design in order to develop a more inherent and intuitive design application, creating a design that is based on the user's natural understanding of the objects. To accomplish this, the environment's psychological impact on the user has to be analyzed, along with the user's ability to act and react under the particular given circumstances. The relationships between the user, the task and the environment have to be evaluated to determine whether the design has to be made more intuitively understandable and usable or not.

I begin by suggesting the concerns and matters of design, and follow with a categorization of work spaces by the development of an analysis design tool. Then, applying methods to apprehend valuable information about the work spaces themselves and the users' workability within their environments, this study demonstrates an approach in evaluating and gauging tight workspace designs.
2.0 MATTERS OF DESIGN

What are the concerns and matters of design? More often than not, people have no idea about the profession of design. The purpose of design as an occupation often eludes the average person, and the common assumption is that a designer's responsibility lies in making things look nice and appealing. The problem is that designers are not in general working alone, but hand in hand with others in various disciplines. In many companies designers are the last to be asked to join in the development process for a product or any other manufactured good. Trying to find a definition for design by referring to a standard dictionary is, unfortunately, not helpful, as it does not match the designers' job description. The official definition of design found in Webster's Universal Unabridged Dictionary is the following:

\textit{design:}
\begin{enumerate}
\item a plan; scheme; project
\item purpose; intention; aim
\item a thing planned for or outcome aimed at.
\item a working out by plan; as, do we find a 'design' in history.
\item a secret or sinister scheme (often with on or upon); as, he has 'designs' on her property.
\item a plan or sketch to work from; a pattern; as, the 'design' for a house
\item the art of making designs or patterns.
\item the arrangement of parts, details, form, color, etc., especially so as to produce a complete and artistic unit, artistic invention; as, the 'design' for a rug.
\item a finished artistic work.
\end{enumerate}
As a designer, to look up the term design in a dictionary is not satisfying. It gives not quite a correct answer for design as a profession. A designer’s work is more than giving color and shape to forms, or inventing a pattern, and it is not to be seen as art.

The design profession basically evolved out of craftsmanship, engineering, and, to a degree, architecture. Whereas these disciplines have always had their own position in history, design is still seen as merely ‘artsy’, helping to make things look prettier. This common misjudgment is not only caused by these other disciplines underestimating the power of design, but also by design as a profession not establishing itself as an important partner to them. Design has the knowledge to bridge all the participating professions within the development process. The advantage of design lies in that it is the discipline with the ability to merge human needs and desires with technological and manufacturing possibilities. Design has the responsibility to balance the user and the environment with emphasis lying on the user’s capability to perform in certain situation.

Endnotes:
Webster’s Universal Unabridged Dictionary

2.1 DESIGN SEMANTICS

Among others, one of the important aspects of design is design semantics, the meaning of objects in context, which depends on individual experiences under cer-
tain conditions. Design semantics considers variations and changes within contexts, as well as variations within users. It not only considers users, but also clients, buyers, sellers, manufacturers, and other stakeholders in the process. This is important for a usable design solution, because as the environment changes it is not always predictable in ways that would be convenient. A design has to be able to adapt to user and use; only then can it be really successful.

In 1984, a group of international designers, including Prof. Klaus Krippendorff, Prof. Reinhart Butter, and Prof. George Burden, established the term 'product semantics'. These designers pointed out that industrial products not only have to be functional and aesthetically pleasing, but they also have to be meaningful to the user. Products carry meanings that have to be seen in contexts, both physical as well as psychological. People 'mark' objects with their own labels. Each individual is connects differently in abstract ways to any given object. Some people think of incidents in the past when looking at objects, some attach certain smells to them, and some remember a particular environment. Even though the purpose of an object might be predetermined, the meaning it carries varies from user to user. The concept of 'form follows function' attributed to the famous architect Mies Van der Rohe is being replaced or reformed by product semantics with the concept of 'form follows meaning'. Not only is a certain and still valuable functionality important for the design process, but also individual meanings in various circumstances. Klaus Krippendorff defined product semantics in 1995 as:

"...product semantics entails both, the systematic exploration of how artifacts arise, make sense and mean in their user's understanding and the design of artifacts that either afford or supportively intervene in meaningful human interfaces with them."
He redefined the term in 1998:

"...product semantics can be defined as the systematic inquiry into how artifacts acquire meanings for their (users or) stakeholders and, as a methodology for intervening in a cultural reality in which designers cannot specify the meanings that artifacts have for others, but may support their emergence selectively."²

Product semantics is concerned with a 'second-order understanding', the so-called 'understanding of understanding', in order to define the users needs and desires. And product semantics is also concerned with practical methods that support the design process with an explanatory rhetoric. According to Krippendorff, four theories of meaning have to be considered in this process: 'artifacts in use', dealing with the relationship between artifact and user; 'artifacts in language', concerning the communication between people about those artifacts; the 'genesis of artifacts', how and where these artifacts take place in reality; and the 'ecology of artifacts', meaning the relationship between artifacts themselves. However, not only products are part of this concept, but all manner of designs are affected. And so, the term 'product semantics' has expanded to become 'design semantics'.

Design semantics, in simplest terms, brings all participants and parts to the development and postdevelopment processes in relation to one another. This is crucial for design processes, because not only do users change, but so do the environment and circumstances. Therefore, it is important to the development process to anticipate and assess various situations and circumstances, not focusing on one particular event, but considering the variety of possibilities within the process. What is true for products is true for spaces as well, especially in the field of workspace design.

In this context, it is important to recognize how individuals may understand
and perceive an environment, and what sorts of experiences a designer can presuppose.

Endnotes:
1 Krippendorff, Klaus: The Semantic Turn: An Introduction to Product Semantics with Reference in Ulm. The Annenberg School for Communication, 1995; page 5


2.2 PERCEPTION

"It is not an exaggeration to say that your view of reality is determined largely by how you perceive the objects and events in the world, or that perception is the gateway to understand the world."

With these words E. Bruce Goldstein defines perception as how people become aware of objects and events in their surroundings. Designers are responsible for the development, appearance and presentation of objects and of environments, and of objects in particular environments. Therefore, perception must be anticipated and considered by the designer, with concern for how and how much individuals are able to perceive and process without stress from overwhelming stimuli.

A small environment has the advantage of incorporating all required tools and materials in an immediately accessible area. Unfortunately, this may also lead to an overload of information within such a small space. To develop acceptable and usable design solutions, it is important to know how people process information. In
other words, it is important to know how people perceive.

Perception is the transformation of environmental energy into electrical energy in the nervous system. All five senses are involved in the process of perception by transforming energy. The visual sense receives electromagnetical energy, like visible light with both rod and cone receptors in the eyes. Pressure changes in air or water, mechanical energy, is responsible for the bending of hair cells in the ear, which results in hearing. Another mechanical energy form, pressure on skin, is known as the sense of touch, where receptors in the skin are stimulated. Olfaction and taste are transformations of chemical energy in gas, liquid, and particulate forms, as receptors in the nose and tongue are stimulated by them.

Take the visual perceptual process, for example. It starts with a distal stimulus, which could be an object in the environment. This object becomes an image 'in' the eye, and is called the proximal stimulus. Then environmental energy is transformed into electrical signals as tens of thousands of visual receptors transduce the external stimuli in internal 'data'. These "electrical signals flowing through nerve pathways in the brain" transform into a perception of the particular object. What follows is the cognition process, a recognition of the object as a particular known, or unknown object. In most cases, an action follows as a direct response to the visual stimuli. The triggering stimulus is compared with existing images or experiences and if a match is found the recognition process starts, as in the child's game of 'memory' or with a library's catalogue search and find system. And though sometimes the recognition starts immediately, it can take longer, where the connection is not even made until days later. This delay may be described as the 'aha-effect', where the recognition occurs suddenly, or where a second stimulus triggered the previous connection.
Attentiveness, which is important in all working environments, plays a distinct role in perception, it can either be attended or unattended. In general, movement attracts attention. If something moves in the peripheral vision it is likely to attract attention and the head is turned to be able to focus on the object, to either see or hear it more clearly. "The movement of an object provides information about the object's three dimensional shape." If something moves it segregates from the background and is easier to recognize. While perceiving an object's movement, one coordinates it with his or her own movement. The faster one or the other moves, the more likely will there occur a miscalculation, as it is more difficult to assess the correct distance. In the case of driving a car, miscalculations can easily lead to dangerous situations. Once attention is focused on one particular object, action, or thought, awareness of everything else is drastically decreased and even could become lost entirely.

If a design addresses important decision-making performances, it must keep in mind that on average the left brain is in charge of language processing, whereas the right brain is responsible for spatial decisions. These two distinct perceptual processes should not be crossed, because one or the other will be overpowered, which could result in confusion and stress, and likely lead to fatal decision making.

Another important aspect to consider is the perception of colors which are divided into achromatic colors, like white, black and shades of grey, and chromatic colors, like blue, green, yellow and red. Achromatic vision is perceived by the rods in the eyes, whereas chromatic vision is perceived by the cones. There are far more rods than cones, with over 120 million rods compared to only 6 million cones, in the retina. As a result, chromatic colors are perceived faster than chromatic colors, even though the cone foveal vision has the greater acuity. If the concern lies in the detail,
the cones are responsible for precision. For immediate attention, achromatic colors might be the better choice, but for detailed information chromatic colors might be more suitable. As it is known, there are complementary colors, like red and green, which are perceptually paired with one another. This can cause the effect that by looking at one of the colors the other will occur as an afterimage. The average color sensitivity of the human eye is in the proportions of 64% red, 32% green and 25% blue. As a person ages, color sensitivity decreases in general, but blue colored objects tend to fatigue the eye for all age groups.

Perception is a highly complicated process which needs proper examination and attention in developing design. Perception ought to be seen as a fundamental tool in communication. People perceive environments with all their senses in parallel, but not in equal levels, and the visual sense the most engaged. The reason for this imbalance is not because vision is the strongest among the senses, but because our environment is aimed at it. Up to now, most workspace interiors are visually oriented, whether they be vehicle interiors or office environments. If it were possible to balance perception by addressing the other four senses, the visual sense could be relieved, and the user may be less stressed, distracted, and exhausted by the environmental visual stimuli.

By designing interiors, especially car cockpits, this knowledge is of fundamental importance. The driver should not be overwhelmed by information, especially inside the car. Design can not control the given exterior environment as much as it is able to control the interior.

Endnotes:


2.3 INSTINCT AND INTUITION

As we have learned, the way humans perceive is very important in foreseeing decision making processes. Especially if immediate response is necessary when there is almost no time to react. Instinct and intuition are likely to take over in those split second reflex-level decisions. But what should this mean for design? Is there a difference between instinct and intuition? When is a reaction automatic and when is a response natural?

According to the Webster New World Dictionary, instinct (Latin: instinctus) is "an inborn tendency to behave in a way characteristic of a species; natural, unlearned predictable response to stimuli" without involving reason. The performance of instinct is not based upon past experience. Whereas, intuition (Latin: intuitus) refers to a knowledge or "direct learning of something without the conscious use of reasoning". It involves an immediate understanding. Therefore, intuition is based on knowledge and experience, whereas instinct is inborn. If a reaction is auto-
matic, it happens without conscious thought or volition and may be based on reflexes, either inborn or as a result of routine, such as catching a ball, or steering a car. Sometimes actions are made independently of any outside stimuli, such as sleep-walking. And some are not even conscious actions, like a heartbeat. An automatic action can therefore be both instinctive and learned. A natural response is innate, it is never the result of experience; it is the essential character of a thing.

Consideration of these aspects in designs may be of beneficial influence to the usability of workplaces themselves, not only saving time in decision making processes, but also helping to reduce stress and support productivity. Natural mappings and metaphors, discussed as follows, could be used to trigger innate or intuitive reactions.

Endnotes:
1 Websters New World Dictionary

2.4 MAPPING AND NATURAL MAPPING

Mapping is a technical term for associating one thing with another and is almost always dependent on individual experiences and particular contexts. According to Donald A. Norman, mapping means "the relationship between two things". He uses the example of steering a car to prove his definition. Turning the steering wheel clockwise lets the car turn right, turning it counterclockwise lets it turn left. Once this mapping is adopted it is always remembered because "the wheel and the
clockwise direction are natural choices...". A contrary example might be the steering of a boat with an outboard engine. Pushing the rudder to the right makes the boat turn left, pushing it to the left makes the boat turn right. This is not an instinctive application, but depends on the mechanics behind the engine, it has to be learned and recalled. It will become an automatic or intuitive action over time.

Natural Mapping is the term for associating instinctively one thing with another, whereby these things could be concepts, objects, experiences, or actions. According to Norman, natural mapping takes "advantage of physical analogies and cultural standards" which "leads to immediate understanding". In the case of spatially restricted environments, the objects should address the required performance in a natural, instinctive way, to both improve the space and to save time and avoid confusion and stress. In other words, the user should be able to interact with the designed object without additional information. To trigger the correct performance, instinctive and intuitive action [as discussed in the previous chapter], as well as the way people perceive and therefore process information, must be considered and anticipated by designers.

One approach may be to use knowledge about perception and human behavior. Another might be to use common mental models, that is to use generic experiences or generic images to provide appropriate mappings. Natural mapping could be seen as a step further than design semantics and its definition (Section 2.1). This method not only considers objects in context and the 'understanding of the understanding of stakeholders', but also inherent actions and behavior, emphasizing natural and/or automatic understanding.

Endnotes:
2.4.1 EXAMPLE OF MAPPING FOR HEADLAMP SYMBOLS

In September 2002, I conducted a survey at Lear Corporation in Southfield, Michigan. Engineers, designers, and consumer market researchers were asked to describe certain functions in a car to somebody who a) never drove a car, and b) did not speak English. The results were surprising in that almost all of them used the given signs and symbols one can find in present-day cars. People have gotten so used to them that they consider them as natural and logical, though they have to be explained and learned in the first place.

Take, for instance, the standard sign for head lamps, one can determine an origin to vehicles that were modern 60 to 80 years ago. Standard symbols for headlamps, to find in many cars and handbooks about symbols:

Figure 2.1: Standard headlamps

Figure 2.2: Ford Model T
The headlamps were originally shaped in the way to which the symbols are still referring. In the 1920ies, these symbols were quite up to date, and naturally understood. Because the shape of cars and headlamps has changed due to aerodynamic and manufacturing reasons, and the lamps are now completely integrated into the fender and hood, these symbols are relics of former times. They have to be explained, learned, and remembered. Over time, these signs have become intuitive in understanding, but they are in no sense inherent anymore.

2.4.2 EXAMPLES OF INFORMATION FLOW IN NATURE

One way for designers to develop a model for presenting information is to apply knowledge, or common mental models, about nature. The idea is to map designs with a natural application. The way nature deals with processing could be used as a sort of mapping information flow.

A leaf on a tree, the end of the chain of roots, stem, and branches, has to get nutrition, meaning water and other substances. The veins in a leaf transport those required substances. This schematic could be used to design information processes, such as the way the veins are distributed in the leaf. If it is possible to work with color, a green leaf could stand for new information, an autumn brown leaf could stand for older, but still available information, whereas a leaf that is no longer connected to a branch and is lying on the ground cannot serve as information anymore. One leaf could stand for one particular interest in information presentation. Several leaves on a branch could present different information clusters. The bigger the leaf
the more important the information, or the more information is available.

Figure 2.3: Single Leaves
Figure 2.4: Different sized leaves

Leaves on the ground do not transfer any valuable information anymore, but they could serve as reminders of information that was important before. Branches that split could show changes in information that have the same roots, but different applications.

Figure 2.5: Leaves on ground
Figure 2.6: Leaves on branches

The four seasons could stand for change, with spring being new information, summer being established information, fall being older information, and winter being lost information or change in progress. Or the seasons could stand for certain processes in development, with spring being the beginning, summer being the devel-
opment phase, fall being the phase of application, and winter being the end of the process.

Another natural mapping is to compare information flow, or state of information presented, to a river. A calm river could stand for the system operating within acceptable boundaries, a river that is in visible motion could serve as a warning sign that things are not going smoothly, and a river that ends in a waterfall could stand for an emergency situation. The state of information could be presented by images of a river from peacefully calm to dangerously fast.

Figures 2.7: Rivers in different states

Information that is merging into existing information, or those which develop in parallel and then merge into each other, could be represented by a river and its tributaries. Information that spreads, or thins out, could be shown by a river and its distributing branches.

Figures 2.8: Rivers top view

These examples are based in nature and have been part of the common
human understanding for very many centuries. Each of these images is able to communicate a message. They transfer meaning and foster a mental model in peoples' minds. They can be used as natural mappings, and are closely related to the application of metaphors.

2.5 APPLICATIONS OF METAPHORS IN DESIGN

The examples of the previous section are metaphors based in nature that can be used to generalize communication and force intuitive and inherent reactions. The term metaphor, having its origin in traditional rhetoric, is an important tool in daily life. A metaphor is a transformation of a word out of its original meaning in a figurative way. This is how design can use metaphors to its own advantage, by transforming meaning out of the original context and applying it to another situation. According to Lakoff and Johnson, metaphors are more than a matter of language alone, they are the main part of a human's conceptual system. Without metaphors communication is nearly impossible.

In our daily lives we are surrounded by almost countless metaphorical concepts, one pointed out by Lakoff and Johnson is 'time is money'. Time has a certain value in western cultures. Time is precious and so is money. And so, time can be equated with money. Taking this literally, as we usually do, we end up with metaphors like, 'wasting time', 'saving hours', 'spending time', 'running out of time', etc. We acquire a metaphorical entailment which characterizes the metaphorical
concept and a corresponding system of metaphorical expressions.

