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The effect of system aesthetics on trust, cooperation, satisfaction and annoyance in an imperfect automated system

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Abstract. Lack of system reliability has been repeatedly identified as a factor that decreases trust. However, aesthetics has an important role in the development of trust. Most of the research concerning the connection between aesthetics and trust focused on mobile commerce and websites while very little has been done in examining aesthetics in automated systems. This study integrated aesthetics manipulations into an imperfect in-vehicle automation system and focused on the power of aesthetics to decrease the negative effects of errors on trust, satisfaction, annoyance, and human-automation cooperation perceptions. Participants used the navigation system in either 100% or 85% accuracy levels with an aesthetic or non aesthetic system (4 conditions). In both aesthetic and non aesthetic systems, perceptions of trust, satisfaction and human automation cooperation were decreased in the imperfect system compared to the perfect one. However, in the annoyance rating, this trend was found only in the aesthetic system while in the non-aesthetic system no difference was found between the two levels of accuracy. This single effect may indicate upon the possibility that in automated systems aesthetics affects trust and satisfaction more moderately compared to mobile commerce applications and websites. However, more research is needed to assess this assumption.

Keywords: trust, satisfaction, imperfect system, aesthetics, reliability

1. Introduction:

A main concern while designing in-vehicle information systems is the need to provide drivers with accurate and reliable information. However, since many systems do not provide the driver with information that is 100% accurate, the perceived system's credibility and trust level may decrease. Previous research has pointed out the importance of trust when interacting with systems [15]. Researches from both social science and engineering perspectives agree that trust is a multi-dimensional, dynamic concept and most researchers do not view trust as a stable personality trait [11], but rather consider it to be a dynamic attitude that evolves along with the developing relationship [18].

1.1. Reliability and trust

Reliability (i.e., the system's ability to perform its functions under certain conditions for a specified period of time) is an important factor for building trust in a system [17]. Previous studies found that when the automation failed, trust and self-confidence in the system were decreased. However, once the human perceived the automation as reliable again, trust and self-confidence in the system increased [31]. Furthermore, trust decreases with decreasing reliability and below a certain level of reliability, trust declines quite rapidly. The absolute level of this drop-off seems to be highly system and context dependent, with estimates ranging from 90% and 70% to 60% [15].

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1.2. Aesthetics

1.2.1. Aesthetic in human computer interaction, in automated consumer products and in complex systems

Human computer interaction and aesthetics. Aesthetics plays a major role in our private, social, and business life as well as in information technology. This assumption is based on three theoretical reasons: (1) for many users, other aspects of the interaction hardly matter; (2) our evaluations of the environment are primarily visual, and the environment becomes increasingly replete with information technology; and (3) according to Maslow's self-actualization theory, aesthetic is one of the higher order human needs which contributes to the users' interactive experience satisfaction; these needs are increasingly supplied by information technology [25].

Gait was one of the first to argue that attention to pure aesthetics is important in making interfaces understandable, memorable and appealing for computer users [13]. In addition, Research on visual aesthetics in computer interfaces showed high correlation between aesthetics and system's perceived usability even before actual use of the system; this high correlation increases the likelihood that aesthetics may considerably affect system acceptability [24].

Automated consumer products and aesthetics. The discussion of consumer products requires reference to the personal meaning of purchasing these products. Malhotra showed that consumers tend to buy or use products which are more congruent with their self concept (psychology construct which represent the totality of the individuals' thoughts and feelings). Social self concept is one of the components in self concept which represents people efforts to insure that others will perceive them as a certain type of person. An example of these efforts is our consumption behavior [26]. These findings indicate on the involvement of personal meaning in purchasing and using automated products as opposed to using an ATM system for example, or some website.

In the context of the aesthetics of these products, aesthetic appeal or styling is becoming essentially important in modern society. Furthermore, from the users' viewpoint, styling is strongly related with product usability and amenity, and it is one of the key components for better product acceptance [9]. Norman also claimed that attractive things work better. Moreover, Norman argued that when people are in a relaxed or neutral situation, an attractive and pleasant design increases positive effect, broadens the creativity and increases the tolerance for minor difficulties and problems in the interface [7].

