

## **ABSTRACT**

Recent research into user experience has identified the need for a theoretical model to build cumulative knowledge in research addressing how the overall quality or 'goodness' of an interactive product is formed. An experiment tested and extended Hassenzahl's model of aesthetic experience. The study used a 2x2x(2) experimental design with three factors: principles of screen design, principles for organizing information on a web page and experience of using a web site. Dependent variables included hedonic perceptions and evaluations of a web site as well as measures of task performance, navigation behaviour and mental effort. Measures, except Beauty, were sensitive to manipulation of web design. Beauty was influenced by hedonic attributes (identification and stimulation), but Goodness by both hedonic and pragmatic (user-perceived usability) attributes as well as task performance and mental effort. Hedonic quality was more stable with experience of web-site use than pragmatic quality and Beauty was more stable than Goodness.

*Keywords:* user experience; aesthetics; hedonic quality; usability; web site; modelling

## 1. INTRODUCTION

Aesthetics can be seen as an aspect of the broader concept of user experience (Hassenzahl and Tractinsky, 2006), which can include usability, beauty, overall quality and hedonic, affective and experiential aspects of the use of technology. The aesthetics of web page design is a crucial but until recently, somewhat neglected area of empirical investigation. The visual impact of a web page can have a significant influence on user experience and has important implications for effective communication (Hoffman and Krauss, 2004) and, in particular, the interaction users have with a site (Schenkman and Jönsson, 2000). Indeed, poorly designed pages could rapidly turn users away, an irritation for a web site run by an academic, but a major problem for a company that may derive a significant proportion of its revenue from e-commerce (Ben-Bassat, Meyer and Tractinsky, 2006; Lindgaard, Fernandes, Dudek and Brown, 2006). Conversely, a web site that participants feel is aesthetically pleasing may have a positive effect on trust (Karvonen, 2000).

Nonetheless, usability remains a necessary, but not in all contexts a sufficient, condition for positive judgements of system quality (Nielsen, 2007), and these judgements may also be related to a user's goal in interacting with a specific site, depending on whether the goal is functional (e.g. booking a train ticket) versus hedonic (e.g. reading the latest entertainment news). When investigating aspects of user experience that go beyond the instrumental, arguably one of the most important questions to answer is "how the overall quality or the 'goodness' of an interactive product is formed, given pragmatic and hedonic aspects and underlying needs" (Hassenzahl and Tractinsky, 2006, p. 93). This question is addressed in this paper.

## 2. BACKGROUND

Tractinsky, Cokhavi, Kirschenbaum and Sharfi (2006) distinguish two approaches to the identification of higher-level concepts in web-site design as a basis for making progress with design that aims to enhance user experience. First, a screen-design-based approach (e.g. Kim, Lee and Choi, 2003; Ngo, 2001; Park, Choi and Kim, 2004) focuses on identifying design factors in the objects and their organization on a web page that impact on user experience. Although this approach could work to support design for usability and has led to design guidelines for usability (e.g. Galitz, 1997), Tractinsky (2004) raises doubts about its usefulness for designing aesthetics: this design will have to address a very large number of combinations of design options combined with a wide range of individual differences in users' preferences. Second, an information-processing approach focuses on users' processing of the attributes of artefacts (Hassenzahl, 2004), including web pages (e.g. Lavie and Tractinsky, 2004), at different levels of cognition (Norman, 2004).

A theoretical model is required to build a cumulative body of knowledge, when addressing the question of how the overall quality or 'goodness' of an interactive product is formed (Hassenzahl, 2004). There is a dearth of such models, although Hassenzahl's (2003, 2004) model of user experience provides a starting point.

In Hassenzahl's (2003, 2004) model of user experience, users construct product attributes by combining a product's features with personal expectations or standards. Product attributes, such as content, presentation, functionality and interaction style, influence users' perceptions of product attributes. Two main types of product attributes perceived by users are Pragmatic quality (user-perceived usability) and Hedonic quality (pleasure-producing product qualities), two forms of which are stimulation (personal) and identification (social). A product can be stimulating by offering novelty and challenge and can lead to identification by communicating important personal values to relevant others. A product character is "a bundle of attributes ..." which "can be understood as a cognitive structure that integrates product attributes and their covariation" (Hassenzahl, 2004, p. 322). According to Hassenzahl (2004, p. 322), "using a product with a particular ... character in a particular situation will lead to consequences, such as emotions (e.g. satisfaction, pleasure), explicit evaluations (i.e. judgements of appeal, Beauty, Goodness), or overt behaviour (i.e. approach, avoidance)". Perceptions influence evaluations, in particular judgements of Beauty and Goodness (overall quality of interaction), which Hassenzahl (2004) considers as high-level constructs ("verdictive", in the sense of "expression an authoritative judgement", p. 323) and which are distinct from its low-level determinants (perceptions which are "substantive", in the sense of "relating to the essence or substance", p. 323). Perceptions are separate from evaluations because a positive perception of pragmatic or hedonic product attributes can lead to a positive evaluation, though this is not automatic. In contrast to Hedonic quality, Pragmatic quality is changed through experience of using a system. Therefore, Beauty - which is only influenced by Hedonic quality - is relatively stable, but Goodness is less stable as it is influenced by both Pragmatic quality and Hedonic quality.