This metaphorical systematicity uses "one aspect of a concept in terms of another." One interesting definition of language is made by Michael Reddy as 'the conduit metaphor':

"Ideas or meanings are objects,
linguistic expressions are container, and
communication is sending." ²

Applying this to a discussion between two people we have the following situation. One partner in the discussion puts objects in a container and sends it to the other. The receiving partner opens the container and takes the objects, puts new objects in the container and sends it back. This conduit metaphor leads to ideas that 'get across', that 'come through' and which have to be 'packed into fewer words', etc. We almost use postal language for it.

The advantage for design lies in the use metaphors, because they are already established in daily life. Some metaphors may be more tangible while others may have to be transformed into design tools. But, in general, metaphors are an easy way to use the experiences of individuals to the advantage of design.

Endnotes:
1 Lakoff and Johnson, Metaphors We Live By, The University of Chicago Press, Chicago, 1980, page 10

² Lakoff and Johnson, Metaphors We Live By, The University of Chicago Press, Chicago, 1980, page 10
2.6 HUMAN FACTORS, ET AL.

Besides mental models and an understanding of the environmental effects on the user human measurements in relation to the given space must be considered in design. Anthropometrics to some degree, but especially ergonomics, human factors and the like, are the disciplines that consider human measurements, space measurements, and psychological aspects affecting human performances. Anthropometrics, is concerned with, the physical sizes and shapes of humans, as well as related aspects such as reach and visual capabilities. With interest in the varieties of populations and the differences between them, anthropometrics provides data that help designs to accustom the user. There are two distinctions within this discipline, 'static anthropometry', concerned with physical sizes, and 'dynamic anthropometry' that is focused on physical strength, both being enormously relevant for successful designs.

The fascination with the human body, its shapes, dimensions, and proportions can be dated back centuries. Leonardo da Vinci's famous human figure of dimensions is based on the Vitruvian man which was invented by the roman Vitriivius in the 1st century B.C. Almost 2000 years after Vitriivius invention the french architect Le Corbusier developed the Modular No.1. Involving mathematics and human measurements, Le Corbusier developed a figure based on Fibonacci’s golden means, enhanced by his own understanding of space that human need to be able to move.

Henry Dreyfuss shows in his book, The Measure of Men and Woman, a variety of human dimensions and how much space people need to fulfill certain movements, including holding a handle or a knob, etc.

With industrialization and the two World Wars emphasis in designing usable
and efficient environments found its definition in human factors, or ergonomics. Both terms are basically describing the same field of studies, the affect of physiological as well as psychological aspects on human performances. The term ergonomics which has its origin in the Greek, 'ergos' meaning work and 'nomos' meaning natural rules or laws, is recently becoming the total application of all human factors.

Ergonomics is the study of problems of people in adjusting their environment. It is the science that seeks to adapt work or working conditions to suit the worker. It is the interface between human and the various components of interior space. Moreover ergonomics is the engineering science which deals with the physical and psychological relationship between machines and the people who use them. Its objective is to improve the efficiency of operation by taking into account the person's size, strength, speed, visual acuity, and physiological stresses, such as fatigue, speed of decision making, and demands on memory and perception. Ergonomics is, simply put, the intersection between:

- a human's physical size and his or her environment
• a human's psychological processes and his or her environment, and
• a human's activities and/or objectives and his or her environment.

To be able to assess these intersections between the user and its needs, the task and the environment have to be defined.

2.7 HUMANS' NEEDS

Every person is a highly complex 'system'. Each individual acts and reacts differently. Everybody has different experiences, moods, and interests. Each of us has his or her own character, thoughts, wishes, aims and goals. People wear different clothes, form different friends and families, different educations, different behaviors, and different tastes, etc.

However, to talk about the user means understanding and considering generic human performances and needs. The idea is to examine the individual's circumstances in order to satisfy the user’s psychobiological needs with the aid of an appropriate design. According to a French study conducted by Serge Wunsch, psychobiological needs can be characterized as 'processes directly related to the functional structure of the organism.' The absence of those needs can cause, inter alia, severe dysfunctions.

He divided psychobiological needs into three main parameters:

• 'somatic' needs;
• 'neurostructural' behaviors and needs; and
• 'psychic' needs.
Somatic' needs are "needs intrinsic to the functional structure of the body". These would be nutrition, dapsic, and respiratory needs. Briefly, basic physiological needs without which a human would not be able to survive. 'Neurostructural' behaviors can be described as "nociception (reflexes, suffering), emotional behaviors (stress, rage, ...), and behaviors of orientation and attachment". 'Neurostructural' needs are the need for stimuli (oxysmic), need for sleep (hypnic), and need for exploration (epistemic). For example, a lack or deprivation of sensory stimuli could cause psychological disorder. Lack of sleep could cause an inability to concentrate and consequently work. 'Psychic' needs are divided in philic (Greek: philein, to like), and praxic (Greek: praxis, action). Philic needs are mainly those for existing and being of use to others. Praxic needs are those which enable "to control and act on the immediate environment.".

Humans not only need to eat, drink, and sleep, but we also need stimulation, motivation, and to be productive. We need to know that we are needed, valued, and safe. And the responsibility of design is to support these needs, it is charged with of providing environments and objects that are stressfree and stimulating.

Endnotes:
1,2,3,4 Serge Wunsch: http://psychobiology.uvaton.org/textes.uk/uk-txt-p04.20-besoinspsychobiologiques.htm
2.8 TASKS AND THEIR OBJECTIVES

A task, or problem to be solved is what work is to be done. That work may be more physically or more mental, but either way it can cause stress. Depending on the task, work is to be done by one, two or more people. In some cases, a user is responsible for the lives of others and sometimes for a tremendous amount of money, or for an expensive and complicated machine. And sometimes the user has to finish his or her work before another can make the next step.

Design ought to reduce exhaustion and mental stress, and to create an environment that supports human performances in a positive way. The task performance and their specific objectives will be defined in chapter 3, Tight Workspaces.

2.9 ENVIRONMENT, INTERIOR AND EXTERIOR

An environment is the space providing everything needed to fulfill a task. Because this study is especially concerned with spatially restricted workspaces, the challenge to these surroundings lies in that information, objects, and 'personal moving space' share the same limited space. Not only are ergonomics of concern, but the organization of information and when it becomes meaningful and must be accessible for the user are also of importance. How the environment influences performance, supports productivity, and efficiency is of special interest for design.
2.10 SUMMARY

Working in the field of design, more often than not, means not only to operate in a team consisting of different individuals, but also with people from various disciplines, like engineering and market research.

Design has the ability to bridge involved professions in the development process by balancing between human needs and desires and technological and manufacturing possibilities. In order to fulfill this role in such a collaboration design must have tools for proving and defending its solutions and importance.

The previously discussed matters of design shall serve as background for designing spatially restricted workspaces. In combination with the following developed analysis and evaluation tools, design may have means to not only develop applications and solutions for those kinds of spaces, but also means for communicating with the participating professions by making design more clear, comprehensible, and tangible.
3.0 TIGHT WORK SPACES

The spaces that are of concern to this study are tight work spaces, which are those spaces that are physically restricted. Though there are exceptions, emphasis will lie on those spaces where only one user at a time has room to do its work comfortably. The term space itself could be seen rather relatively, as it can be both physically and mentally bound. A space may be restricted through obstacles, transparent as well as solid ones, or it can be personally restricted through a person’s thoughts and feelings. Outer space is something hard to imagine without having been there. Inner space is barely explicable, as it can neither be seen nor touched. A virtual space is absolutely artificial, created to replace reality for certain purposes like games or tests, for example. A tight work space is one that is primarily restricted through physical boundaries, and is likely to interfere with everyone’s...

3.1 PERSONAL SPACE

As the term implies, this is something very emotional and personal. It is one of the crucial aspects of human social interaction. In general, personal space can be described as the immediate space surrounding a person. Dimensions vary from cul-
titure to culture and from personal relationship to personal relationship, but personal space is widest in the front, narrower at the sides, and even closer in the back. In some cultures, like Russia or southern Europe, people are often touching each other while in a discussion. Generally, friends or acquaintances of the same gender maintain this shared personal space, and it would be very impolite not to do so. Comparatively in North America and northern Europe, people have a much wider personal space and only share it with each other if they are very close friends or family. Moreover, people of the same gender don’t touch each other as much as in Russia, for example.

Measurement of personal space depends on circumstances, given environments, individual contexts, and gender. While, people can interfere with this space as well as objects, the former are more likely to cause stress and discomfort than the latter. When a person is driving a car, for example, the interior already interferes with the individual’s space. The side windows are closer than in most environments, and the steering wheel is very close in the front. Sitting right next to a stranger in public is only acceptable if there is no other vacant spot. When someone gets too close without an obvious reason (as when in a crowded train during rush hour), most people in western cultures would find themselves very uncomfortable and sometimes even provoked. Moreover, people need room for thoughts. If this is not provided by a workspace, productivity is likely to suffer. Not only must every person have his or her own individual space, but every task requires one as well. Tight work spaces are those which already interfere with one’s personal space boundaries. These boundaries need to be examined to be able to assess how they influence the user’s performance and how design can improve them to support a pleasant and comfortable workspace that fosters whatever is most important for the success of the user, task, environment relationship.
3.2 DEFINITION AND CATEGORIZATION OF TIGHT WORK SPACES

Considering the aspect of personal space, analysis of restricted workspaces requires not only defining the dimensions within a space, but also defining and considering the effect of that space on the user's mental performance. It affords to look at the user, the task, and the surrounding in a semantical way, to look at them in parallel. All three parameters affect each other and, moreover, depend upon each other. Because the user is the active member in this triad, he or she ought to be the center of attention. The designer's responsibility is to provide the appropriate interior or for particular tasks and occasions. Therefore it is a fundamental concern to exactly define the space itself, before analyzing and designing it, because every single piece of the environment somehow influences the user and his or her performances. Even though the objectives or matters of concern are spatially restricted spaces, within each space there are different categories that require various task demands.

The first category is whether a space is an indoor, or an outdoor one. This project considers indoor spaces to be those which give shelter from the natural environment, within which the user does not have to deal with changing weather conditions as much as someone who works outdoors. An indoor space could be a building, as well as an enclosed vehicle, like a car or a plane. Outdoor spaces are those without all-around protection, such as a hot dog stand or a motorcycle.

The second category, is whether a space is stationary or mobile. This category is especially important because it results in different responsibilities, requirements, and needs for the user and the space. For example, a mobile space requires safety, both for the environment as well as for passengers or cargo inside the vehicle.
A driver not being aware of the exterior for a few seconds can easily cause a severe accident. An office space, on the other hand, needs to foster productivity and motivation. It is unlikely that someone would be injured by an office worker not paying attention for ten seconds. But someone can become seriously sick from understimulation doing a routine job in a monotonous environment.

Add a third category with the options of active and passive, and several combinations occur. There are for example indoor-stationary and indoor-mobile spaces, or outdoor-stationary and outdoor-mobile spaces. Active or passive generally only apply to mobile spaces. A person can either be actively or passively part of the transportation. So an indoor-stationary-passive space is for example an office. An indoor-mobile-passive space could be the galley of an airplane, or the sanitary space in an ambulance. An indoor-mobile-active space, for example, could be either a car cockpit or an airplane cockpit.

Another category to be considered has to do with the construction of the space, if it is an open, half-open, or closed space. This category is related to the presence of surrounding walls or obstacles. These walls could be windows, solid plaster, drywall, just cardboard, etc. Depending on the kind of enclosure there is, different conditions influence the user such as the noise and sound of machines or other people, natural or artificial light, and odors, such as exhaust, machines, perfumes, etc.

It is well known that mirrors give the impression of a bigger room, windows open a space with daylight, and high ceilings create a similar effect. Sometimes walls protect the inside from the outside and sometimes it is the other way around. People accept walls or windows close to their sides or in the back, but not in front of them (see 3.1 Personal Space). For example in a car the windshield is far enough
away to not distract, whereas the side windows are relatively closer. If the windshield were just a short few inches away from the driver’s face, it would be very distracting, and it would probably be almost impossible to drive. However, wearing a helmet enclosing the head completely gives a motocyclist a feeling of safety.

Also important to consider, is whether a space is public or private. A public space could be a bus or another form of public transportation. Private spaces could be those where there is only the user alone. This study considers a car with a driver and passengers a public space as well, even though the passengers might be related to (or otherwise familiar with) the driver. The reason for this will become clearer after the following examples of spaces and their categorical assignments.

The last category to be considered here for analyzing tight workspaces is whether they are single-user or multi-user spaces. Because of the spatial restriction, the discussed spaces in this study are generally used by one worker at a time, but it is possible that several workers use the same spot one after the other (e.g. bus drivers).

This design semantical approach will show the relationships between user, task, and environment, such as the environmental context in relation to the user’s tasks, and the user’s needs according to the task requirements. As we can see, it is important to define the context of the space exactly, all factors depend on each other and influence each other. The following categories serve as scaffold to first physically define the spaces.

The questions to ask are, is the space:
- indoor or outdoor?
- mobile or stationary?
- open, semi-closed, or closed?
- active or passive?
• public or private?
• single-user or multiple-user space?

Once these questions are answered, the next step is to show the relationship between the environment and the task. Every single category entails a particular task demand, such as productivity, motivation, safety, responsibility, etc. Mobile spaces, for example, usually do not involve productivity, whereas office spaces do. Office workers lack more outer stimuli than drivers do, and the latter should not become distracted under any circumstances, whereas the former could take a break and close their eyes without causing severe damage. A street vendor needs to be very friendly and has to keep the working place more than tidy, while an office may be messy as long as it is not a selling area and the same is true for a car interior.

The next pages will show selected tight workspaces and their categorization, as well as a first approach to derive task demands related to the specific space.
3.3 EXAMPLES OF VARIOUS SPATIALLY RESTRICTED WORK ENVIRONMENTS

Street Vendor, North High Street, Columbus Ohio

Categorization:
• open
• stationary/mobile
• outdoor space
• single-user environment

Task objectives:
• good quality
• friendliness
• cleanliness
• productivity

Figures 3.1: Street Vendor, N. High Street, Columbus, Ohio
Parking Facility Booth, College Street, The Ohio State University

Categorization:
- closed
- stationary
- indoor space
- multi-user environment
  (shift change after 8 hours)

Task objectives:
- safety and security
- mental endurance
- communication
- accuracy

Figures 3.2: Parking facility Booth, OSU campus, Columbus, Ohio
Open Plan Office, Lear Corporation, Southfield Michigan

Categorization:
- semi-open
- stationary
- indoor space
- multiple single-user environments

Task objectives:
- productivity
- communication
- orientation
- control

Figures 3.3: Open Plan Office, Lear Corporation, Southfield, Michigan
Misc. transportation spaces, airplane, spaces huttle, train cockpit, space station

Categorization:
- closed
- mobile
- indoor
- single, and/or multi-user environments

Task objectives:
- safety
- communication
- mental endurance
- comfort

Figures 3.4: Various tight workspaces in transportation
Local diners, Columbus Ohio

Categorization:
- semi-open
- stationary
- indoor space
- multi-user environment

Task objectives:
- quality (food)
- friendliness
- cleanliness
- accuracy

Figures 3.5: Diners, Columbus, Ohio
Freightliner Truck Cockpit

Categorization:
- semi-open
- mobile
- indoor space
- single-user, as well as multi-user environment

Task objectives:
- safety
- responsibility (freight, truck)
- comfort
- mental endurance

Figures 3.6: Truck cockpit, Freightliner, Columbus, Ohio
Standard school bus, United States

Categorization:
- semi-open
- mobile
- indoor space
- multi-user environment

Task objectives:
- safety
- responsibility (students, bus)
- communication
- comfort

Figures 3.7: School bus cockpit, International, Columbus, Ohio
Misc. car cockpits

Categorization:
- semi-open
- mobile
- indoor space
- single, and/or multi-user environment

Task objectives:
- safety
- responsibility (passengers, car)
- comfort
- mental endurance

Figures 3.8: Various car cockpits
Ladder Control, Fire Engine, No.13, Clintonville, Columbus Ohio

Categorization:
- semi-open
- mobile
- semi-indoor space
- multi-user environment

Task objectives:
- safety
- communication
- trust, reliability
- responsibility

Figures 3.9: Fire Engine, Ladder Control, Ladder 13, Columbus, Ohio
3.4 A DESIGN ANALYSIS TOOL

After categorizing the previous spaces and attempting to derive task objectives, it becomes clear that there are correlations between space and task. Different spaces in similar categories demand the same task characteristics. These similarities help in the understanding and definition of the relationships between the user, the task, and the environment by showing how one aspect leads into another and how each is effective and being affected.

Though it may sound simple, it is a very important process. Because these factors are hard to measure and there are so far no rules or forms that can be applied, there is no graph that shows ‘a’ equals ‘b’ and leads to this design demand. Categorizing different spaces shows that spaces with different purposes have similar claims and needs for task, user, and environment. A space category asks for a particular objective of the task, which then leads to either a need for stimuli or a need for stress relief for the user.