As an example, a study showed that a digital audio player reasonably low in usability but perceived as very appealing was preferred over a digital audio player which was high in usability but lower on aesthetics. These findings demonstrate that aesthetic dimensions compensate for low usability and that in these kinds of products aesthetic products are preferred over high usability ones with low aesthetic [29]. Similar findings were reported in a health-related information website [22].

Complex systems and aesthetics. Complex systems relate to systems that present several processes, which occur in sequences or in parallel. Due to the many automated processes in complex systems, the user's role changes in a way that he becomes primarily a supervisor of the operations which are performed by computerized systems. Thus, creating working environments that are more demanding in terms of their cognitive-reasoning requirements from the operator rather than sensory–motor skills [27].

Complex systems are common in varied areas such as flight simulators, telecommunications exchanges, electrical power equipment, military systems and airplanes [28]. In these systems, aesthetics is being used as a tool which can take very complicated feelings and emotions and adjust them to the objective world. In practice, aesthetic is an integral part of the perceptual faculty which is called intuition or imagination. It is important to emphasize that "imagining" or "using our intuition" are not related as verbal activities; instead, they are preconscious forms which their called up to consciousness is dependent upon the direct perception of the meaningfulness of our environment [4].

The driving environment represents a complex environment in which the driver must allocate attention wisely. Schreiber found that aesthetic perception of a map in car navigation systems is affected also by the cognitive load of the situation: e.g., in a low cognitive situation (road trip), a complex information map which served users' demands for additional information, was perceived as more aesthetic. By contrast, in situations of high cognitive load (city trip) simple graphic interfaces which contained only reduced information were perceived as more aesthetic [16].

In summary, aesthetic is a major determinant of user satisfaction, usability perceptions and pleasure. This idea is relevant to daily products, through human computer interaction and even in the domain of

complex systems. Since our study focused mainly on trust, the next section will further review the aesthetic topic specifically with regard to trust.

1.2.2. Trust and aesthetics

One of the most important effects of aesthetics is expressed in human trust [19]. Research about the connection between aesthetics and trust focused mainly on human computer interaction systems such as cyber-banking systems, websites and mobile commerce [14, 35]. In the context of websites, aesthetics design is an important tool to develop feelings of trust, to attract customers and capture their attentions [19]. In cyber-banking systems interface, elements which induced trustworthiness feelings were: cool colors increased trustworthy feelings more than warm colors, the main color of the interface should be a moderate pastel color and colors with low brightness [14].

An additional study found that when the same content was presented using different levels of aesthetic treatment, the content with the higher aesthetic treatment was judged as having higher credibility compared to the low aesthetic treatment. The authors called this "the amelioration effect of visual design and aesthetics on content credibility" and suggested that this effect is operational within the first few seconds a user views a web page [6].

Li and Yeh explored mobile trust in an extended model which related also to other factors associated with trust. According to the model, higher levels of design aesthetics of a mobile website increased the perceived usefulness of the website, the perceived ease of use, and the customization of the website. It was also found that high levels of all those factors led to higher levels of mobile commerce trust. In addition, higher levels of aesthetics directly led to high mobile commerce trust. These findings emphasize the existence of valid antecedents to mobile trust: perceived usefulness, perceived ease of use, customization of the website and design aesthetics. Moreover, the antecedents themselves were also influenced by the design aesthetics [35].

The impact of perceived visual attractiveness of a web site was also demonstrated in the extended technology acceptance model (TAM). The attractiveness of the website refers to the general visual elements of the site, mostly to colors and the website layout. According to the model, visual attractiveness of a web site affected users' enjoyment, ease of use and usefulness. Moreover, all those factors had significant impact on attitude towards using, intention to use and actual use [12].

Although not addressed in the current study, it is important to note that aesthetic views are cultural dependent. For example, Cyr, Head and Larios showed the different impact of website color treatments (grey, blue and yellow) on users' trust, satisfaction, and e-loyalty across different cultures (Canadians, Germans and Japanese). Their findings indicated that for all cultural groups, color appeal significantly increased users' trust and satisfaction. Furthermore, higher online trust and satisfaction were confirmed as strong predictors of e-loyalty (which defined as the user intention to visit the website again or to purchase from it in the future). Nevertheless, Canadians had stronger preference toward the grey color scheme while the Germans showed stronger preference for the blue one. These findings support the "Cultural Relativism view" which suggests that color perception is mostly shaped by culturally specific language associations. However, parts of the results support the "Universalistic view" by showing the same color effect to all three cultures (e.g., all three cultures tend to dislike the yellow websites) [5].