The current study is based on Hassenzahl's theoretical approach. According to Hassenzahl (2003, 2004), system design characteristics that make a design more usable should improve its users' experience in terms of Pragmatic quality and consequently Goodness (overall quality). Hedonic quality and consequently overall Beauty should not be affected. In contrast, Tractinsky, Shoval-Katz and Ikar (2000) predict that (more) beautiful products are perceived to be (more) usable. The current study investigates the effect of system design characteristics in web pages on user experience. Although Hassenzahl studied the effect of

experience on perceptions and evaluations, his work does not explicitly address human-system interaction in terms of efficiency, effectiveness and workload. In this paper, we therefore propose and explore a set of models based on the following principles:

P1: System characteristics have an effect on system perceptions, for example clearer interfaces are associated with greater perceived ease of use (e.g. Ahuja and Webster, 2001; Davis and Wiedenbeck, 2001);

P2: System perceptions have an effect on system evaluations. Systems which, before use, are viewed as possessing positive attributes are more likely to be evaluated positively by users (Hassenzahl, 2003, 2004);

P3: System characteristics have an effect on actual usability ('quality in use'). Usability can be measured by a variety of metrics including effectiveness, efficiency and satisfaction and manipulations of the system can have measurable consequences for usability (see e.g. MacLeod, Bowden, Bevan, and Curson, 1997, for the effects of a redesign of a bank's computers on efficiency);

P4: Usability has an effect on system perceptions. Several papers have highlighted the interplay between usability and system evaluations, for example Hassenzahl (2004) found more usable MP3 player skins led to more positive assessments of systems than less usable ones.

According to our model of aesthetic experience before (or without) using a system, system characteristics directly influence perceived quality and this in turn will have an effect on evaluations (see Figure 1a). When the system is used, then in an interaction-based model, system characteristics, such as the presentation and organization of information on-screen, will affect users' immediate interaction outcomes, such as correctness of task performance and mental effort. Outcomes of this interaction will have an effect on subsequent perceptions of product attributes and these perceptions have an effect on evaluations (see Figure 1b). Alternatively, a perception-based model specifies experimental manipulations before and during use, pre-use perceptions, pre-use evaluations and post-use perceptions as predictors of post-use evaluations (see Figure 1c). We conducted an experiment in which participants used different versions of an existing educational intranet site to address the following aims:

- 1 to test the effect of cognitive design principles on perceptions of product attributes (Pragmatic and Hedonic quality) and product evaluations (Beauty and Goodness) as well as task performance using a web site.

*Hypothesis 1:* violation of design principles has a negative effect on task performance, Pragmatic

quality and Goodness, but no effect on Beauty (Hassenzahl, 2003, 2004). In this study, the concepts of Goodness and Beauty are defined as degree of overall quality and aesthetic pleasure, respectively.

- 2 to test models of aesthetic experience in Hassenzahl's (2003, 2004) theoretical framework, including the effect of experience (before versus after use) on the relation among attributes and evaluations.

*Hypothesis 2:* Hedonic quality is a predictor of both Beauty and Goodness, but Pragmatic quality, task performance and mental effort are predictors of only Goodness.

*Hypothesis 3:* Beauty (Hassenzahl, 2004; Lindgaard et al., 2006; Tractinsky et al., 2005) and Hedonic quality (Hassenzahl, 2004) are stable over time and are not influenced by human-system interaction; however, Pragmatic quality and Goodness are less stable over time and are influenced by interaction (Hassenzahl, 2004). Because Beauty is relatively stable, the effects of pre-use perceptions and Beauty on post-use Beauty are partially mediated, but, because Goodness is relatively unstable, the effects of pre-use perceptions and Goodness on post-use Goodness are completely mediated.