The assignments of objectives are supposed to be intuitive rather than artificial. The main objective in a mobile space is always safety, in the sense of taking care of both external and in-vehicle situations. An office space’s main objective is most often productivity. The user must produce results. An indoor space lacks physical attachment to nature. An outdoor space’s objective is security, first of all for the user itself, second for the equipment. An outdoor space does not provide protection in the sense an interior space does. The following graphic creates a structure to visualize the relationships between space, task, and user, by deriving objectives and users’ needs from the space categories.
<table>
<thead>
<tr>
<th>Space Category</th>
<th>Task Objective</th>
<th>Entails User's Need for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor</td>
<td>Freedom</td>
<td>Stimulation</td>
</tr>
<tr>
<td>Outdoor</td>
<td>Security</td>
<td>Stress Relief</td>
</tr>
<tr>
<td>Mobile</td>
<td>Awareness</td>
<td>Stress Relief</td>
</tr>
<tr>
<td>Stationary</td>
<td>Motivation</td>
<td>Stimulation</td>
</tr>
<tr>
<td>Active</td>
<td>Safety</td>
<td>Stress Relief</td>
</tr>
<tr>
<td>Passive</td>
<td>Productivity</td>
<td>Stimulation</td>
</tr>
<tr>
<td>Public</td>
<td>Responsibility</td>
<td>Stress Relief</td>
</tr>
<tr>
<td>Private</td>
<td>Independence</td>
<td>Stimulation</td>
</tr>
<tr>
<td>Open</td>
<td>Privacy</td>
<td>Stress Relief</td>
</tr>
<tr>
<td>Semi-open</td>
<td>Interaction</td>
<td>Stimulation Stress Relief</td>
</tr>
<tr>
<td>Closed</td>
<td>Communication</td>
<td>Stimulation</td>
</tr>
<tr>
<td>Single-user</td>
<td>Autonomy</td>
<td>Stimulation</td>
</tr>
<tr>
<td>Multi-user</td>
<td>Reliability</td>
<td>Stress Relief</td>
</tr>
</tbody>
</table>

Figures 3.10: Analysis Tool, space, task, user relationship

For further evaluation and description, the task objectives can be itemized with more detail with the aid of attributes. The category 'indoor' demands the objective 'freedom', e.g., liberty of action, possible view, pleasant odors, and sounds. If the user does not have the possibility to move, he or she might feel trapped. If there is no view, the attachment to nature is totally cut off. The same is true for odors, for
example, when the only smell is that of the running computer. Moreover, if there are no sounds, the environment basically does not exist. People do not want to work in the midst of a loud and busy train station, but they need to know what’s going on. Further, a certain sound level can support productivity. On the other hand, there are sound wavelengths that can disturb peoples physical state. For example, it is known that particular megahertz can have a negative impact on the stomach. People can become sick by riding in the rear seat of a car because the sound waves are heavily disturbing. In this manner there are attributes for each task objective which help to identify the user’s needs and desires. These Attributes can help to clearly define the problems within a space. The following examples of the generated category structure demonstrates how these attributes might be defined.

- **space category**
  - demands task objective
  - entails user’s need for stimulation or stress relief

### Indoor
- **freedom attributes:**
  - liberty of action
  - view
  - odors
  - sounds

### Outdoor
- **security attributes:**
  - physical shelter
  - mental protection

### Mobile
- **awareness attributes:**
  - knowing
  - awakeness
  - comfort

### Stationary
- **motivation attributes:**
  - encouragement
  - animation

Figures 3.11: Analysis Tool, general task attributes 1/3
**space category**

- demands task objective
  - entails user's need for stimulation or stress relief

**active**

- safety attributes:
  - environment
  - interior
  - occupants

- stimulation
  - stress relief

**passive**

- productivity attributes:
  - information access
  - appropr. tools
  - efficient processing
  - enabling

- stimulation
  - stress relief

**public**

- responsibility attr. :
  - for passengers
  - for equipment
  - for quality

**private**

- independence attr.:
  - competence
  - information access

- stimulation

**open**

- privacy attributes:
  - sound relief
  - personal room

- stress relief

**semi-open**

- interaction attributes:
  - information flow
  - w/ environment
  - w/ interior, tools
  - feedback

- stimulation
  - stress relief

**closed**

- communication attr.:
  - information
  - transfer
  - synchronization

**Figures 3.12: Analysis Tool, general task attributes 2/3**
The attributes ought to be adapted to fit the particular space being analyzed. The shown derivations serve as a frame to identify the appropriate descriptive terms. This category structure will be part of the entire space evaluation later in this study (see chapter 5.0 Development of a Design Methodology). It will serve as a tool for keeping the design focused on the user's needs and desires.
4.0 ANALYZING WORK PERFORMANCES

The previous categorization of workplaces demonstrates that spaces in similar categories have comparable features. This leads to defining levels of importance within the spaces in relation to the user and his or her task. Analyzing work performances gives insight into user-task-space relationships and may help with gathering information on positive and negative aspects of this collaboration. If no space to observe is available, appropriate tools to apply are personas and scenarios, as discussed later in this chapter.

4.1 SYSTEMATIC OBSERVATIONS

As mentioned above, systematic observations lend support in defining the relationships between user, task, and environment. One method to obtain detailed information about a workspace is by observation of the worker doing his or her work in a particular environment. By looking for motion sequences, frequently used spots, less used spots, and typical movements, can be pointed out easily. Zones of importance, zones of efficiency, or zones of particular relevance can be defined, and these can help to define levels of importance within tasks and task objectives, which will be of importance for the development of the design methodology in the next chapter.

Various parameters are of interest when observing a space. It is always useful
to follow a certain schematic for generating the information. The following scaffold is an attempt to cover crucial aspects within the space/task/user relationship, to describe and how to observe a user doing his or her work.

Description of:

1. ...the generic task
2. ...the user's general performances, like motion sequences and routines
3. ...the user's physical activities are being seatbound or standing performances
4. ...the user's personal space (e.g. room for mugs, newspapers, lunch, etc.)
5. ...varieties within the task/work
6. ...the interaction and communication with colleagues, passengers, etc.
7. ...the required environmental awareness
8. ...responsibilities to passengers, for equipment, or for freight, etc.
9. ...the user's qualitative and quantitative productivity
10. ...entertainment features
11. ...the resulting mental claims

The evaluation may show the user's mental demand, the mental workload, his or her load of responsibilities. How the space influences the user's performances is further evaluated within the methodology for design evaluation in chapter 5. The next pages illustrate the application of the systematic observation scaffold to a bus driver's workplace.
4.1.1 EXAMPLE OF OHIO STATE CAMPUS BUS DRIVERS’ PERFORMANCES

The following example shows four Ohio State University campus bus drivers, driving the same loop on the campus. The task includes shift changes, typical tasks and tasks besides driving, descriptions of the interior, and a brief evaluation. The systematic observation describes the drivers’ work environment and their workload. As a rule, it is helpful to not only observe and interview the user, but to take pictures of the space. This is of high benefit for analysis and proof of the findings.

The driver’s space consists of a steering wheel, various controls, gauges, and displays, a seat, and pedals. It is restricted by a window to the left, by the windshield and steering wheel in the front, and by a thin wall in the back.

Figures 4.1: Sketch, bus driver cockpit

1. The task descriptions

Driving the campus loop, both southbound and northbound:

The standard shift takes 8 hours, with two breaks. The average number of circuits of the route within a shift is 16.
The main task is to transport passengers (mostly students) within the loop. There are no tickets required, therefore bus drivers do not have to charge the passengers. Besides all the activities above, time sheets have to be filled out at certain intersections. The time sheets sit next to the side window, there is no predefined spot for them.

![Bus driver observation, filling out forms](image)

2. Depicting the user's general performances, like motion sequences and routines

   The standard driving performances are steering, accelerating, and breaking. Shifting the gears is not required, because of the automatic transmission. The driver has to stop at each bus stop, which is usually less than half a mile from another. Each stop requires use of the turn signal device, which is located on the left of the steering wheel next to the side window. Each stop requires opening and closing the front and back doors, and checking the aisle and the doors. Passengers move in and out. Mirrors have to be checked frequently. Drivers must be extremely aware of traffic. The drivers change at the end of an 8 hour shift. This shift change occurs at certain bus stops. One driver leaves the bus and another comes in and takes over. While passengers wait in the bus seat position and steering wheel height and angle are adjusted and while the new driver stores personal items such as drinks, food, radio, cough drops.
3. Description of the user's physical activities, are being seatbound, standing performances

all performances are done completely seatbound, every movement is made in a seated position, like leaning back and forward, turning the upper body and the head slightly, using hands, arms, and feet.

4. Description of the user's personal space

There is no place to keep or put personal things, like bags, mugs, radio, glasses, or paper within the immediate space. One storage bin exists behind the driver, above his or her head. The workspace is enclosed on the left by the window, in front by the windshield and dashboard, and to the rear by a thin wall. The right side is completely open to the passenger cabin so that there is no physical protection. All passengers sit in the back of the driver, if it is crowded passenger stand next to the driver.
5. Depicting variations within the task/work

There is no change within the main task. The route is the same for 16 circuits. The only variables are passengers and traffic.

Figures 4.5: Bus driver observation, standard performances 2

6. Interaction and communication with colleagues, passenger, etc.

Drivers rarely talk to passengers, generally only when the bus is very full and passengers have to stand next to the driver. There is almost no communication between drivers during a shift change.

7. Description of the afforded environmental awareness

Awareness of general traffic, vehicles, street signs, people, buildings, etc.

8. Description of the responsibilities to passengers, for equipment, or for freight...

The driver has responsibilities to passengers and the bus.

9. Showing the user’s qualitative and quantitative productivity

There is no tangible productivity but transportation of passengers.
10. Showing entertainment features

The radio is the only permitted entertainment feature, but is not included in the cockpit equipment.

Figures 4.6: Bus driver observation, adjusting radio

11. Showing mental requirements

Mental requirements are standard driving performance and total traffic awareness.

First Findings / Summary:

Some drivers like to talk, but no opportunity for communication is provided by the space and the drivers get bored. The driver has to cope with all sorts of weather conditions and seasons. There is no real privacy provided. With no shelter and no cover, the cockpit is open in direction of the cabin, and the passengers sit behind the driver and can’t be seen. There is very little personal space provided. The driver vary in body shape, and the cockpit has to be able to adapt this. Moreover, after a shift change, the seat is still warm from the previous driver and the steering wheel feels sticky, and this interferes with a driver’s personal space, making him or her feel uncomfortable. If entertainment such as a radio is desired, the driver must bring his or her own and no room for storage of such items is provided. Adjusting the radio can be very distracting, because it is not integrated into the interior. This space is does not provide enough safety. Drivers can become distracted easily.
4.2 CREATING PERSONAS AND SCENARIOS

Systematic observation is a great design tool for gathering information about the task, user, space relationship. In the case that neither a space nor a user are existent, other tools need to be considered. Tools that have become more and more common are personas and scenarios. Personas are imaginary people that are based on market research, target group research, certain defined parameters, to name a few. Scenarios are situations that these personas are 'going through' certain experiences they have which are related to the field of interest. Personas have their own circumstances, i.e. certain educational levels, particular professions, social relationships like friends and family, property, etc. The idea is to make them as real as possible in order to assess their feelings and emotions and predict how they would react in certain situations. These personas are living in created environments and they are using imaginary objects. The advantage to them as tools lies in that it is possible to design for certain groups of people by evaluating their needs and desires.

Creating personas means to construct artificial users built around certain parameters like age, gender, personality, character, education, etc. The idea is to place different types of user, these personas, into different kinds of situation and circumstances, their scenarios. Certain generations, or people within certain professions could be target groups represented by personas, while scenarios should, be based on the space of interest to the design with regards to tasks and workload. Personas and scenarios are powerful tools to model an environment and therein the user's possible actions and reactions. They can help to point out problems, or needs and desires, and to define solutions. Relating to the group of interest, personas can be created to
cover different typical and non-typical individuals.

Personas ought to be nearly tangible people with experiences, feelings, emotions and moods. Once these are defined, scenarios can be developed. Then the personas 'experience' different stories and situations in different environments based upon design tasks.

4.2.1 SCAFFOLDS AND GUIDES

The following graphic shows a basic scaffold to develop personas. Parameters for building a persona include name, gender, and age. But the parameter that describe a character in depth are those that give a persona the necessary and required volume.

Figure 4.7 Persona Scaffold, basic
Depending on the area of interest, more parameters may be of help in creating a real personality. With the aid of behavioral and personality traits, the persona becomes more and more real. Some examples of which attributes might be useful for this development are listed below.

![Persona Scaffold, detailed 1/2](image)
Depending on the task and environment, it is helpful to follow a certain scaffold for creating scenarios as well. This scaffold may include parameters like task purpose, surroundings, weather conditions, time of day, duration, interaction with others (known/unknown), etc. If different generations of users are targets of the design, it is useful to develop a timeline with past and current political, economic, sports, entertainment, local, national, and international events. These timelines are especially valuable to show the differences in generations and the differences in the development of these generations. Examples of eight different personas and their related scenarios, created for a collaborative research project, are attached in Appendix A. Two are presented on the next pages in order to illustrate how to apply the developed persona scaffold, and how to create scenarios.
4.2.2 EXAMPLE OF PERSONAS AND SCENARIOS

The two following personas and associated scenarios were part of a research project at the Department of Industrial, Interior, and Visual Communication Design at The Ohio State University, which required definition of possible drivers’ needs and desires in the future. Four generations were considered covering different target groups. Due to confidentiality constraints some of the findings and results have been modified.

Working with different generations means that the target groups have different historical contexts and experiences. As mentioned previously, it is helpful to build a timeline reflecting political and economic, as well as entertainment, developments. Furthermore, it is helpful to write a short historical context for each group, pointing out differences, which makes the personas more tangible by revealing something about their past. In addition to the scaffold, it is useful to describe the personal context in more detail. This makes it easier to empathize with the persona.

The two presented personas are members of the baby boomers generation. Their names are Linda and Larry and they are both 68 years old at the target time of 2015. They have a common historical context. When Linda and Larry were born in 1947, Harry S. Truman was President and World War 2 was over for only two years. Artists like Frank Sinatra, Bing Crosby, Vaughn Monroe, and Count Basie had number one hit songs that year, and Louis Armstrong was already a very well-known jazz musician. The telephone area code system for world zone 1 (North America) was introduced, allowing operators, and later automatic switching systems, to handle nationwide telephone calls. Aluminum foil was
invented and Tupperware was available for a year. The invention of a point-contact-amplifier, the first step in the direction of personal computers, was made that year Ferrari was found. Volkswagen finally sold the beetle commercially and began to conceive of a minivan which was developed two years later.

Larry's scaffold:

<table>
<thead>
<tr>
<th>Educational background</th>
<th>major in Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>graduated in Economics</td>
</tr>
</tbody>
</table>
|                        | BS in Business Administra-
|                        | tration                 |
|                        | MBA                    |
| Professional experience| owns and runs family    |
|                        | construction company   |
| Body type              | overweight             |
| Physical, health condition | recent stroke       |
|                        | heart condition        |
| Personality traits     | grandfatherly          |
|                        | seasonalal depressive  |
|                        | short tempered         |
| Behavioral traits      | jolly                  |
|                        | gregarious             |
| Activities             | used to sail           |
| Interests              | church                 |
|                        | organizes the monthly  |
|                        | church cook-out        |
| Financial status       | medium income          |
| Living conditions      | big rural house        |

Figure 4.10 Persona Scaffold, Larry
Larry's personal context:
Larry grew up in the San Francisco area where he still lives. He graduated from High-school in '65, studied Architecture and Economics and got lost in the summer of love in 1967. He joined the Peace Corps in a small West African nation from '69-'71, helping to develop economic conditions there. When he returned, he married Sue, whom he had known since High-school. He took over his father's construction company and finally completed his MBA in the late '70s. In 1998, he lost almost all of his investments when the construction business decreased rapidly. He managed to keep his company but had to cut down on employees and offices. A year later his wife died and he had a stroke he is still recovering from. His son is gradually taking over the business, while Larry starts to cut back as much as he can.

Linda's personal context:
Linda graduated from college in 1969, and soon after married her husband Paul. He began to work at the NASA Kennedy Space Center in Florida, and she took a job teaching nearby. They raised three children. At the age of 49, Linda went back to college and worked on a Ph.D. in Early Childhood Development. In 2000, she was made a job offer by the University of Richmond, where one of her daughters lives now. Linda accepted and moved up to Virginia. Soon, with the added pressure of geographical distance, the already broken marriage with Paul ended in divorce. She also inherited her parents' condo in Melbourne/Florida, that year. Linda never liked to fly. She always preferred to drive by car. Even at 68, she still loves to drive from Virginia down to Florida, most of the time all by herself.
Linda's scaffold:

<table>
<thead>
<tr>
<th>Educational background</th>
<th>MA Education</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>major Child Psychology</td>
</tr>
<tr>
<td></td>
<td>Ph.D. in Childhood Development</td>
</tr>
<tr>
<td>Professional experience</td>
<td>elementary teacher</td>
</tr>
<tr>
<td></td>
<td>part time prof. at the University Richmond</td>
</tr>
<tr>
<td>Body type</td>
<td>medium-build</td>
</tr>
<tr>
<td></td>
<td>active</td>
</tr>
<tr>
<td>Physical, health condition</td>
<td>overall good</td>
</tr>
<tr>
<td></td>
<td>eye-sight declining</td>
</tr>
<tr>
<td></td>
<td>hearing declining</td>
</tr>
<tr>
<td>Personality traits</td>
<td>impulsive</td>
</tr>
<tr>
<td></td>
<td>extrovert</td>
</tr>
<tr>
<td>Behavioral traits</td>
<td>'busybody'</td>
</tr>
<tr>
<td>Activities</td>
<td>Yoga</td>
</tr>
<tr>
<td>Interests</td>
<td>grandchildren</td>
</tr>
<tr>
<td></td>
<td>volunteer work</td>
</tr>
<tr>
<td></td>
<td>'gardening'</td>
</tr>
<tr>
<td>Financial status</td>
<td>high income</td>
</tr>
<tr>
<td>Living condition</td>
<td>rural condominium</td>
</tr>
<tr>
<td></td>
<td>within city limits</td>
</tr>
<tr>
<td></td>
<td>2nd home in Florida</td>
</tr>
</tbody>
</table>

Figure 4.11: Persona Scaffold, Linda
Sample scenario Linda, situational context:

It is between Christmas and New Years Eve in the year 2015. Linda is packing her car. She will be leaving for Florida in the next hour. It is snowing and very cold. The plan is to meet her friend Richard in three days at her condo down in Melbourne. This trip she wants to drive along the east coast. She doesn't like to drive longer than three hours at a time, and wants to drop by at her sister's in Atlanta. So Linda sets her Navigation select good stops to have a snack and get cheap gas.