To sum, most of the research on the effects of aesthetics on trust focused on mobile commerce and websites with the notion that aesthetic affects customer intent to stay, purchase and also revisit a website [35]. The current study focused the impact of aesthetics on trust aspects in a semi-autonomous system. In order to deeply examine trust related issues, participants' perceptions of trust, human-automation cooperation, satisfaction, and annoyance in an imperfect system were examined. In the next section the impact of various graphic design elements on user perceptions of aesthetics, usability and trust will be displayed.

1.2.3. Graphic design implications

Our study investigated aesthetics in semi-autonomous navigation system. The main components of the interface were two map images (as described in section 2.2). Therefore, the aesthetics variable was manipulated by modifying the look of these maps.

Several studies showed the impact of the colors in the map [23], the amount of data that presented on the map [33] and the overall graphic style of the map [32] on the user's aesthetic and usability perceptions. Beside maps, these effects were also found in websites and products. With regard to colors, a number of simple rules were identified for creating good inter-

faces such as: opposite colors go well together; use blue as background and avoided pure blue for text, thin lines and small shape; keep the number of colors small; use bright colors for danger or for getting user's attention; be aware that older operators need higher brightness levels to distinguish colors [1,10].

In the context of maps, using a colored map improved the accuracy of responses and shortened response time, relative to performance with a monochrome map [23]. Examination of in-vehicle electronic navigation map configurations revealed that color schemes affected only on the objective measures (e.g., the gray schema produced the best results in response time and in the number of correct responses). On the other hand, color schemes did not affect aesthetic and usability perceptions [33]. Lavie et al. also found that maps with minimal details produced superior objective performance and received higher evaluations in the aesthetic and usability subjective ratings [33]. Further study showed an effect of the overall graphic style of the map on aesthetic perceptions, usability perceptions and user performances. Graphic style refers to a variety of design aspects beside color, such as layout, typography, fonts, textures, themes, motifs, and so forth. This finding indicates that the entire style of the map is more influential on subjective evaluations, compared to just altering map colors [32].

In our study, aesthetics was manipulated by altering the overall graphic style of the maps (as described in section 2.1). In addition, maps contained only the minimal necessary data relevant for the task (e.g., 'No entry' signs) without unnecessary information (e.g., locations further away from the desired route, etc.).

2. Method

2.1. Preliminary aesthetics evaluation pilot-experiment:

Maps generation. Relying on Lavie and Oron-Gilads' findings [32], three maps were designed by a professional graphic designer (two non aesthetic maps and one aesthetic map). Differences between the maps were expressed in the general graphic style of the maps including the following design aspects: colors schema, layout, highlights and shades. In the context of color schema, there were two main differences between the maps: hue and saturation. As shown in Figure 1, the aesthetic map was designed with a low level of saturation using gray, red and dark blue colors while the two non aesthetic maps were designed with higher levels of saturation, one of them with orange, yellow, blue and green glowing colors and the other with pink, orange and green colors. The purpose of this pilot experiment was to identify the most non-aesthetic map of the two "non aesthetic" maps, and to examine differences in aesthetic perceptions between the aesthetic and the most non aesthetic maps.

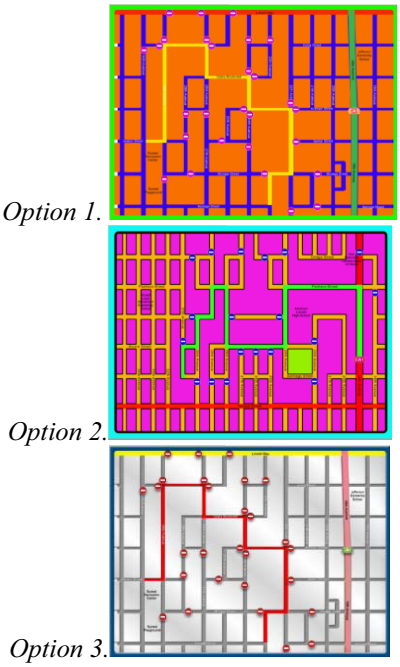


Fig 1. The three map styles which were examined in the preliminary experiment: the two non aesthetic maps (options 1 and 2) and the aesthetic map (options 3).