\_\_\_\_\_ Insert Figure 1 about here. \_\_\_\_\_

### **3. METHOD**

#### **3.1. Experimental design**

The experiment used a 2x2x(2) experimental design with three factors: presentation principles (principles of screen design either followed or violated), information-organization principles (principles for organizing information followed or violated) and experience of using an intranet web site (before use and after use). The first two independent variables were between-subjects. A wide range of design principles have been found to influence user interactions in earlier research (see overview in van Schaik and Ling, 2007). For the first independent variable, user interface design principles were complied with (Figure 2a, 2b) or violated (Figure 2c, 2d) on web pages. These included preserving the context of information units, using higher-order information units, avoiding gratuitous animation, being consistent, using conventions for appearance and using colour contrast to enhance readability. For the second independent variable, we presented information using a topical organization scheme (Rosenfeld and Morville, 2002) (see Figure 2a, 2c) or without systematically organizing the information (see Figure 2b, 2d). The third independent variable was used within

subjects to test the effect of experience on hedonic and aesthetic value. Outcome measures included perceptions of product attributes, evaluations of web pages, mental effort and objective-performance and navigation-behaviour measures.

\_\_\_\_\_ Insert Figure 2 about here. \_\_\_\_\_

### **3.2. Participants**

There were 111 undergraduate psychology students (84 females and 27 males), with a mean age of 22 years (SD = 5.95). They took part in the experiment as a course requirement. All had used the Web. Mean years of experience using the Web was 6.37 (SD = 3.13), mean years of confidence in using the Web was 4.66 (SD = 2.85), mean time per week spent using the Web was 13.02 hours (SD = 16.19) and mean frequency of Web use per week was 13.18 hours (SD = 10.69).

### **3.3. Materials and equipment**

An existing intranet site, developed by a university psychology department for its previous cohorts of students was used. Four versions of the site were created by combining the two levels of each of the two independent variables (presentation principles - followed or violated - and information-organization principles - followed or violated): presentation followed - organization followed (Figure 2a), presentation followed - organization violated (Figure 2b), presentation violated - organization followed (Figure 2c) and presentation violated - organization violated (Figure 2d). The experiment ran on personal computers (Intel Pentium, 2.8 GHz, 512 Mb RAM, Microsoft Windows XP operating system, 15 inch monitors). The screen dimensions were 800×600. Contrast and brightness were set to optimal levels.

Participants gave responses to two questionnaires: the questionnaire used and validated by Hassenzahl (2004) to measure hedonic and aesthetic value and the Subject Mental Effort Questionnaire (SMEQ) (Zijlstra, 1993). The first questionnaire included 21 items to measure perceptions of three product attributes (Pragmatic quality, Hedonic quality-identification and Hedonic quality-stimulation - 7 items each) and two items to measure product evaluations (Beauty and Goodness - one item each); all items used a 7-point semantic differential scale (see Appendix). The SMEQ consisted of a single-item visual analogue scale with graded categories and numerical values (range: 0-150).

Factor analysis was conducted on the items for the perceived product quality of three attributes or groups ('perceptions'): Pragmatic quality, Hedonic quality-identification and Hedonic quality-stimulation. A three-

factor solution was found for both pre-use- and post-use scores after removing the following items: PQ1, HQI1, HQI4, HQI5, HQI6 and HQS6, with Pragmatic quality (Factor 1), Hedonic quality-stimulation (Factor 2) and Hedonic quality-identification (Factor 3) each constituting one factor (see Table 1). Using the items selected in the factor analysis, the scales for Pragmatic quality, Hedonic quality-identification and Hedonic quality-stimulation possessed high reliability both before and after System use (see Table 2). Subsequently, overall scores - PQ, HQI and HQS respectively - were calculated for each of the reliable scales by averaging item scores per scale (see Table 2 for descriptives and correlations). The correlation between Beauty and Goodness was .64 before use and .63 after use, both  $p < .001$  (41% and 39% overlap in variance respectively), indicating a strong association, but the two constructs were not identical.