Her car is already set for the long trip. Everything she needs during the drive such as her coffee, water, cell phone, some treats and the old fashioned maps are in their places right next to her. Linda almost had an accident once because hot coffee spilled over her legs. Since then, she appreciates the advantages of her short and long term settings in the car, where everything is in the right place for every occasion. Her children still don't like that she always travels all by herself and that she occasionally picks up hitch-hikers. Therefore her car sends them automatically every two hours data about her location and her well-being. It is 9 AM and Linda is about to hit the road, everything sits in the right place. The presents, her luggage, the new armchair she bought for the apartment, some books, discs and, of course, the cooler. When she leaves, the car sends a message to her children that she started the trip and where she is heading next. Her first stop is at a gardening store, where she wants to get some plants for her sister. It is hazy, and the view is less than ideal. Linda activates the windshield system, which makes objects more visible and detectable on or next to the road.

There is some traffic on the freeway and, unfortunately most of it is semi-trucks. They are driving fast and erratically as everyone is trying to get home in time for New-Years-Eve. They are overtaking whenever it is possible, throwing mud
on the passenger cars’ windshields. Linda is glad that her car sits higher than the average car, and lets her have a better overview.

The first six hours have passed by and she has already stopped twice. The well-venting system sets the temperature a little bit cooler than cozy warm, so that Linda won’t get sleepy. Her backrest changes the lumbar and side supports a little, so does the seat-pan, for better blood circulation.

After eight hours on the road, it is already dark and Linda is close to her sister’s. The car gives an alert that there is an animal on the road and automatically slows down; due to the wet and muddy road, the radio reduces the volume. Linda escapes with only a little scare. She had already felt somewhat sick before she left Richmond this morning. Now that she has been driving for more than 8 hours and the near accident with the deer, she wishes she were already at her sister’s in Atlanta. Linda is fatigued, the well-venting system measures her temperature and she already has a low grade fever. Luckily she only has one more half hour to drive. Her sister gets a message from the car that Linda is not feeling well. She prepares hot tea and a hot bath. By the time Linda arrives, everything is set, dinner is almost prepared and Linda takes a long bath. The next morning, she decides to stay another day, because of a cold she is developing. She doesn’t feel like calling everybody, so she uses her car to send them messages that they don’t have to worry.

This scenario shall shows an idea how to use the persona/scenario tool for design developments. It explores the possibility to derive concepts for interior systems and design applications. It shows needs and desires of this person in the particular context. Due to the confidentiality restriction not all the results are permitted to be posted here.
5.0 THE EVALUATION OF SPACE, TASK, AND USER RELATIONSHIPS

"We can measure with a tape whether or not a man can reach something, but we must apply an entirely different set of standards to judge the validity of an individuals' feeling of being cramped."
Edward T. Hall, The hidden Dimensions,

5.1 DEVELOPMENT OF A DESIGN EVALUATION TOOL

As described in section 2.7, human beings have crucial needs to survive and needs to feel comfortable. On one hand, there are basic needs such as water, food, or sleep, and on the other hand, there are also needs for mental stimuli, like impulses, or motivation. Both the lack of mental stimuli and stress overload are able to cause severe diseases. Therefore, it is important to not only consider 'measurables', such as accessability, but also 'unmeasurables', like mental effects on the user. Design has the ability and also the responsibility to positively improve upon the needs for stimuli and stress relief. A 'good' design fosters motivation, awareness, and efficiency, whereas a 'bad' design causes stress, distraction, and lack of productivity. However, how can one know if a design addresses the right performance, or if a design is really 'good'?

The attempt of this thesis is to develop a method which allows the designer to measure, analyze, and evaluate an interior design, specifically the use of objects, and
tools, and their effect on the user’s mental performances. This is a methodology that makes design more tangible, traceable, and comprehensible for users, designers, manufacturers, et al.

As a first step, the relationships between user, task, and environment have to be defined, as shown in section 3.2 Categorization of Tight Workspaces. Adding to this, the present chapter deals with categorising tasks in relation with the senses used in accomplishing them. The findings of either systematic observations or personas and scenarios (see previous chapter, 4.2 Creating Personas and Scenarios) will be applied and serve as empirical data. By assigning levels of importance within the tasks, the concerns for whether a task is a minor or a major distraction, i.e. whether a task is a source of positive stimuli or a source of stress overload, can be evaluated. The intent is to balance between the used senses and the resulting stimuli and stressfulness and to prove the effect of the space-task relationship on the user’s mental performance.

5.1.1 Task-User-Performance Relationship

The relationship between the task and the user’s performance could be described as how the user accomplishes the task by utilizing which of the five senses, by attempting to divide into mentally-related and physically-related tasks. Mentally-related tasks are those which afford an understanding, a comprehension of the use of objects and tools those which entail mental activity. These tasks require stimuli, impulse,
motivation, and productivity. Physically-related tasks are those which can be measured, like access time or access distance. These deal with activities which can be done subconsciously in some cases, e.g. steering a vehicle. A task is more likely to be classifiable as mentally-related if the afforded sense is either visual, auditory, gustatory, or olfactory. The tactile sense is usually more physically-related and everything which has to be adjusted, moved, turned, etc. is part of it.

With the aid of systematic observations or the creation of scenarios, the performed tasks can be assigned to the use of particular senses. Inquiry into the reason to assign a task to a particular sense might be necessary. The idea is to balance the utilization of the senses, because, as mentioned in chapter 2.2 Perception, the sensational perception of the environment is less than balanced.

People perceive environments with all their senses in parallel, but not in equal levels, and the visual sense the most engaged. The reason for this imbalance is not because vision is the strongest among the senses, but because our environment is aimed at it. Up to now, most workspace interiors are visually oriented, whether they be vehicle interiors or office environments. (see page 10)

Relieving the visual sense for example, might lead to more productivity and motivation, and less distraction and stress. Therefore, to be able to assess whether a space-task relationship is balanced, it must be examined with regard to the use of the senses.
5.1.2 CATEGORIZING THE TASKS, ASSIGNING IMPORTANCE

The categorization of tasks and their performances, with regard to the utilization of senses, serves as a scaffold for the evaluation of the user's mental load. The intent is to elaborate how the user becomes overstressed by accomplishing the tasks, and which part of the design has to be improved to reduce stress. The task objectives, derived in 3.2 Categorization of Tight Workspaces, are being used to keep focus on the space's usability. With the task performances assigned to the senses, in accordingly, the levels of importance can be defined, either by means of research, or by help of professional support from other disciplines. The distinctions to consider are high (1), medium (2), and low (3) importance. Though this may sound complicated, it is an easy process.

First: assign the task to the use of the senses.

Second: define the importance levels by keeping the task objectives in mind.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>task a</td>
<td>1 2 3</td>
</tr>
<tr>
<td></td>
<td>task b</td>
<td>1 2 3</td>
</tr>
<tr>
<td></td>
<td>task c</td>
<td>1 2 3</td>
</tr>
<tr>
<td></td>
<td>etc.</td>
<td>1 2 3</td>
</tr>
</tbody>
</table>

Figure 5.1: Evaluation tool, assigning importance to task performances

Frequent or emergency performances, as well as performances that deal with responsibility for others or safety issues could be of high importance. Periodic and
occasionally conducted performances, as well as occasionally applied/used tools or objects could be of medium importance. Less utilized performances could be of low importance.

5.1.3 A DESIGN EVALUATION TOOL

As developed in chapter 3.0 Tight Workspaces and its categorization of space, the space-task relationship can cause either stress or tedium, and demands either stress relief or stimuli. The intent of the proposed methodological evaluation is to define the stress load and the tedium level. The findings of the space categorization demonstrate whether the emphasis of a space lies in one or the other.

Once the tasks, their performances, and the corresponding levels of importance are defined, they can be elaborated by looking at how stressful or how dull they are for the user. The more high importance performances have to be fulfilled, the more they interfere with each other, and the more likely the user will become overwhelmed, distracted, and stressed. On the other hand, routine tasks can cause severe tedium, they tax mental endurance, and though they are less likely to cause stress directly, they definitely cause a need for mental stimuli. Less frequently performed tasks can be exciting, but they might require complicated perception processes and, because of this, no other task can be fulfilled in parallel. These performances are likely to lead to distraction, which then could cause stress.

Two aspects have to be evaluated, one being the caused stress load, and the other being the resulting tedium level. Each aspect is now divided into five steps: low influence, (still) acceptable influence, interfering influence, severe influence, and
unacceptable influence. The graphics bring visualization to possible levels.

<table>
<thead>
<tr>
<th>Low tedium:</th>
<th>Low stress:</th>
</tr>
</thead>
<tbody>
<tr>
<td>uity:</td>
<td></td>
</tr>
<tr>
<td>Acceptable tedium:</td>
<td>Acceptable stress:</td>
</tr>
<tr>
<td>Interfering tedium:</td>
<td>Interfering stress:</td>
</tr>
<tr>
<td>Severe tedium:</td>
<td>Severe stress:</td>
</tr>
<tr>
<td>Unacceptable tedium:</td>
<td>Unacceptable stress:</td>
</tr>
</tbody>
</table>

Figure 5.2: Evaluation tool, description of stress and tedium level

Stress level increases with performance overload, the more instinctive and natural the responses, the lower the distraction. The less challenging performances may be, the less changing and the more repetitive, the more dull and sickening the task.

Several aspects may serve as evaluation aids for stress load. For physical activities, the 'measurables', the aspects that influence a successful performance, such as fast vs slow access, and obvious vs hidden access, are of interest. Mental activities could be evaluated by means of aspects such as natural and instinctive vs learned understanding and clear-cut vs ambiguous comprehension. In general, all performances that do not require an educational process, or the in-depth study of a manual, those which rely on inherent behavior, are the least stressing, because these reactions and actions do not demand a complicated perceptual process (see chapter 2.3 Inherent vs Learned, a definition of the terms instinctive, intuitive, automatic,
and natural). Those tasks which require active involvement of the user are more likely to provide mental stimuli. Aspects that could serve as evaluation for tedium level are repetition, challengelessness, lack of self-involvment, and no interaction.

Assigning the task performances of the utilization of the different senses and differentiating them into either low, medium, or high importance, the stress load and tedium level can be evaluated and the scaffold is completed.

Derivation:

First: assign the task to the use of the senses.

Second: define the importance by keeping the task objectives in mind.

Third: evaluate of tedium level and stress load for the user.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>xyz sense</td>
<td>task a</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>task b</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>task c</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>etc.</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.3: Evaluation tool, assigning stress and tedium level

This scaffold can now be used to break down the task performances, their stressing effect, and their needs for stimuli to the user. Advantage lies in just this, as it makes it possible to specifically point out the failures within interior designs. Moreover, it shows where design has contributions and responsibilities and at which point other disciplines must be involved in improving the space-task-user relationships. The design analysis tool that categorizes the workspace, and the design evaluation tool that categorizes the task performances, are tools that can be used either to develop
new designs or to evaluate existing ones. They can help to distinguish between duties during development processes, and they make design more tangible and understandable, because they demonstrate how to measure and evaluate.
6.0 APPLICATION ON CAR COCKPITS IN GENERAL

The following example shows how to approach the categorization and evaluation of car interiors in general. Spatially restricted spaces like these relate more often than not, to information overload and disorganization. The hierarchy of information presentation, when it becomes meaningful and must be shown, or has to become accessible, is of important concern for the efficiency and safety of the driver's performance. Moreover, cockpits usually do not support enough physical freedom as would be necessary for the user's convenience. These circumstances can directly affect the driver's mental performance and are, therefore, likely to lead to stress, distraction, fatigue, confusion, uncomfortability. They are also likely to interfere with the space's main objectives, such as safety, responsibility, and awareness. In order to identify the weaknesses and strengths within car interiors they ought to be examined precisely.

6.1 CATEGORIZATION OF CAR COCKPIT SPACES

The definition of a space is the first step in the evaluation process. A car cockpit is an indoor space, because it is separated from the environment and it gives
the driver shelter. It is an active mobile space, because the user is actively part of the driving. Were it the passenger’s side of the compartment, the space would be passive mobile. The car is a semi-open space, because it has windows, which allow interaction with the environment. This example involves passengers, therefore it is a public space. The car is driven by only one person, making it a single-user environment.

The following graphic shows the application of the analysis tool developed in chapter 3.

<table>
<thead>
<tr>
<th>Space Category</th>
<th>Demands Task Objective</th>
<th>Entails User’s Need for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor</td>
<td>Freedom Attributes:</td>
<td>Stimulation</td>
</tr>
<tr>
<td></td>
<td>liberty of action</td>
<td></td>
</tr>
<tr>
<td></td>
<td>view, pleasant/necess.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>odors, stimul/calming</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sounds</td>
<td></td>
</tr>
<tr>
<td>Mobile</td>
<td>Awareness Attributes:</td>
<td>Stress Relief</td>
</tr>
<tr>
<td></td>
<td>knowing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>awakness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>comfort</td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>Safety Attributes:</td>
<td>Stress Relief</td>
</tr>
<tr>
<td></td>
<td>environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>interior</td>
<td></td>
</tr>
<tr>
<td></td>
<td>occupants</td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>Responsibility Attr. :</td>
<td>Stress Relief</td>
</tr>
<tr>
<td></td>
<td>for passengers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for quality</td>
<td></td>
</tr>
<tr>
<td>Semi-open</td>
<td>Interaction Attributes:</td>
<td>Stimulation Stress Relief</td>
</tr>
<tr>
<td></td>
<td>information flow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>w/ environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>w/ interior, tools</td>
<td></td>
</tr>
<tr>
<td></td>
<td>feedback</td>
<td></td>
</tr>
<tr>
<td>Single-user</td>
<td>Autonomy Attributes:</td>
<td>Stimulation</td>
</tr>
<tr>
<td></td>
<td>knowledge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>experience</td>
<td></td>
</tr>
<tr>
<td></td>
<td>routine</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.1: Analysis tool, categorizing car cockpits
Having defined the categories, the derived task objectives, and the resulting basic user needs within this space, the next step is to observe working performances, interaction between car and driver, as well as interaction between driver and environment. Because this example is supposed to be seen generally, the following observations are meant to have overall validity and application.

6.2 INTERNAL AND EXTERNAL ASPECTS INFLUENCING THE DRIVER IN PROBLEM SOLVING SITUATIONS

"Man's entire organism was designed to move through the environment at less than five miles per hour. How many can remember what it is like to be able to see everything nearby quite sharply as one walks..."

"Not only is the nearvision blurred by speed of the automobile but one's relationship to the countryside is vastly altered."
Edward T. Hall, The Hidden Dimensions

The car cockpit is one of the most complicated and overwhelming work spaces for non-professional users. Compared to other working environments which require particular professional education, the car is accessible for almost everyone from 16-99. Some countries require less driving education than others, and it is possible that people with almost no experience drive cars. Variations among drivers are enormous, but variety among cars is not. The intent is to observe and define exterior and interior factors and aspects that affect and distract the driver, including personal mood and stage.
6.2.1 THE DRIVER AND ITS STATE

Very many aspects influence people in daily life. There are good and bad moods, exciting situations and boring ones. People get upset when they are hungry, they have headaches when they are thirsty, etc.

There are even more aspects influencing human performance while driving. Therefore it is important to consider the different moods, conditions, and contexts to develop a usable, productive, and safe working environment.

Figure 6.2: The driver and its state
6.2.2 DRIVER-CAR INTERACTION

The driver has to make a great number of adjustments in the cockpit before and while driving. Those like the individually adjustable seat and its position, the mirrors, and the steering wheel are among some which have to be fixed before starting the car. All other devices and controls have to be managed while driving. Some of them are devices to control the car itself, some are to communicate with the exterior, some of them give feedback. And sometimes the driver has to communicate in the car while doing all the above.

Examples of adjustments:

- Controls: steering wheel, horn, ignition, headlamp, turn signal, identification lamps, clearance lamps, high beam, hazard warning system, illumination intensity, windshield wiper, windshield washer, manual transmission shift lever, automatic vehicle speed system, manual choke, hand throttle, windshield defogging/defrosting system, rear window defogging/defrosting system, driver's sun visor, service breaks, accelerator, clutch, etc.

- Displays: speedometer, turn signal, gear position, brake failure warning, fuel, engine coolant temperature, oil, high beam, electrical charge, etc.

- Entertainment Features: radio, cd-player, tv, internet, phone, etc.

- Consumer Goods: drinks, food, cigarettes, etc.

- Occupants: front, rear-left, rear-middle, rear-right, relatives, friends, acquaintances, colleagues, customer, stranger, etc.

- Seat & Adjustments: back-forth, up-down, backrest angels, armrest, headrest, lumbar support, seatpan angel, heat, etc.

Figure 6.3: Driver-car interaction
6.2.3 TACTILE ADJUSTMENTS

Adjustments in the car have to be made mostly by hand, while driving and holding the steering wheel. Only some operations have to be done with the feet, like accelerating, braking and using the clutch.

Tactile control and operation:

Figure 6.4: Tactile adjustments in the car cockpit

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6.2.4 VISUAL AND AUDITORY FEEDBACK

Most of the feedback is given visually, some is auditory related, and almost none is
tactile, olfactory or gustatory.