Participants. Eighteen participants who had a personal acquaintance with the experimenter and volunteered to take part in the experiment.

Procedure. Maps were presented to each participant on a computer in a randomized order. While looking at each map, participants were requested to rate their aesthetics degree according to the aesthetic scale which included 10 items measured by a 7-point Likert scale [33].

Results – pilot-experiment. A repeated measures ANOVA found that the three maps affected differently on participants' aesthetic perceptions, $F(2,34)=30.64$, $p<0.01$. Option 1 was perceived as

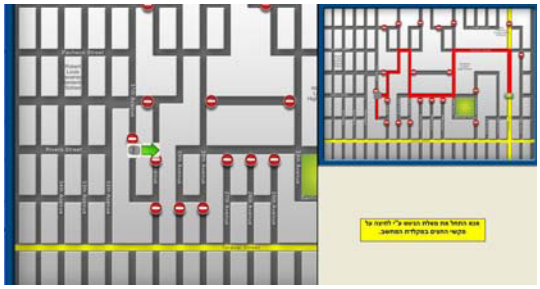
the most non aesthetic map with a mean rating of M=3.3, SD= 0.7, option 2 had higher mean rating of M=3.7, SD= 0.8 while the map in option 3 had the highest mean rating of M=4.3, SD= 0.7. Significant differences were found between option 1 and option 2 ($F(1,17)=5.81$, $p<0.05$) and also between option 2 and option 3 ($F(1,17)=24.52$, $p<0.01$). Therefore, option 1 was chosen as the non aesthetic map and option 3 as the aesthetic map.

2.2. Experimental method

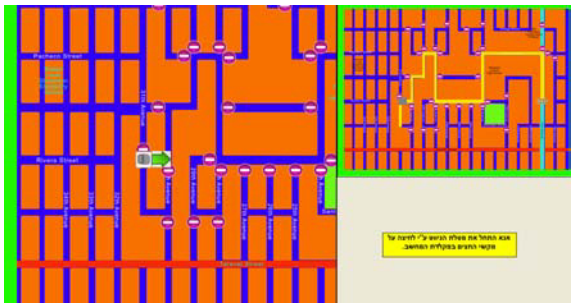
Participants. 141 students (M=25 age range of 20-29 years) from the Department of Industrial Engineering and Management at Ben-Gurion University of the Negev participated in this study as part of course requirements.

Experimental system. In order to neutralize the effect of prior experience of the users with existing in-vehicle systems, a PC based experimental system simulating a navigation system was developed for the study. The user was presented with a route and requested to direct the car symbol to follow the route by pressing arrows in each intersection (left, right, down or straight ahead). The navigation screen presented two types of maps: (1) the main map that the user used to navigate with, in which the vehicle was controlled and navigated, and (2) an overview map presenting the required driving route. The main map was dynamic and progressed as the vehicle moved along the route. The overview map was static but also showed the progress of the vehicle. When the system acted correctly the vehicle turned as directed. In incorrect cases the system took a different move than the one specified by the user. The user was then required to return back to the intersection (which was now emphasized in red) while following the traffic laws.

In order to avoid variance, the maps were designed in such a way that 'No entry' signs limited variation in the way participants could return back to the route. Four different blocks were presented (a different map with a different route for each block) and each route included 10 intersections. Based on the preliminary experiment's findings, two different systems were created: aesthetics navigation system vs. non aesthetic navigation system as shown in Figure 2.



Aesthetic navigation system



Non aesthetic navigation system

Fig 2. Illustration of the navigation task and interface configurations (upper aesthetic, lower non aesthetic). The interface consisted of two maps; the main map was used to navigate the vehicle and the smaller overview map was used for orientation.