Visual feedback
- fasten seat belt sign,
- tachometer, gear position,
- speedometer, fuel display, turn
- signal, hazard light, high beam,
- empty tank alert, oil tempera-
- ture, brake failure warning,
- engine coolant temperature

Auditory feedback
- fasten seat belt, turn
- signal, hazard light, turn
- light off, don’t
- forget key in the lock

Figure 6.5: Visual and auditory feedback given by the car system
6.2.5 DRIVER-EXTERIOR INTERACTION

The environment consists of different aspects. There are those ones which don't change, either in location or in form, or there are those which move fast, and the those that move slowly. The weather conditions change and sun, rain, fog, and snow influence the driving ability drastically. All of the above directly affect the mental and physical performance of the driver, and are therefore not to be underestimated.

Figure 6.6: Driver-exterior interaction
6.2.6 DRIVER EXTERIOR COMMUNICATION

The driver has several possible ways to communicate with the environment. Some of them are active, some of them are more passive.

Activated once

- headlamp
- tail light
- fog light
- identification lamps

Active hand controlled
- hazard warning system
- turn signal
- horn

Active foot-controlled
- break light

More passive
- engine noise

Automated
- alarm

Figure 6.7: Driver-exterior communication
6.2.7 EXTERIOR DRIVER COMMUNICATION

How the exterior communicates with the driver, and which senses are addressed.

Figure 6.8: Exterior-driver communication
6.3 CATEGORIZATION OF DRIVER’S TASKS

As developed in chapter 5.0 Evaluation of Space, Task, and User Relationships, the tasks have to be assigned to the utilization of the senses before evaluating the stress impact on the user’s mental performance. The information gathered by observing the user in the environment (chapters 6.2.1-6.2.7) is used to assign the task-sense relationship.

In the case of the driver’s workplace (cockpit) the tasks could be described as follows:

<table>
<thead>
<tr>
<th>Task</th>
<th>Frequency / Demand or attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>open door, entering the car, sit down</td>
<td>once / comfort</td>
</tr>
<tr>
<td>adjust seat, if necessary</td>
<td>once / comfort</td>
</tr>
<tr>
<td>adjust mirrors</td>
<td>once / safety</td>
</tr>
<tr>
<td>fasten seat belts</td>
<td>once / safety</td>
</tr>
<tr>
<td>start engine</td>
<td>once / routine</td>
</tr>
<tr>
<td>car /engine check</td>
<td>occasional / routine</td>
</tr>
<tr>
<td>check environment, react</td>
<td>frequent / safety</td>
</tr>
<tr>
<td>shift gears, accelerate, brake, use clutch</td>
<td>frequent / routine</td>
</tr>
<tr>
<td>use turn signal</td>
<td>occasional / safety</td>
</tr>
<tr>
<td>adjust light</td>
<td>once / safety</td>
</tr>
<tr>
<td>adjust heat/air/ac</td>
<td>occasional / comfort</td>
</tr>
<tr>
<td>adjust radio, et al.</td>
<td>occasional / stimulation</td>
</tr>
<tr>
<td>etc.</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.1: Description of drivers’ task performances
In a car-user interaction the following adjustments are, as of now, generally made by hand: seat adjustment, front/rear washer/wiper, defogging-defrosting system, temperature control, air conditioning, ventilation, radio, sun visor, parking brake, cruise control, ignition, gear shift, steering wheel, etc. Meanwhile, only the break, accelerator, and clutch adjustments are made by foot. In some cases, the parking break has to be set by foot and released by hand. Almost all feedback given by the car is visual, such as the fasten seat belt sign, tachometer, gear position, speedometer, fuel display, turn signal, hazard light, high beam indicator, empty tank alert, oil temperature, brake failure warning, engine coolant temperature, et al. Only some feedback is made acoustically, like the click of the turn signal and the hazard lights and the buzzer or bells alerts to fasten seat belts, turn the headlights off, and not to forget the key in the ignition. The following graphics show how to organize the gathered information in preparing it for evaluation. First divide the Performances by utilization of the senses and assign importance.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>steer car</td>
<td>high: 1</td>
</tr>
<tr>
<td>visual</td>
<td>adjust driving controls</td>
<td>med: 2</td>
</tr>
<tr>
<td></td>
<td>adjust atmosphere controls</td>
<td>low: 3</td>
</tr>
<tr>
<td>tactile</td>
<td>use breaks</td>
<td>high: 1</td>
</tr>
<tr>
<td></td>
<td>accelerate</td>
<td>med: 2</td>
</tr>
<tr>
<td></td>
<td>shift gears</td>
<td>med: 2</td>
</tr>
<tr>
<td></td>
<td>start engine</td>
<td>high: 1</td>
</tr>
<tr>
<td></td>
<td>adjust seat</td>
<td>med: 2</td>
</tr>
<tr>
<td></td>
<td>fasten seat belts</td>
<td>low: 3</td>
</tr>
</tbody>
</table>

Figure 6.9: Analysis tool, driving performance hierarchy 1/2
<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>visual</td>
<td>observe &amp; check the environment such as traffic, streets, lights, obstacles, etc.</td>
<td>1 2 3</td>
</tr>
<tr>
<td></td>
<td>check driving display constantly, such as speedo &amp; tachometer, etc.</td>
<td>1 2 3</td>
</tr>
<tr>
<td></td>
<td>check environmental displays, such as light, turn signal, etc.</td>
<td>1 2 3</td>
</tr>
<tr>
<td></td>
<td>check maintenance displays, such as oil, fuel, temperature</td>
<td>1 2 3</td>
</tr>
<tr>
<td>auditory</td>
<td>react to warning sounds</td>
<td>1 2 3</td>
</tr>
<tr>
<td></td>
<td>react to emergency alerts</td>
<td>1 2 3</td>
</tr>
<tr>
<td></td>
<td>react to reminder sounds</td>
<td>1 2 3</td>
</tr>
<tr>
<td></td>
<td>react to maintenance signal</td>
<td>1 2 3</td>
</tr>
<tr>
<td>olfactory</td>
<td>react to unusual smells</td>
<td>1 2 3</td>
</tr>
</tbody>
</table>

Figure 6.10: Analysis tool, driving performance hierarchy 2/2

Once the tasks and sense relationships are defined, their impact on the user's performance and the resulting tedium levels and stress loads can be evaluated. According to the importance and the frequency of the performance the stress level can be higher or lower. Some performances are so rarely conducted that they can cause a high stress load, because their application has to be recalled and cannot be done automatically or naturally.
6.4 EVALUATION OF STRESS AND TEDIOUM LEVEL

After years of experience, driving a car is an automatic action. It becomes almost instinctive. It does not stress an experienced user as much as it stresses a beginner. However, steering requires constant awareness and checking the environmental situation, and its stress level is at least intermediate. Braking becomes routine as well as does accelerating and shifting gear. But, if someone has to hit the brakes to prevent an accident, it will definitely cause severe stress load. Design has to make sure that the brake is not to be confused with either the accelerator or clutch. Driving a standard transmission car for the first time can be very stressing. Adjusting driving controls might be more distracting because the driver has to look at whatever is to be adjusted while driving, therefore the stress level ought to be higher. This is also applicable to the atmospheric controls.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile visual</td>
<td>steer wheel</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tactile</td>
<td>hit breaks</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>push accelerator</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>shift gears</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tactile visual</td>
<td>adjust driving controls</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust atmosphere controls</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tactile</td>
<td>start engine</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust seat</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>fasten seat belt</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.11: Analysis tool, driving performance, stress and tedium level 1/5

84
The tedium level is almost unimportant for the tactile sense. There is no need to stimulate a driver to push the accelerator or push the brake. Two aspects that may annoy and bore people are adjusting the seat and fastening the seat belts.

Observing and checking the environment is one of the most exhausting performances for a driver. One has to be basically aware of everything outside the car. Even though everybody should have some education in driving, and though it should be common sense to take care of each other in traffic, more often than not, that someone makes a mistake. If people did not pay attention to each other, there would definitely be more accidents. Checking the driving displays is not very stressful. It might be stressing, if one has to stay within a certain speed limit and the speedometer is covered by the steering wheel. Checking the environmental displays is generally not very stressing either. But checking the maintenance controls could be very stressful, if for example the fuel is almost empty and no gas station is in sight, or if the oil temperature rises for no obvious reason, etc. The tedium level of the different visual performances depend on the duration of the trip. Driving in the city is less dull than driving on a highway for hours. If the environment does not vary at all, the driver needs to be stimulated to not be distracted.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>visual</td>
<td>observing &amp; checking the environment, see 6.2.5</td>
<td>high</td>
<td>med</td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>constant driving display check (speedometer, tachometer, et al.)</td>
<td>1 2 3</td>
<td>□ □ □</td>
<td>□ □</td>
</tr>
</tbody>
</table>

Figure 6.12: Analysis tool, driving performance, stress and tedium level 2/5
The Sense

<table>
<thead>
<tr>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>visual</td>
<td>constant environmental displays check, (light, turn signal, et al.)</td>
<td>high med low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>checking maintenance displays, such as oil, fuel, temperature</td>
<td>high med low</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.13: Analysis tool, driving performance, stress and tedium level 3/5

There are not very many acoustically-related controls and devices in a car cockpit. For the most part, warnings and alerts of minor importance are presented by sounds, like the 'fasten seat belt alert', or the 'turn off the headlight reminder' when the engine has been turned with the headlight still on. Reminder sounds are usually more annoying than stressing, but in some cases they could become stressful. Emergency alerts are generally related to alarms, as when someone tries to break in the car. If such an alarm goes off while a person is in the car it can be quite stressing, embarrassing and shocking at the same time. A visual maintenance sign could be the fuel gauge giving an alert that the car will run out of gas soon. The auditory performances are less tedious, since there are not very many, and since they occur relatively seldom.

The Sense

<table>
<thead>
<tr>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>auditory</td>
<td>react to reminder sounds</td>
<td>high med low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>react to emergency alerts</td>
<td>high med low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>react to maintenance sign</td>
<td>high med low</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.14: Analysis tool, driving performance, stress and tedium level 4/5
As far as research is concerned, there are no devices or controls based on smell or taste. The only smell which could influence the driver would be if the car had a bad smell, like that of a hot engine smell or burning oil. The driver would have to react to this immediately, which would probably cause a high stress load. This performance definitely requires no extra stimuli.

The Sense

<table>
<thead>
<tr>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium</th>
<th>Stress</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>olfactory</td>
<td>react to unusual smells</td>
<td>high</td>
<td>med</td>
<td>low</td>
</tr>
</tbody>
</table>

Figure 6.15: Analysis tool, driving performance, stress and tedium level 5/5

The space categorization demonstrated that car cockpits are more stressful environments than those where the user has to be stimulated constantly. Therefore, it makes sense that by evaluating the performances the tedium level generally not important at all. This level depends highly on the context whether it is a short or a long distance trip. Theling trips require for more stimuli than the short trips, because there is less change and fewer new stimuli involved. Passengers influence the driver in a way that asks for stress relief, whereas someone driving a car without occupants needs more stimulation. Evaluating space-task-user relationships always depends on the certain circumstances. Therefore, it is important to observe the particular aimed working performance.

With the tasks assigned to the senses, the importance of the particular performance defined, the stress level and tedium level evaluated, a more specific situation needs to be considered to be able to give specific results. A specific car and a specific driver persona would have to be involved in the evaluation process to generate more detailed results. The results that can be generated up to this point concern car cockpits in general. The evaluation showed that the driver is most distracted and

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stressed by visual input, both environmental and system feedback. The tactile sense is involved constantly as well, because steering, accelerating, and braking are constant performances. The auditory input in a car is barely identifiable because the sounds that are heard are almost always the same for more than one application. The olfactory and gustatory senses are not involved at all, though certain alarm controls could be supported by a smell as well. And pleasant odors, for example, could be used to reduce stress.

However, these findings are more general rather than specific. They can be used for in-depth examination of a car interior space. As an example, the following pages show applications of the evaluation methodology based on scenarios created in a mock-up environment. The space of interest is the cockpit of a hybrid SUV. Different interiors were designed at The Ohio State University by the senior industrial design class of winter quarter, 2003. The evaluated designs are shown in full-scale, preliminary mock-ups presented by each team.
7.0 EXAMPLES OF SPACE ANALYSIS AND SPACE EVALUATION

In winter 2003 the senior design class at The Ohio State University was asked to design a cockpit for a hybrid SUV vehicle, which was a part of a nationwide competition with the Center for Automotive Research (OSU). After attempts to fit the official engineering requirements in the design, it became obvious that there would not be much room for change and improvement. As a result, the requirements were reduced and the students had basically all the freedom they needed to create an interior that would fit SUV-drivers’ future interests. The class was divided into five groups, three of them are represented in this study. By mid-term, the students were asked to simulate scenarios/situations with their mock-ups to identify the problems of their designs. Pictures were taken by me to document the findings.
### 7.1 Exemplary Analysis of Design Students' SUV Interiors

<table>
<thead>
<tr>
<th>Space Category</th>
<th>Demand Task Objective</th>
<th>Entails User's Need for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor</td>
<td>Freedom Attributes:</td>
<td>Stimulation</td>
</tr>
<tr>
<td></td>
<td>• liberty of action</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• view, pleasant/necess.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• odors, stimul/calming</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• sounds</td>
<td></td>
</tr>
<tr>
<td>Mobile</td>
<td>Awareness Attributes:</td>
<td>Stress Relief</td>
</tr>
<tr>
<td></td>
<td>• knowing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• awareness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• comfort</td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>Safety Attributes:</td>
<td>Stress Relief</td>
</tr>
<tr>
<td></td>
<td>• environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• interior</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• occupants</td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>Responsibility Attr.:</td>
<td>Stress Relief</td>
</tr>
<tr>
<td></td>
<td>• for passengers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• for equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• for quality</td>
<td></td>
</tr>
<tr>
<td>Semi-open</td>
<td>Interaction Attributes:</td>
<td>Stimulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stress Relief</td>
</tr>
<tr>
<td></td>
<td>• information flow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• w/ environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• w/ interior, tools</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• feedback</td>
<td></td>
</tr>
<tr>
<td>Single-user</td>
<td>Autonomy Attributes:</td>
<td>Stimulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• knowledge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• experience</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• routine</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.1: Analysis tool, car cockpit

As shown in the previous chapter, the car cockpit is an indoor, mobile, active, mostly public, semi-open, and in these cases single-user space.
The task to evaluate is getting the engine started, which means finding the key hole, starting the engine, and adjusting driving settings.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>putting key into position</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>start engine</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust driving settings</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this configuration, the position of the key seems to be somewhat hidden. A key-like device has to be held above a specific spot to get the system started. The key does not stay in this position. Therefore, I consider this performance stressful, because it is confusing and not obvious and it has to be learned. The steering wheel moves automatically to a pre-set position. This task seems more unusual to current state of the art than stressing.
Figures 7.4: Team red, task performances 2

This scenario shows three performances combined in one. The steering device steers, accelerates, and brakes. Turning the device to the left or right makes the car turn. Pushing it forward makes it brake, pulling it back makes the car accelerate.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>steering</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>accelerat</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>breaking</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.5: Evaluation tool, task performances 2

I consider this device more than stressful. Steering and accelerating at the same time is very uncomfortable. The hands have to be held in an unnatural position. Moreover, the metaphor of pulling to accelerate is contrary to an instinctive or intuitive understanding. It is safe to brake while pushing the steering device forward, but it not safe to brake and turn at the same time. It does not seem to be intuitive, because the wrists are bent forward. There is no power or control with the wrists in this position.
The task to evaluate here is the convenience of storing a bag under the middle console access to it while driving.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>store bag</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>access parking position</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>access while driving</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Storing the bag in a parked position is convenient as long as the car has a higher clearance than a standard passenger car. If not, one has to reach down too far.

Accessing the bag in a parked position is not stressing to the driver, but reaching for the bag while driving is stressing, because the pedals and the driver's legs are blocking the storage area. This performance, once again, does not have a tedium level.
Figures 7.8: Team red, task performances 4

This task involves adjusting a 'multipurpose device', which includes navigation, entertainment features, and heat and air adjustments for the back.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>adjust multipurpose device from front seats</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust multipurpose device from rear seats</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.9: Evaluation tool, task performances 4

To adjust this device is obviously more convenient and less stressing from the rear seats than from the front seats. The curiosity of human nature makes people want to see what is on the screen, even though this would be dangerously distracting. The screen should either be totally hidden for front passengers or it has to be accessible and visible for all.
The overall rating of the evaluated tactile performances is the following:

Five of the eleven evaluated performances have an unexceptional stress load, this is a state of severe stress. Two of them are even high importance tasks, one is of medium importance, two have lower importance. This design definitely has to be improved. Safety and specifically an easy and instinctive understanding of how the device works, is almost not being considered at all. The driver would be too preoccupied to be able to pay enough attention to the exterior.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>steering</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>breaking</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>putting key into position</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>start engine</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>accelerating</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust driving settings</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>bag access while driving</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>store bag</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>access in parking position</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust multipurpose</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>device form front seats</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust multipurpose</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>device form rear seats</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.10: Evaluation tool, team read, synthesis of task performances 1-4

Everything within the shaded zone between tedium level and stress level is acceptable for the particular priority. Every influence beyond this zone needs to be improved.
7.1.2 TEAM ORANGE, SYSTEMATIC OBSERVATION AND EVALUATION

Figures 7.11: Team orange, task performances 1

The task performance to evaluate here is putting the steering device into driving position. That means the device has to be pulled close to the driver and it has to be pulled apart to be fully functional.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>getting in driving position</td>
<td>high</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 7.12: Evaluation tool, task performances 1

This performance is of high importance. Due to the complicated process of pulling and opening the steering device, which takes time, this performance is stressful. People want to drive immediately after starting the car and anything which disturbs this process can be considered stressful.
The task that has to be evaluated is adjusting a certain device. Some buttons are integrated in the steering device, some are integrated in the center console.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>adjust buttons on upper part of steering device</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust buttons on lower part of steering device</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust buttons on center console</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.14: Evaluation tool, task performances 2

The performances are of medium importance. Adjusting anything on the upper part of the steering device not only looks very uncomfortable, moreover, it distracts from actual driving performance. It is highly dangerous, because the driver is likely to steer in an awkward direction while adjusting. Lower-placed buttons on the steering device and the buttons on the center console require attention, but stress-causing.
The task to evaluate is how to get feedback from the driving controls. The speedometer and tachometer are located directly above the steering device. Arrows which indicate when to turn are located at the right and left ends of the dashboard. More navigation information is in the middle of the dashboard, as well as the time and date.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>visual</td>
<td>reading speedometer and tachometer</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>reading navigation at the dashboard ends</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>reading center screen</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.16: Evaluation tool, task performances 3

Reading the speedometer and tachometer carries a higher stressload because it uses two different presentations. It is depicted by figures as well as by a blue bar which increases with speed. As a color, blue is perceived the worst (see section 2.2 Perception), moreover the brain has to differentiate between the figures and the graphic presentation. The arrows at the ends of the dashboard are less distracting, though they might not be quite obvious. The center screen is too small to easily present information and it is confusing which of the screen gives which information.
The overall rating of this interior seems to be not as positive as it could be. The steering device is more complicated with all these special features, compared to existing steering wheels. It has too many controls to be adjusted. By looking at the images it becomes clear that the handling of it is neither comfortable nor easy. The displays add more stress than they should and it is not quite clear which information is shown where.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>get in driving position</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust buttons on upper part of steering device</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust buttons on lower part of steering device</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust buttons on center console</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>visual</td>
<td>read speedometer and tachometer</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>read navigation at the dashboard ends</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>read center screen</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.17: Evaluation tool, team orange, synthesis of task performances 1-3
7.1.3 TEAM GREEN, SYSTEMATICAL OBSERVATION AND EVALUATION

Figures 7.18: Team green, task performances 1

The performances to evaluate, are steering and adjusting the turn signal which is placed on top of the steering device.

![Tactile Tasks and Levels]

Figure 7.19: Evaluation tool, task performances 1

Steering this vehicle is not as stressful as it seemed to be with the steering device of team red, whereas adjusting the turning device is more complicated. The button for the indicator sits in the upper part of the steering device. In order to set the turning device to blink on the right side, while turning to the left (a common occurrence), the thumb cannot reach the button quickly and easily.

100
The task to evaluate is how to adjust the controls in the center console, which are heating and cooling, and entertainment features.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>adjust controls</td>
<td>high</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>visual</td>
<td>get visual feedback</td>
<td>med</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 7.21: Evaluation tool, task performances 2

Adjusting the controls is highly stressful, because the driver has to precisely look at them to be able to know which button to press. All buttons sit under a flat foil which does not give any tactile feedback. Moreover, they are too far out of reach and the driver must lean forward to be able to push them. The visual feedback given causes medium stress. The contrast of the colors is not high enough, as light blue and light grey are difficult to distinguish.
Three different screens serve for information presentation. One screen, for navigation, is placed on the steering device. Speedometer, tachometer, fuel, and oil temperature are placed on a semi-transparent screen right before the windshield above the steering device. A third screen sits in the windshield and enhances environmental information.

The Sense

<table>
<thead>
<tr>
<th>The Tasks</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium</th>
<th>Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>visual read navigation info</td>
<td></td>
<td>high</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>read driving control info</td>
<td></td>
<td>med</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>read environmental info</td>
<td></td>
<td>low</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.23: Evaluation tool, task performances 3

The screens are not quite distinguishing from each other. The only screen which interferes little with the others is the navigation screen sitting on the steering device. Unfortunately this one is too close to the driver, so that the distance adjustment of the eye takes to long. The other two screens distract from the view of the street. The driving controls are too small and interfere with the windshield information.
The visual displays of this interior design are quite confusing. These three screens add more confusion than they should. Moreover two of them block almost entirely the center view. The tactile controls are not distinctive, with neither tactile feedback nor precise visual feedback supporting easy, fast, and safe use.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium</th>
<th>Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>steering</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust turns signal</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>adjust controls</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>visual</td>
<td>get visual feedback</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>reading driving control info</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>reading environmental info</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>reading navigation info</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.24: Evaluation tool, team green, synthesis of task performances 1-3

As is obvious, all of the interiors must be improved to match the standard car cockpit requirements. Some of the designed features could be applied as is. Therefore it makes sense to separately analyze them to be able to see which part is appropriate and which one needs refinement.
7.2 A CHARTER BUS DRIVER'S COCKPIT

The space to evaluate is the cockpit of a charter bus. The bus driver is hired to drive people to their particular destination. In this case, a class of senior students is going on a three day trip from Columbus, Ohio, to Holland and Grand Rapids, Michigan, in order to visit several companies. The driver is to drive this party in their travels over the three days, including staying with them overnight in a hotel, and picking them up at scheduled times.

The bus interior has a toilet and a small kitchenette in the rear, several monitors and a VCR, and luxury seats for the passengers. Though there is a lavatory provided on it, the bus makes frequent stops. On the first leg of the trip, to Michigan, the group is under no real time constraints and each stop adds to what will be a three hour delay upon their arrival at the hotel.

During each of the company visits the bus driver waits between three and five hours. During these waits he either reads, sleeps, or cleans the bus.

The bus cockpit is an indoor, mobile, active, public, semi-open, multi-user space. The space asks for more stress relief than for stimuli which makes sense since the bus driver has responsibilities to his passengers, the bus and the rest of the equipment, as well as to other vehicles and drivers.
<table>
<thead>
<tr>
<th>Space Category</th>
<th>Task Objective</th>
<th>Demands</th>
<th>Stimulation or Stress Relief</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor</td>
<td>Freedom Attributes:</td>
<td>liberty of action, undistracted view, pleasant odors, sounds, besides engine</td>
<td>Stimulation</td>
</tr>
<tr>
<td>Mobile</td>
<td>Awareness Attributes:</td>
<td>knowing where to go, awareness, no fatigue, comfort</td>
<td>Stress Relief</td>
</tr>
<tr>
<td>Active</td>
<td>Safety Attributes:</td>
<td>responsible for safe driving, knowing how to use the controls, etc.</td>
<td>Stress Relief</td>
</tr>
<tr>
<td>Public</td>
<td>Responsibility Attributes:</td>
<td>for passengers, for equipment, for service on board</td>
<td>Stress Relief</td>
</tr>
<tr>
<td>Semi-open</td>
<td>Interaction Attributes:</td>
<td>information flow, w/ environment, w/ interior, tools, feedback</td>
<td>Stimulation, Stress Relief</td>
</tr>
<tr>
<td>Multi-user</td>
<td>Reliability Attributes:</td>
<td>responsible for clean and intact equipment</td>
<td>Stress Relief</td>
</tr>
</tbody>
</table>

Figure 7.25: Analysis tool, bus cockpit

The following evaluation demonstrates when the space supports stress relief or adds to more stress load. The bus driver's private space will be evaluated as well as the standard driving performances and the arrangement of driving controls.
The tasks to evaluate are standard driving performances such as steering, breaking, and accelerating. The bus has an automatic transmission, so shifting gears is not necessary.

![Figure 7.26: Bus driver observations, task performance 1](image)

The bus driver is driving for hours and even though this space asks more for stress relief, most of the tasks are routine tasks and tend to be tedious after a while and bring about fatigue. All the required controls are within reach and are not ambiguous.

![Figure 7.27: Evaluation tool, task performance 1](image)
The performances to evaluate are access to private belongings, such as sun glasses, drinks, food, the cell phone and the check lists.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>access to private goods</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>access to cell phone</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>access to check list</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.29: Evaluation tool, task performance 2

There are no predefined spots for the above mentioned items. Because the driver needs almost all of them while driving, access is of higher importance. Unfortunately, easy and ready access is not provided, by the space and these become stress-causing tasks.
The evaluated task here is checking the driving displays while driving. The bus tends to shake and it is not as easy as it may seems to get a precise look at the displays.

Reading the driving displays is not as easy as it seems to be. The bus is shaking all the time, so the displays become blurred, as seen above. If the driver needs information from the display he has to really focus. This takes time away from looking at the road.
Here the tasks to evaluate are adjusting the driving controls and the entertainment features on the right hand side of the dashboard.

Adjusting the entertainment features can be considered of medium importance because it is one of the bus driver's job duties to entertain the passengers. This device is far out off his reach and the controls are not very distinct. Adjusting the driving controls is stressful because all the buttons are looking exactly the same. The driver has to remember which button adjusts which feature, because after frequent use the small icons fade away.
This workspace is already very stress-intensive and the interior does not support stress relief at all. Most of the observed tasks are tactile. As usual, all of the feedback is given visually. Besides his driving workload, the driver has to take care of passengers. This space does not support the required task objectives, which are freedom, awareness, safety, responsibility, interaction, and reliability. The space could support the driver’s duties by being more usable and reducing the immense stress-load.

![Diagram of task importance and stress levels]

Figure 7.34: Evaluation tool, bus driver observations, synthesis of task performances 1-4
7.3 PARKING FACILITY TOLL BOOTH AT OSU

The space of interest is one of the parking facility toll booths on the Ohio State University campus. The parking garage has four stories and fits about 800 cars. There are two toll booths, one at each entrance. The booths are very small, roughly 5 foot by 7 foot, and face into the garage. There are windows almost all around the booth, and only the the wall is covered. The toll booth operators responsibilities are to cash the parking stubs of those without a permanent parking pass. Usually this garage is used by people who pay yearly in advance. Twice per shift, a co-worker stops by and picks up the cash. The operators deal with money all day long. Communication with the customer takes place through a window on the left side of the booth, even in the winter time, the window must remain open. A space heater is placed right below this window. There is a door across from the window on the right side of the booth. Before 4 PM, the garage is not open for public use, indicated by a small sign in front of the entrance. More often than not, people try to get into the garage before that time. The employee has to get out of the booth to tell these people in the cars to turn around. There is one lunch break, which must be coordinated with the operator in the other booth, because he or she has to take over. There is no restroom next to the booth. Other than when the cash is picked up and when customers pay for their parking, there is not much opportunity for communication during an eight hours shift.

This workplace is an indoor, stationary, passive, public, semi-open, multi-user space. As one can see on the next page, this space demands more stimulation than stress relief. As in every workplace, both factors have to be balanced and it makes sense that the emphasis of this space lies on stimulation, because the user has neither
<table>
<thead>
<tr>
<th>Space Category</th>
<th>Demands Task Objective</th>
<th>entails User’s Need for</th>
<th>Stimulation or Stress Relief</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor</td>
<td>Freedom Attributes:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- liberty of action,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>to move inside the</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>booth</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- more pleasant view</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- odors, no car</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>exhaust</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- sounds, other than</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>cars</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stationary</td>
<td>Motivation Attributes:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- encouragement to be</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>friendly</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- animation to do the</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>job</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive</td>
<td>Productivity Attributes:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- information access,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>of other co-workers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- appropriate tools,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>to store tickets,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>money, forms, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>Responsibility Attributes:</td>
<td></td>
<td>Stress Relief</td>
</tr>
<tr>
<td></td>
<td>- for customers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- for equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- for correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>transactions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semi-open</td>
<td>Interaction Attributes:</td>
<td></td>
<td>Stress Relief</td>
</tr>
<tr>
<td></td>
<td>- interaction w/</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>customer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- interaction w/ co-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>worker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi-user</td>
<td>Reliability Attributes:</td>
<td></td>
<td>Stress Relief</td>
</tr>
<tr>
<td></td>
<td>- responsibility for</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>correct handing over</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- responsible for clean</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>space</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.35: Analysis tool, Parking facility toll booth, OSU campus

much input, nor much responsibility. The user’s responsibilities lie in giving the correct change and in keeping an eye on the ground floor of the facility. How well this space supports stimulation and a pleasant working atmosphere is evaluated on the next pages.
The task performances to evaluate here are the shift change duties. Forms have to be completed, money has to be counted, the collected parking stubs have to be sorted, and customers passing through must be helped. The space is too small for two people at once, so the take-over has to wait until all duties are fulfilled.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile</td>
<td>fillout forms</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>count money</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sort tickets</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.37: Evaluation tool, task performances 1

All three task performances are very important. Counting money is the most stressful, because the worker is responsible for the accuracy. Similarly, the tickets that must be sorted, as they prove how much money should be there. Even though both performances seem to have a high stress load, counting money is more stressful.

This task becomes routine and may cause more tedium, than stress, there is not much space provided to fulfill both duties at the same time. The only ‘working’ area is in front of the ticket machine and it is used to write, store, and count.
The main duties for the parking facility employee are cashing parking tickets, and taking care of the groundfloor area outside of the booth. As observed there are not many customers who do not have a permanent parking permit.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile, visual, auditory</td>
<td>cash parking stubs, check parking time, give price, take money, give change, store ticket</td>
<td>high</td>
<td>med low</td>
<td>1 2 3</td>
</tr>
<tr>
<td>visual</td>
<td>checking the groundfloor</td>
<td>1</td>
<td>2 3</td>
<td>o...</td>
</tr>
</tbody>
</table>

Figure 7.39: Evaluation tool, task performances 2

Cashing the parking stubs is an important task, but it is not very stressful. It becomes a completely routine performance, therefore the worker has to be stimulated to best perform. Checking the groundfloor is an important duty as well, because the parking facility is offers a safe parking area. The worker does not have to leave the booth, as checking is only supposed to be visual. This duty asks for a lot of stimulation.
The fourth task to fulfill is to hand out the cash to the co-worker who stops by twice per shift. Forms have to be filled out and the money and tickets have to be handed over.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile, visual, auditory</td>
<td>fill out forms</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>hand out money, and tickets</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.41: Evaluation tool, task performances 3

Filling out the forms is a medium stress task because it asks for precision. After several shifts, this task becomes routine as well and is more dull than it is stressful. Handing out the money is not really stressful, except that it be counted and that the transaction must be correct might add to a certain stress load.
The parking facility booth worker has basically only four duties to fulfill, therefore all of the tasks are high of importance. Other than fulfillment of these duties there is, in fact, no work to do and the operator has to be kept motivated and stimulated all the time. The semi-open space allows daylight into the workspace itself, but during winter time there is not much sun and daylight. During that time the main light comes from the ceiling light and the light of the garage. This garage light is orange light and may cause headaches.

<table>
<thead>
<tr>
<th>The Sense</th>
<th>The Tasks</th>
<th>Importance</th>
<th>Tedium Level</th>
<th>Stress Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>tactile, visual, auditory</td>
<td>cash parking stubs, check parking time, give price, take money, give change, store ticket</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tactile, visual</td>
<td>fill out forms (shift change)</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>count money</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sort tickets</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>fill out forms</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>hand out money, and tickets to co-worker</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>visual</td>
<td>check the groundfloor</td>
<td>1 2 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.42: Evaluation tool, synthesis of task performances 1-3

There is no possibility to enhance the duties to make this job more positively demanding. The space itself has to be changed to support the necessary motivation. One main problem is the light that comes from the garage and the light provided within the booth. The following graphics show an attempt to solve the lighting issues.
Figures 7.43: Lighting improvements for toll booth workspace

Improving the light settings within this space would definitely contribute to a positive well-being or feeling for the toll booth operator. The light beams in the corners serve as working lights for seeing everything on the desk. The distributed lights in the ceiling are the main source of light and support a better atmosphere than the two light beams that were there before.
8.0 CONCLUSION

The previous chapter demonstrated how to apply the analysis and evaluation tools by using systematic observations of spaces as information resources. These tools, that were especially developed for restricted workspaces, may serve as guides for designers in demonstrating importance within particular space-task-user relationships. Different spaces with similar categories may be compared by using the analysis tool and serve as analogies for each other. Even though the compared spaces could be different, their usable and positive solutions may be applied in other contexts.

These tools can help designers within the development process and may serve as communication devices. With their visualization of relationships and the possibility to serve as evaluation tools, they arm designers with arguments for either clients, co-workers or other professionals with whom designers work. Both tools can help to point out positive and negative features within designs themselves and may even show whether a design is 'good' or not. These tools make it possible to express design, as well as to show designers' responsibilities in development processes. Further, they may help designers to see their own lack of knowledge in order that they might consult other disciplines with specific questions. By implementing the analysis and evaluation tools explored in this study these questions can be presented in context, making communication with those other professions easier.
8.1 OPEN PLAN OFFICE,
EXAMPLE OF EXISTING IMPROVED APPLICATIONS

The following and last restricted workspace presented here demonstrates the application of analysis and evaluation tools with examples of existing improvements. The examined space is a generic open plan office. The standard interior is a three sided cubicle. Workers either have printers on their desks or share them with co-workers in a separate room. They tend to send each other emails instead of walking across the room to talk with colleagues. They often have to make phone calls, however they are less likely to deal with customers at their desks. This workplace is an indoor, stationary, passive, public, semi-open, single-user space.