Subjective questionnaires. Three questionnaires were employed: (1) An Initial questionnaire presented at the beginning of the study which included 11 items based on a number of sources [8,20,34]. It examined basic user characteristics concerning technology bias and propensity to trust. (2) An Intermediate question about the participant's general satisfaction from the system was presented following each block. (3) A final questionnaire which included 18 items was presented at the end of the experience. The first 7 questions focused on participants trust, reliance and expectations from the system's performance [21,30,34]. In addition, two questions were added by the researchers specifically for this experiment (e.g., satisfaction and annoying). Six More questions were the Halden Human-Automation Cooperation Questionnaire which focused on the cognitive aspect concerning the cooperation between the user and automation [2]. The last three questions focused on aesthetics perceptions of the system [35]. All items in these questionnaires were translated to Hebrew and were measured by a 7-point Likert scale.

Procedure. Participants were assigned to the lab in groups of 19 - 23 and each individual participant sat in front of a computer. At first, the experiment was described to the participants by the experimenter. Afterward, each participant filled the initial questionnaire and experienced with a learning session. Then, each participant was required to perform the navigation task (4 consecutive blocks of 10 intersections). Following each block participants were asked the Intermediate subjective question. Once they completed all tasks in all four blocks, they filled the final questionnaire.

Participants were assigned randomly to one of the four experimental conditions, which varied according to the following variables: (1) System accuracy: each participant used the system in one of the following accuracy levels: 100% and 85% (i.e., 6 errors out of 40 trials). (2) Aesthetics: each participant interacted with either the aesthetics navigation system or the non aesthetic navigation system.

3. Results

Results related to the final questionnaires are presented. The effect of aesthetics and system accuracy on the participants' perceptions of: the systems' aesthetics, trust, satisfaction, annoyance and human-automation cooperation was examined.

At first, the final questionnaire was divided into five parts. For each part alpha Cronbach analysis was performed: (1) trust (7 items) examining trust and credibility aspects (α=0.89); (2) satisfaction from the system; (3) annoyance from the system; (4) human-automation cooperation questionnaire (6 items) examining the cooperation between humans and automation (α=0.84); and (5) aesthetics questionnaire (3 items) examining aesthetics perceptions (α=0.86). Now separate analyses for each part are presented.

3.1. Aesthetics.

Aesthetics questionnaire. A one-way ANOVA revealed a significant difference in aesthetics perception after using the system, $F(1,139)=19.07$, $p<0.01$. Mean aesthetics ratings for the aesthetic system M=4.2, SD=1.5, non aesthetic system M=3.1, SD=1.4.

Trust questionnaire, Satisfaction, Annoyance and Human-Automation cooperation questionnaire. For each one of these dependant variables a one-way ANOVA (with aesthetics as the between variable) was conducted. For all four constructs, no significant differences were found between the two levels of aesthetics. i.e., aesthetics of the interface per se, did not affect participants' perceptions of trust, satisfaction, annoyance and human-automation cooperation.

3.2. System accuracy.

Trust questionnaire, Satisfaction, Annoyance and Human-Automation cooperation questionnaire. For each one of these dependant variables a one-way ANOVA (with system accuracy as the between variable) was conducted. For all constructs questionnaires, it was found that the imperfect system (85%) led to lower levels of trust ($F(1,139)=30.1$, $p<0.01$), satisfaction ($F(1,139)=27.5$, $p<0.01$) and human-automation cooperation ($F(1,139)=42.9$, $p<0.01$), as well as to higher level of annoyance ($F(1,139)=13.4$, $p<0.01$), compared to the perfect system.