- **space category**: demands task objective entails user’s need for stimulation or stress relief
- **indoor**
  - freedom attributes: stimulation
    - liberty of action, space to move
    - pleasant view
    - odors, fresh air
    - pleasant, productive sounds
- **stationary**
  - motivation attributes: stimulation
    - encouragement to communicate
    - animation to be productive

Figure 8.1: Analysis tool, open plan office 1/2
<table>
<thead>
<tr>
<th>space category</th>
<th>demands task objective</th>
<th>entails user's need for stimulation or stress relief</th>
</tr>
</thead>
<tbody>
<tr>
<td>passive</td>
<td>productivity attributes:</td>
<td>stimulation</td>
</tr>
<tr>
<td></td>
<td>• information access, of other co-workers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• appropr. tools to do the job</td>
<td></td>
</tr>
<tr>
<td>public</td>
<td>responsibility attributes:</td>
<td>stress relief</td>
</tr>
<tr>
<td></td>
<td>• for productivity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• for quality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• for equipment</td>
<td></td>
</tr>
<tr>
<td>semi-open</td>
<td>interaction attributes:</td>
<td>stimulation stress relief</td>
</tr>
<tr>
<td></td>
<td>• interaction w/ customer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• interaction w/ co-worker</td>
<td></td>
</tr>
<tr>
<td>single-user</td>
<td>autonomy attributes:</td>
<td>stimulation</td>
</tr>
<tr>
<td></td>
<td>• know-how</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• experience</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• routine</td>
<td></td>
</tr>
</tbody>
</table>

Figure 8.2: Analysis tool, open plan office 2/2

Five of the space-task relationships require stimulation, two demand stress relief in this space. Motivation, productivity, and interaction are three important task objectives in this space that entail a need for stimulation. Freedom of space, with the resulting desire for more attachment to nature, is another. The images on the next pages show a generic open plan office situation including an evaluation that is not focused on particular task performances within the space but on general demands on the space-task relationships. The provided positive examples shall give an idea of how to convert the findings into usable applications.
Interaction and communication with other co-workers is considered of high importance. Working all day long inside the cubicle is no sense stimulating, it may even contributes to a certain stress load. One possible positive improvement may be a coffee-bar as a casual meeting point in the middle of the entire space, as opposed to the upper example of a kitchen which is outside the working area.
Productivity is a very important task objective within an office. Therefore, the surroundings must foster stimulation, motivation, and inspiration. The above examples are more likely to provide boredom and stress due to the uninspiring environment.

An easy way to foster inspiration is a bookshelf with all sorts of magazines and literature as a positive distraction. Another possibility may be dividers that can be changed individually to bring some color and personality into the office space.
Another important factor within an office space is organization. For either to foster individual accomplishment or to coordinate teamwork. A simple way to organize tasks is to post them on top of the monitor (see picture 8.1.15). A way to communicate with co-workers is to have displays that can be reached via computer or on the spot which show information to those who pass by.
8.2 FINAL SUMMARY AND OUTLOOK

Providing design and related fields with analysis and evaluation tools may help to communicate ideas and innovations to those who cannot imagine the immeasurable. The matters of design that were discussed in the very beginning of this study may help in implementing the synthesis of the space-task-user evaluation into usable design solutions.

Even though these tools were especially developed for spatially restricted workspaces, the methodology itself may be applied to all kinds of spaces and even to products. Differences would lie in the categories and the resulting changes of relationships between user, task, and environment, or user, task, and product. The state of these tools is progressing, and they ought to be seen as a beginning in developing tools with the purpose of balancing design. To now, they are mere theory and weren't applied in an actual design process, which would be the next step.

This study's aim is to supply design with tools that support its work, and that make it easier to communicate it. Moreover, considering the concerns and matters of design, this study's intent is to support a multi-sensory application in design, which is supposed to relieve the visual sense and focus on all senses in parallel, and to develop designs that are intuitively understood. Because...
...design's responsibility is to take more into account than only human dimensions.

Figure 8.14: The Human-Mind-Dimensions-Figure
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Licht, German Light Magazine

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APPENDIX A

PERSONAS AND SCENARIOS DEVELOPED IN THE COLLABORATIVE RESEARCH PROJECT 'SMART COCKPIT' 2002/2003

In the year 2002/2003 a study was conducted at the Department of Industrial, Interior, and Visual Communication Design at The Ohio State University, in collaboration with the Center of Automotive Research, the Department of Mechanical Engineering, and the Department of Industrial and Systems Engineering. Focus of this study was on topical cognitive, operational, and technological issues aimed at enhancing driver-vehicle-environment interaction, with the intend to develop 'Visionary Concepts for Tomorrow's Automotive Cockpits and Interiors'.

Part of this study was to develop personas and scenarios to define users needs and desires in the future. The following examples show how to use this tool to generate data in order to develop concepts that can be transferred into actual design applications. Generations of interest were baby boomers, generation X, generation Y, and the so far nameless last generation which we called Z. Each generation is represented by two individuals. All developed personas have a personal context as well as an historical context. The bold text passages show were concepts may be derivat-ed from the situational context. A timeline shall give examples of common experiences that these generations share or not. Included are the two already presented personas of chapter 4.2.2.
The following pages show the selected users by 2015 including their stories based on the combination of the general historical and their personal contexts with the situational circumstances.

Generation Baby Boomers presented by Linda and Larry with the age of 68.
Generation X presented by Joe and Judy with the age of 49.
Generation Y presented by Eve and Eric with the age of 35.
Generation Z presented by Adam and Amy with the age of 21.

Generation baby boomers historical context:

When Linda and Larry were born in 1947, Harry S. Truman was president and World War 2 was over for only two years. Artists like Frank Sinatra, Bing Crosby, Vaughn Monroe, and Count Basie had number one hit songs, and Louis Armstrong was already a very well-known jazz musician. The telephone area code system for world zone 1 (North America) was introduced which allowed operators and later automatic switching systems to handle nationwide telephone calls. Aluminum foil was invented and Tupperware was available for a year. The first invention in the direction of personal computers were made, the invention of a point-contact-amplifier. Back in these days, Ferrari was founded, Volkswagen finally sold the beetle commercially and started to think about a minivan, which was developed two years later.

Generation X’s historical context:

When Judy and Joe were born in 1966, Mexico City prepares for the Olympic games, television was changing to color, and the Soviet Union accomplished the first unmanned landing on the moon.

Arpanet: the first nationwide computer communication network was established.
While the Beatles had #1 hit songs like, 'Nowhere man', and 'Paperback Writer', and James Brown, The Rolling Stones, Simon and Garfunkel, The Temptations, The Beach Boys, Steve Wonder, Bob Dylan, The Who, Jimmy Hendrix and many many more, were successful this, the previous, and the following years.

Major military confrontations developed between the US and North Vietnamese forces.

Generation Y’s historical context:

When Eve and Eric were born in 1980, Ronald Reagan wins the presidency in a landslide over Jimmy Carter. John Lennon is assassinated in New York City in front of his apartment at the Upper East Side.

The US boycotts the summer Olympics in Moscow, USSR, and CNN is launched as the first news-only network. Japan surpasses the US as the world’s largest car-manufacturer. Charles and Diana get married and the computer game Pac-Man is introduced with great success.

Generation Z’s historical context:

Adam and Amy were born in the year 1994, when the existence of the black holes in the Universe were proven.

Movies such as Forrest Gump, Pulp Fiction and The Lion King were running in the theatres. Erich Honecker (the former president of the German Democratic Republic), and Richard Nixon just died. So did John Candy, Cab Calloway, and Henry Mancini, any many many others with whom Linda and Larry, born in 1947, grew up with.

Adam and Amy are contemporaries of Home-Computers, the Internet, e-mails, and cell phones. The cold war was over for years, but terrorism began to spread rapidly and increasingly uncontrollably.
Personal scaffold Linda:

- Linda
- 68 years old
- female
- divorced for 13 years, two children, several grand children

**Educational background**
- MA Education, major Child Psychology
- Ph.D. in Childhood Development

**Professional experience**
- elementary teacher
- part time prof. at the University Richmond

**Body type**
- medium-build
- active

**Physical, health condition**
- overall good
- eye-sight declining
- hearing declining

**Personality traits**
- impulsive
- extrovert

**Behavioral traits**
- 'busybody'

**Activities**
- Yoga

**Interests**
- grandchildren
- volunteer work
- gardening

**Financial status**
- high income

**Living condition**
- rural condominium
- within city limits
- 2nd home in Florida

Figure A1: Persona Scaffold, Linda
Linda's personal context:

Linda graduated from college in 1969, right before she married her husband Paul. He soon started to work at the NASA Kennedy Space Center in Florida, where she was teaching at the same time. They had three children. 49 years old she went back to college and worked on her Ph.D. in Early Childhood Development. In 2000 she was made a job offer by the University of Richmond, where one of her daughters lives now. She accepted and moved up to Virginia. Soon the already broken marriage ended in divorce. She inherited her parents' condo in Melbourne/Florida.
Linda never liked to fly. She always preferred to drive by car. Even with 68 she still loves to drive from Virginia down to Florida, most of the times all by herself.

Larry's personal context:

Larry grew up in the San Francisco area, where he still lives. He graduated from High-school in '65, started to study Architecture and Economics and got lost in the summer of love in 1967. He joined the Peace Corps in West Africa from '69-'71 helping to develop their economic conditions. When he returned he married Sue, whom he knew since High-school. He took over his father's construction company, and finally completed his MBA in the late 70ies. In 1998 he lost almost all of his investments, while the construction business decreased rapidly. He managed to keep his company, but had to cut down on employees and offices. A year after his wife died he had a stroke he still recovers from. His son is gradually overtaking the company, while Larry starts to cut back as much as he can.
Personal Scaffold Larry:

- Larry
- 68 years old
- male
- widower for 1.5 years, big family

- educational background
  - major in Architecture
  - graduated in Economics
  - BS in Business Administration
  - MBA

- professional experience
  - owns and runs family construction company

- body type
  - overweight

- physical, health condition
  - recent stroke
  - heart condition

- personality traits
  - grandfatherly
  - seasonal depressed
  - short tempered

- behavioral traits
  - jolly
  - gregarious

- activities
  - used to sail

- interests
  - church

- financial status
  - medium income

- living condition
  - big rural house

Figure A2: Persona Scaffold, Larry
Baby boomer scenario Linda, situational context:

It is between Christmas and New Years Eve in the year 2015. Linda is packing her car. She will be leaving for Florida in the next hour. It is snowing and very cold. The plan is to meet her friend Richard in three days down in Melbourne in her condo. This time she wants to drive along the east coast. She doesn't like to drive longer than three hours at a time, and wants to drop by at her sister's in Atlanta. So Linda sets her Navigation to figure out good stops to have a snack and get cheap gas. Her car is already set for the long trip. Everything she needs during the drive such as her coffee, water, the cell phone, some treats and the old fashioned maps are in their places right next to her. Linda ones almost had an accident because the hot coffee spilled over her legs. Since then she appreciates the advantages of her short and long term settings in the car, where everything is in the right place for every occasion.

Her children still don’t like the idea that she always travels all by herself and that she occasionally picks up hitch-hikers. Therefore the the car sends them automatically every two hours her location and her being well. It is 9 AM and Linda is about to hit the road, everything sits in the right place. The presents, her luggage, the new armchair she bought for the apartment, some books, discs and of course the cooling box. Her first stop is at a gardening store, where she wants to get some plants for her sister. It is hazy, and the view is less than ideal. Linda activates the windshield system, which makes objects more visible and detectable on or next to the road. By the time she leaves, the car sends a note to her children that she started the trip, and where she is heading to next. There is some traffic on the freeway, unfortunately mostly semi-trucks. They are driving fast and erratic -everyone is trying to get home in time for New-Years-Eve. So, they are overtaking when-
ever it is possible, throwing mud on the passenger cars' windshields. Linda is glad that her car sits higher than the average car, and lets her have a better overview.

The first six hours went by and she already stopped twice. The Well-feeling sets the temperature a little bit cooler than cozy warm, so that Linda won't get sleepy. Her backrest changed the lumbar and side supports a little, so did the seat-pan, for better blood circulation. After eight hours on the road, it is already dark and Linda is close to her sister's, the car gives an alert that there is a animal on the road, it automatically slows down, due to the wet and muddy road, the radio reduces the volume, and Linda escaped with only a little scare. She had felt already somewhat sick before she left Richmond this morning. Now that she is driving for more than 8 hours and after the near accident with the deer, she wishes she were already at her sister's in Atlanta.

Linda is fatigued, the Well-feeling measures a higher temperature, she has already a low grade fever. Luckily there is only one more half hour to drive. Her sister gets a note from the car that Linda is not feeling well. She prepares hot tea and a hot bath. By the time Linda arrives, everything is set, dinner is almost prepared and she takes a long bath. The next morning, she decides to stay another day, because of a cold she is developing. She doesn't feel like calling everybody, so she uses her car to send them messages that they don't have to worry.
Baby boomer scenario Larry, situational context:

It is 1:30PM on a sunny Saturday in the middle of August in 2015, the temperature reached 94°F, with low humidity, which is rare for this area.

Larry is running some errands. He has to get groceries for the Church cook-out, he is organizing now for almost 20 years. Since he had the stroke six month ago, this is the first time he is back to his routine. Melissa, a good friend of his, did the grocery list and send it to his in-car system last night, which checked the prices at the different stores and transmitted the data to the Navigation. The Navigation prepared the route considering rush hour traffic, new construction sites, and a convenient way to drive. Larry has to stop at two places to get everything they need, such as food to grill and charcoal, as well as beverages and ice. The event is scheduled for late afternoon/early evening, so he has actually plenty of time to do the groceries.

While he has a light lunch, Larry checks the route with the portable Navigation device. He already knows the two shopping malls, one 12 Miles north of his place and another 6 Miles west. There is road construction for quite some time now, but he is not sure whether this will effect his way or not. With the agenda set he sits in his car and drives towards the first mall. Before the Navigation could give an alert they closed the road right in front of him. He did not even get to a full stop, when the navigational already suggests a u-turn, and to go to the other mall first. It is unusually hot and he is grateful for the air-condition. Only half an hour late he gets to the shopping mall. Coming back to his car he runs into an old friend and they are chatting for about an hour. While they are talking the system gets a message from Melissa that he should also buy paper plates and potatoes. His in-car system adds the new items to the grocery list. By the time he gets in the car a new
printed version of the list has been adjusted accordingly.

Larry gets easily stressed out, and now after talking for so long after and the
detour he had to make, he feels under some time pressure. He has one hour left to
get the rest on the list, drive down to the church, and starts the cooking. Short tem-
pered as he is, he starts swearing at the traffic, and drives like a maniac. The
well-feeling system activates after detecting high blood pressure, and wet hands.
A relaxing scent is released into the air, and the temperature is lowered to calm
him down. The communication system, familiar with his time schedule ‘asks’ him
if he wants to send a message to the church group telling them that he will be
late. He accepts the suggestion and starts to relax.

While he gets closer to the shopping center the AC resets to acclimate to
the outside temperature. Since it is very hot outside compared to the inside temper-
ature, the change would otherwise be too extreme. Back in the car he has a 20 min-
utes drive ahead of him. The traffic worsens. He opens a window to shout at
another car, when a bee flies in and stings him in his arm. Larry is allergic of
bees. Fortunately his health record is stored in the well-feeling system, so the car
‘knows’ about his condition. He has enough time to hit the emergency button
which activates the hazard lights, and automatically slows the car down. When it
eventually stops at the curb, an emergency signal is automatically activated and sent,
reporting the incident and Larry’s present location. Emergency and police cars in
the vicinity receive the message. Luckily an emergency car is close to Larry’s posi-
tion, able to help him within 10 minutes. He only needs an injection and after a few
minutes he is recovering. He still has a slight shock, so the ambulance wants to take
him to the hospital, what Larry vehemently refuses to do. He can convince them
that he is safe enough for driving his car, because the safety system would take
over in case he looses control of the situation.

Over at the church, the members already know from the communication-
system that Larry was helped and that he is doing well. By the time he arrives,
everybody is there to welcome him. The only one worrying is the cook, who doubts
that the food is still fresh enough. What he didn't know is that Larry's car's AC
can be adjusted to maintain different temperatures within the interior, meaning
that all groceries were kept sufficiently refrigerated.

Two hours later they eat and drink, and Larry tells the 'congregation' what
happened to him earlier today, and that thanks to the systems in his car, everything
turned out okay.
Personal scaffold Judy:

- Judy
- 49 years old
- female
- married, no children, but two big dogs

- educational background: JD, Ivy League Law School
- professional experience: corporate attorney
- body type: slightly overweight
- active
- physical, health condition: excellent-good
- personality traits: organized
- articulate
- behavioral traits
- activities: camping
- outdoor
- running
- biking
- interests: wine connoisseur
- hobby chef
- arts
- financial status: high income
- living condition: downtown loft

Figure A3: Persona Scaffold, Judy
Judy’s personal context:

Judy grew up in New Hampshire/New England. After graduating from Highschool in 1983 she spend one year in France as an au-pair. She graduated from Yale Law School and accepted a job at a San Francisco law firm, where she met her husband, Gregg while snowboarding at Lake Tahoe. Shortly after, she moved to Seattle/Washington where he already worked at Nintendo. They often spend the weekends camping, hiking, and cycling and with their love for all kind of outdoor sports, they visit friends all over the country if the time allows it. They have no children, but two big dogs.

Joe’s personal context:

Joe met his wife Mary late in life at age 36. Back then he held several part time jobs, mostly as a consultant. The family settled in Boston, where they still live. His two older kids are very active, playing soccer or football, are both members of a theatre group, and thus have many friends they visit frequently in town. Some of them, however, reside in the suburbs so that Joe and his wife often have to drive considerable distances to enable the the kids’ friendships and relationships in a area that still lacks sufficient public transportation.
Personal scaffold Joe:

- Joe
- 49 years old
- male
- married, 3 children (1, 10, 13 years)

- educational background: MBA, major in IT
- professional experience: consultant, media business
- body type: medium build
- athletic
- physical, health condition: excellent-good
- wears glasses
- personality traits: courteous
- alert
- behavioral traits
- activities: jogging
- sailing
- interests: family
- travel
- financial status: high income
- living condition: rural house
Generation X scenario Judy, situational context:

It is a clear and crisp Friday afternoon at the end of April. Judy and her husband Gregg planned on spending the weekend in the mountains. The night before they were brainstorming where to go. Especially Gregg likes to camp outdoors, but both enjoy hiking in the mountains, and definitely want to ride their bikes. Whenever possible Judy visits farms to buy fresh organic food. As usual the dogs are taken on the trip, so Judy and Gregg need to look for areas were dogs are allowed.

While Judy prepares for the trip, Gregg checks the navigation system to search for routes and destinations. He loves this device and keeps adding new sights and potential points of interest while on the road. He basically uses the navigation system as a convenient and flexible information notebook.

With the bicycles already mounted, and all luggage in the car the dogs jump in and the party finally hits road by 4 PM. Judy is driving, while Gregg is configuring the navigation system. He creates several folders to store information about places they have already been and places they may want to visit, considering all kinds of hiking and cycling details.

Judy gets a phone call from her office while driving on a winding stretch of the road. The communication system considers the business call as being very important, and suggests an instant response. It is about a case the office was working on all day, Judy gets instantly deeply involved. Unfortunately she cannot stop, because the road has soft shoulders. On a typical Friday afternoon and in rush-hour traffic people on the road are tired and with their minds focus on the weekend. In addition the dogs are not quiet but horse around in the rear of the car.

Judy is increasingly paying attention to the arranged conference call while trying to continue to drive. This alarms the vehicle-operation system which is
programmed to first warn and to take over the driving operation if necessary. Judy is still involved in the conversation preventing her from noticing the car in front of her is suddenly slowing down. Gregg is still totally preoccupied with the navigation system and not aware of the dangerous traffic situation either. The safety system gives an alert and the vehicle-operation system slows down, before Judy was even able to realize what was happening in front of her. Luckily, the situation resolved itself and they continue their trip to the first stop. After a full work day and three hours of driving were enough, and both realized that they are too tired to go any further. Gregg checks the navigation/system for vacant accommodation, and where dogs were allowed. Not far ahead, some 20 Miles, is an open camp ground which has a nice restaurant next to it. Gregg uses the communication system to reserve a spot on the camp ground as well as a table at the restaurant. Half an hour later the manager welcomes the two of them by name leads them to their site on the camp ground and points them the way to the nearby restaurant, where the already ordered appetizers and the wine are waiting on the table.
Generation X scenario Joe, situational context:

It is one of these foggy fall days, rather windy, with the leaves falling down, and with rain in the air. Joe is leaving a client after a long three hour meeting, and finally on his way. The meeting was exhausting and his mind is still on the subject. He is driving routinely like machine without being fully aware of the situation around him. He passes through an intersection not noticing whether the traffic light was green or red. Since the safety-system would have stopped the car automatically in case the light being red, he suddenly realizes that he seems to drive totally absent minded. To counteract this mode, Joe decides to stop for a run in the forest, requiring to take the nicer scenic route which would take an extra half an hour longer, but is really beautiful during fall season.

Fifteen minutes later Joe changes his outfit. He always has a set of running shoes and sports equipment stored in the car. He sets his in-car system to be back in 30 minutes, just in case the client or one of his colleagues try to contact him. Joe leaves the car but takes the small communication-module which functions as a multipurpose device including keyless entry. This module is able to receive and send short messages from and to the car's communication system. Of course, while he is running, a phone call comes in, it is his office sending an urgent note. He confirms that he got the message, and hits back to his car. He activates the in-car system in case he has to take notes, and calls the office. While dialing, the interior changes from driving status to office status, meaning the steering device gives place for a small work surface with a keyboard-like input device, whereas the windshield affords a large screen. The client had some further questions, and Joe joins the conference call already under way. The windshield-screen allows him to see not only his data but also the participants' faces at the same time. Luckily the
problem was not as hard to solve as he thought. After half an hour all is taken care of.

Meanwhile it started to rain, and in comes another call. His daughter asked him to pick her up in town, because of the decreasing weather condition. She has a similar communication-module device like he has. She immediately received a note from the system that her dad had has an important call on the other line, but will get back to her as soon as possible. The system can differentiate between the callers, and the systems they use. So in this case, the communication system 'knew' it is his daughter based on the same code they use. Joe is on the way to his daughter, but the roads are getting slippery, with wet leaves all over the asphalt. The safety system is on alert to take over if necessary. The need occurs in a number of situations where Joe would have misjudged the traction of his tires. He reaches the meeting point safely and soon after they arrive at home.
Personal scaffold Eve:

- Eve
- 35 years old
- female
- not married, daughter 15 years

- educational background
  - major in Art
  - major in philosophy
  - major in computer science

- professional experience
  - owns coffee shop
  - multimedia-ceramic-artist

- body type
  - medium-build
  - active

- physical, health condition
  - excellent good
  - previous hand injury

- personality traits
  - assertive

- behavioral traits
  - hyper-active
  - confused

- activities
  - swimming

- interests
  - art
  - museums
  - galleries if time

- financial status
  - regular income

- living condition
  - suburban house/loft

Figure A5: Persona Scaffold, Eve
Eve's personal context:

Eve is one of those ‘hybrid’ artists, who combines ceramic techniques and computer installations. She also owns a coffee shop in Cambridge/Mass, which makes her meet the bills. She lives alone with her daughter, 15, in a suburban house. Eve became pregnant when she was in her 2nd year at MIT. As a result she lost her scholarship and had to work full-time to survive. She maintains a good relationship with her former professors, but was never able to finish her college education. Eve is a passionate artist but with too many different jobs, managing the coffee shop, taking care of her daughter, and organizing exhibitions—all on top of her artistic interests. As a driver she behaves confused, is hectic, and has a very bad sense of navigation.

Eric's personal context:

Eric used to be a professional football player until he had a severe knee and shoulder injury. That was 10 years ago, after which he decided to become a football assistant coach, and started to study Exercise Physiology. He met his wife, Laura after college, and being a real estate agent she sold him the house they are now living in. They have been married for 7 years, and their kids are 8 (girl) and 6 (boy) years old.
Having little time for vacation they like to take short trips and love to visit interactive-adventure parks with their children.
Personal scaffold Eric:

- Eric
- 35 years old
- male
- married, 2 children

- educational background: BS, Exercise Physiology
- professional experience: former prof. athlete, college football assistant coach
- body type: tall, muscular
- active
- physical, health condition: pretty-good
- knee, shoulder injury
- personality traits: short tempered, fearless
- behavioral traits: carrying, ambitious
- activities: golf
- family, chess, off road rally
- interests: high income
- financial status: upscale suburban house
- living condition: high income

Figure A6: Persona Scaffold, Eric
Generation Y scenario Eve, situational context:

It is another hot summer day. Eve worked almost the entire night on some new pieces for the next exhibition before she went to open the coffee shop around 6 AM. It appears to be one of these busy days. After work, she needs to run some errands for the coffee-shop before she meets with her gallery agent around 4:30 PM. Afterwards she has to pick up her daughter and meet some friends for dinner. Eve depends on a planning device, since she has a tendency to get lost in time and space. With all her interests and responsibilities, she is definitely overloaded and depends on various systems that keep her organizing and managing the days.

It is now 3 PM and she is about to leave. Even though she has been living in this town for some time, she still cannot clearly remember which route to go. So the navigation system is connected with her schedule and has already arranged the drives for the day. As usual the setting of the safety system is on 'high priority'. During the last couple of months the system has prevented her from several accidents. She has always too much going on to be concentrated and focused on traffic. After shopping, the car is stuffed with ceramics, groceries for the coffee shop, paper-works, and some other loose items.

Close to campus the people don’t pay much attention to the traffic, they jay-walk without looking. The car is automatically slowing down several times, before Eve can even react. Her meeting at the gallery went well and she is on her way to pick up her daughter, when an emergency call from the coffee shop comes in. Instead of next morning they need the groceries right away. Eve picks up her daughter, Dana, as planned and went back to the coffee shop. The traffic worsens even though it is way after rush hour. It finally all stops. Her daughter checks the navigation system for more exact information. The car to car info system sup-
ports communication between vehicles if set for info-flow. Luckily the first car in
the traffic congestion allows to transmit data, so Eve and Dana are able to see on the
screen what is happening a mile ahead. There is a flooded road segment blocking
the intersection, but they can see construction workers already fixing the problem.
Eve decides to wait, because the ‘info-car’ sends out a note that the work is sup-
pposed to be completed within minutes. Meanwhile, the communication system-
sends a message to the coffee-shop, and only a few minutes later the traffic starts
moving again.

At the end of the trip, when they finally arrive at their friends’ place for din-
ner, the safety system has been intercepting four times, and the navigation system
changed the route to go around traffic three times.
Generation Y scenario Eric, situational context:

It is another rainy Sunday afternoon in late October, around 2 PM and the family just had lunch. Eric is supposed to drop off his children at their Sunday activities. His little boy started to play virtual-soccer this season and is eager to go to the training facilities. His older daughter, who just turned 8, has been a member of the theatre church group for almost half a year now. Both kids are excited, they sit in the rear car and horse around. It is supposedly half an hour drive. His daughter needs to practice some lines. She uses the in-car system to help her doing that. The little boy next to her is playing with his soccer ball. The kids start to argue, and fight on the back seats. Eric tries to calm them down when suddenly the weather changes, the sky turns dark, with leaves and branches creating obstacles especially in the heavy rain. Involved in play the kids don’t realize the dangerous situation, and the ball hits the windshield, bouncing back on Eric’s head. He reacts intuitively by turning the steering device without even realizing the possible consequences. The safety system and vehicle-operation system in checking car and environment constantly and not detecting exterior reasons for the sudden lane change takes over and keeps the vehicle in line. To top it all, two umbrellas are flying in front of the car ahead. This time Eric saw it coming, but the safety system already sensed the movement and slowed the car down.

Meanwhile the safety system and well-feeling system, reminded the kids to sit down quietly. The sound comes directly from above only the addressed passenger can hear it. The kids react appropriately and the dangerous situation is effectively resolved. Soon they reach the training facilities for the boy.

The system gets a message from Eric’s wife. She sends a note to the Inter-communication system asking him to run a few errands. Once he dropped of his
daughter he reads the printed shopping list. His navigation system suggests where
to find the items and adjusts the original route accordingly. Eric getting tired,
appreciates the system’s suggestions, and drives to the shopping mall.

Recalling the potential danger of the situation he just encountered, Eric is
once again grateful for the life-saving systems that are available nowadays.
Personal scaffold Adam:

- Adam
- 21 years old
- male
- gets married in 5 months

- educational background: environmental engineering
- professional experience: student
- body type: medium build
- physical, health condition: slightly overweight, good
- personality traits: careful, spolt
- behavioral traits: attentive, ambitious
- activities: hiking
- interests: church
- financial status: support from parents
- living condition: urban apartment

Figure A7: Persona Scaffold, Adam
Adam's personal context:

Adam plans to get married in five months. He just turned 21 this month, and is now owner of one of those new midsize crossover vehicles. His parents gave him the car as a birthday present and early wedding gift. He is very proud of the choice, which has countless special features. Such as the Navigation, the On-Board-Business, and the Safety system amongst others. He and his fiancée are living in a small college town in Colorado. Both are sophomores, and full of enthusiasm for the future. Adam was never a fan of organized sports, but likes to hike and travel around by car.

Amy's personal context:

Amy graduated from High-school at 18 and utilizing her connections transferred immediately to New York City where she found work as a fashion model. With a medium/high income she can afford to live uptown in Morningside Heights, sharing the spacious apartment with colleagues. Although her parents provided her with a small crossover car, she of course commutes by public transportation as much as possible. Amy visits the gym regularly and being a music lover drives from concert to concert in the company of her friends. Amy is a cheerleader type, spontaneous, outgoing and ambitious, and spends much of her money on clothes, fitness, concerts and on nightlife, even on constantly upgrading her apartment.
Personal scaffold Amy:

- Amy
- 21 years old
- female
- single

- educational background: high-school
- professional experience: photo model
- body type: tall, slender
- physical, health condition: excellent-good
- personality traits: outgoing, spoilt, cheeleader type
- behavioral traits: glamorous, ambitious
- activities: sports
- interests: clubbing, movies, concerts
- financial status: medium income
- living condition: shared appartment, NYC

Figure A8: Persona Scaffold, Amy
Generation X scenario Adam, situational context:

It is a nice and sunny spring afternoon in April and the air is crisp and clear. Unfortunately, Adam has a really busy day ahead. He has to drop off his fiancée Laura at the airport, pick up his mother’s birthday present at the store, and needs to stop by at one of his classmate’s to collect the research project’s laptop. He finally has to continue to his parents place for mom’s birthday and the Easter holiday.

Laura likes to tease him about his preoccupation with the features of his new car. Adam sits on the balcony and checks the car’s condition, such as oil, fuel, and tire pressure, with the mobile-communication device. He loves to play with his navigation system and setting it comparing different routes and calculating schedule and timing as accurately as possible. The navigation system reports the weather forecast and sends a warning for severe afternoon storms. Around noon, he drops off Laura at the airport and promptly gets stuck in a traffic jam. The navigation system quickly changes the route to keep him within the timeframe of his reserved short term parking spot at the store. Certain parking meters can be reserved ahead, and luckily he arrives in time.

Not long after picking up the mom’s present, he meets with his classmate. The are talking long enough for Adam running late, which puts him right in the middle of the rush hour traffic. The roads are grid-locked. Nothing moves. He is getting nervous, having planned everything so perfectly. The well-feeling system quietly releases a calming scent, and adjusts the seat’s backrest to a more relaxing position. Not wanting to waste any time he connects the in-car system to his laptop for completing his homework. Parts of the windshield acts as screen, not blocking the view entirely in case needs to react to a change in traffic conditions.

An hour goes by before the traffic starts moving again shutting down the sys-
tem to prevent distraction. Meanwhile the well-feeling system detects diminishing attention caused by low blood pressure and low blood sugar level. It suggests to stop for some food and beverages while the communication system sends a note back home, that he will run a little late. Adam adheres, gets something to drink and eat, and continues his trip.

More than four hours late he arrives at his parents place, and thanks to the smart systems he was able to rely on, both safe and relaxed. The excellent entertainment amenities, the activated seats, and the responsive navigation system amongst others turned an otherwise stressful, exhausting, and time wasting trip into a rather pleasant experience.
Generation X scenario Amy, situational context:

It is Friday late afternoon/early evening. Amy's workday is finally over and she leaves the studio after shooting fashion for a leading magazine. It is hot outside and very humid, with little oxygen left in the air, but plenty pollution.

Amy brought her car downtown this morning to transport material for the shooting, and is now stuck in heavy traffic. She is in a hurry, she has a total of two hours to drive back home, take a shower and change, pack her stuff for a weekend trip, call her parents and come back downtown to meet up with her friends for dinner and to plan the trip.

The traffic is extremely dense, people are driving unpredictably because of the hot weather conditions. Amy is in a hectic mood, she is known for always being late and this time she wants to impress her friends by arriving early. The navigation system suggests to take a detour because of an accident five blocks ahead. The well-feeling system measures high blood pressure and wet hands, and changes the music to more calming tunes, and massage functions in the backrest are activated. The communication system receives a phone call from her mom, and responds by telling her that Amy is moving slowly heavy traffic. Two minutes later the agency calls with a high priority message, the communication system suggests Prompting Amy to stop at the next possible spot, to take the phone call. She forgot to sign a paper at the studio, which requires of her to stop by later on her way back downtown. The in-car system adds the stop in the scheduling device, whereas the navigation system already plans the trip back including the detour. While she is packing, the navigation system checks the route downtown and reserved a short term parking spot near the studio and one medium term at the restaurant where she meets with her friends.
Finally everybody arrived and they are sitting around the portable navigation device and talking about what they would prefer to do over the weekend and even while driving. Options are, visiting concerts and dance clubs, camping, grocery and hardware shopping, checking factory outlets, listening to selected music and watching movies, etc. The navigation system is connected to the Internet, providing all information and music online. There are neither CD's and tapes needed in the car, nor does anything have to be changed while driving.

During dinner, the navigation system is downloading maps, music, concert information and sets up the trip. Coincidentally friends of theirs are planning a similar trip, which they can see on the screen. The navigation system suggests to meet them either at a certain camp area or at a concert.

At 7 PM the party leaves the restaurant and hits the road. Everything is set and the four are sitting comfortably in the car, each with a programmable screen in front. Therefore they offer Amy to help with some of her driving duties. One is taking over the navigation control, the other is checking the traffic, the third is taking care of the entertainment system, the weather check, and keeps in touch with the other group of friends. They decide to meet at a particular motel nearby a club they could visit. The one in charge of the navigation system already booked the rooms and ordered tickets for the club. The group still has almost a four hour drive ahead. The fuel gauge shows that they need refill in 25 Miles, and that there is a station located 5 Miles ahead. They decide to stop there.

Afterwards the ones in the back fall asleep. The system notices that they don't attend their ‘duties’ anymore and pass the systems back to Amy, who never lost the overview during the entire time, but knows now to pay more attention than before. They check into the motel and shortly after drive over to the club.
Which they leave again at 2 AM, they leave the club. Amy had a couple of drinks and wants to start the engine, when the safety system suggests to use the automation. The well-feeling system after checking Amy’s blood alcohol level transferred the information to the safety system which activated the suggestion. In automation mode the car drives completely by itself. This is to be used on either specially equipped lanes or at very low speed.