In addition, a 2-way ANOVA (with aesthetics and system accuracy as the between variables) was performed for each one of the four dependant variables. For both aesthetic and non-aesthetic systems, participants' perceptions of trust (aesthetic- $F(1,71)=19.7$, $p<0.01$, non-aesthetic- $F(1,66)=10.5$, $p<0.01$), satisfaction (aesthetic- $F(1,71)=23.6$, $p<0.01$, non-aesthetic- $F(1,66)=6.4$, $p<0.05$) and human-automation cooperation (aesthetic- $F(1,71)=24.6$, $p<0.01$, non-aesthetic- $F(1,66)=17.7$, $p<0.01$) were significantly lower in an imperfect system compared to a perfect system. However, in the annoyance ratings, a significant difference was found only for the aesthetic system condition ($F(1,71)=11.9$, $p<0.01$). i.e., annoyance level was significantly higher in 85% compared to 100%. As for the non aesthetic system, no difference was found in the annoyance rating between the two levels of accuracy, i.e., the 100% accurate system in the non-aesthetic condition was still perceived equally annoying to the 85%, as shown in Figure 3. It is interesting to see that while there was no difference in annoyance ratings between the two systems (aesthetics and non aesthetics) in the 85% accuracy (mean annoyance ratings in the non aesthetic system- M=5.2, SD=1.7 and in the aesthetic system- M=5.1, SD=1.7), in the perfect aesthetic system, participants were more tolerant to the system compared to the perfect non aesthetic system (mean annoyance ratings in the non aesthetic system- M=4.2, SD=1.8 and in the aesthetic system- M=3.3, SD=1.8). However, the difference between the two levels of aesthetics in the perfect system did not reach signifi-

cance and therefore only indicates on an optional trend.

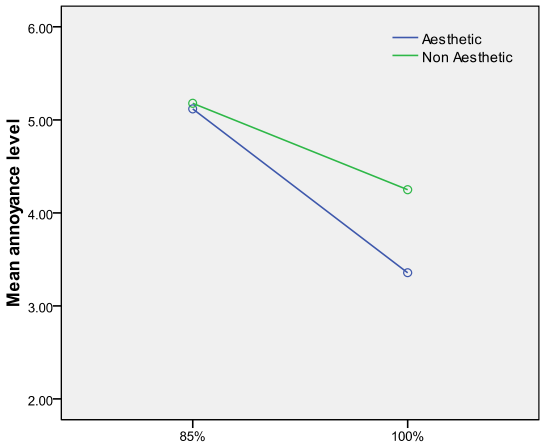


Fig 3. Mean annoyance ratings (1-7) for the two accuracy conditions in the two aesthetics level.

4. Discussion

The goal of this study was to examine the impact of system aesthetics on trust, cooperation, satisfaction and annoyance in an imperfect automated system. Therefore, it included manipulation of system accuracy, as well as, aesthetics of an in-vehicle navigation system.

Participants were sensitive to system errors and their evaluation confirmed that less reliable system operation decreases perceptions of trust and satisfaction [3].These findings correspond with previous research suggesting that the absolute level of trust drop-off is system and context dependent, with estimates ranging from 90% and 70% to 60% [15].

As for the effect of aesthetics combined with accuracy, the fact that no significant difference was found in the non aesthetic system between 85% and 100% and that this difference was found significant in the aesthetic system indicates that while a perfect aesthetical system causes less annoyance, in the non aesthetical system it does not matter whether the system is perfect or not; either way annoyance ratings remained the same.

The lack of effect of aesthetics on participants' perceptions of trust, satisfaction, annoyance and human-automation cooperation contradict previous research findings which showed that aesthetics has a significant positive effect on trust or satisfaction (as reviewed in section 1.2.2). These findings may indicate upon the possibility that in automated automotive related systems aesthetics affects trust and satisfaction more moderately compared to mobile commerce and websites. However, more research is needed to assess this assumption.

According to aesthetics perception, the findings of this study indicated overall higher perceptions of aesthetics design in the aesthetic system compared to the non aesthetic one. The results indicate that the differences in aesthetics perceptions between the two map styles remained stable before using the system as well as after use. i.e., interaction with the system did not change aesthetics perceptions.

5. Conclusions and future research

The results of this study may be used as a base for a wider research about the impact of aesthetics and system accuracy on trust aspects in both perfect and imperfect automated systems. As reviewed in section 1.2.1, automated systems have different properties and differ from using a website or a mobile commerce application. The single effect that was found in the annoyance rating of the non aesthetic system demonstrated the limited impact of aesthetics in automated systems on trust and satisfaction compared to mobile commerce or websites.

Therefore, this research may be a window for a number of future research directions; one option is to examine the impact of aesthetics on trust aspects in different kinds of interfaces (e.g. manual vs. speech controlled systems). Another direction is to keep exploring aesthetics in imperfect systems while examining whether additional options can also mitigate the negative impact of system errors. Either way, more research on aesthetics in the automated system domain is needed to refine the impact of aesthetics on trust aspects in an imperfect automated system.

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