\_\_\_\_\_ Insert Tables 1 and 2 about here. \_\_\_\_\_

### **3.4 Procedure**

The experiment consisted of four parts: a viewing task (of typical intranet pages), followed by the first questionnaire, an information retrieval task and the second larger questionnaire (that also included the first questionnaire). The experiment was run in a computer lab with groups of 15 to 20 participants who worked independently. The information retrieval task included typical tasks that users perform with educational intranet sites such as 'What is PsycINFO?' and 'Who deals with requests for coursework extensions?'. In each trial, a question appeared at the top of the screen. Once participants had read the question, they had to click on a button labelled 'Show web site'. The home page of the intranet site then appeared on the screen and, using the site, they had to find the answer to the question. Participants were told to take the most direct route possible to locate the answer. Having found this, they clicked on a button labelled 'Your answer', which opened a dialog box at the bottom of the screen. Participants typed their answers into the box, clicked on 'OK', completed the SMEQ for the task they had just performed and moved on to the next question. After three practice questions, the main phase consisting of 10 further questions followed. In addition to the items from the first questionnaire, the final questionnaire included demographic questions. The experiment took approximately 45 minutes to complete.

## **4. RESULTS**

Analysis of variance (ANOVA) was used to test the effect of presentation principles (Aim 1). The effect of experience and models of aesthetic experience (Aim 2) were tested using tests of correlations and multiple regression analysis, respectively.

#### **4.1. The effect of presentation principles on outcomes**

A set of 2 (presentation principles)  $\times$  2 (organization principles) ANOVAs was conducted.

##### *Manipulation check*

The manipulation of presentation principles was effective, as the following results demonstrate. More correct answers were given when presentation principles were followed and this was confirmed by a significant main effect of presentation principles on correctness (percentage of correct responses),  $F(1, 107) = 8.63$ ,  $p < .01$ ,  $\varepsilon^2 = .06$ , but there was also a significant interaction effect of presentation principles by organization principles,  $F(1, 107) = 5.47$ ,  $p = .02$ ,  $\varepsilon^2 = .04$  (see also Table 3). The main effect of organization principles was not significant,  $F(1, 107) = 1.25$ ,  $p = .27$ . Simple effect tests demonstrated that the effect of presentation principles was significant when organization principles were followed, with more correct answers when presentation principles were followed,  $t(54) = 3.45$ ,  $p < .001$ ,  $r = .43$ , but not when organization principles were violated,  $t < 1$ .

\_\_\_\_\_ Insert Table 3 here. \_\_\_\_\_

The main effect of presentation principles on mental effort was significant, with less effort when presentation principles were followed,  $F(1, 107) = 16.36$ ,  $p < .001$ ,  $\varepsilon^2 = .12$ , but the main effect of organization principles and the interaction effect were not significant, both  $F < 1$  (see also Table 3). The main effect of presentation principles on efficiency (number of links visited) for incorrect answers was significant, with higher efficiency when presentation principles were followed,  $F(1, 102) = 6.97$ ,  $p < .01$ ,  $\varepsilon^2 = .05$ , but neither the main effect of organization principles nor the interaction effect was significant, both  $F < 1$  (see also Table 3). In sum the manipulation was successful only for presentation principles, but not for organisation principles. This might be due to the strong effect of presentation principles, which may have occluded the smaller effect of organisation principles.

##### *The effect of experimental manipulations on perceptions and evaluations*

Overall, the effect of experience, if any, was smaller than that of presentation principles, as the following results show.

*Perceptions. Pragmatic quality (PQ).* The main effects of experience,  $F(1, 107) = 56.07$ ,  $p < .001$ ,  $\varepsilon^2 = .09$ , and presentation principles,  $F(1, 107) = 64.92$ ,  $p < .001$ ,  $\varepsilon^2 = .27$ , were significant - with higher PQ when presentation principles were followed and before site use (see also Table 4). *Hedonic quality-identification*



(HQI). The main effect of presentation principles,  $F(1, 107) = 36.55, p < .001, \epsilon^2 = .21$ , was significant - with higher HQI when presentation principles were followed (see also Table 4). *Hedonic quality-stimulation* (HQS). The main effect of presentation principles,  $F(1, 107) = 23.22, p < .001, \epsilon^2 = .15$ , and the interaction effect of presentation principles and experience,  $F(1, 107) = 8.30, p < .001, \epsilon^2 = .01$ , were significant (see also Table 4). Because of the significant interaction effect, simple effect tests with Bonferroni correction were conducted. A 2 (presentation principles)  $\times$  2 (organization principles) ANOVA showed that the effect of presentation principles was significant - with higher HQS when presentation principles were violated - before use with a very large effect size,  $F(1, 107) = 31.18, p < .001, \epsilon^2 = .22$ , and after use with a medium to large effect size,  $F(1, 107) = 13.04, p < .001, \epsilon^2 = .10$ . In sum, adherence to presentation principles had a positive effect on PQ before use presumably because this made the web site appear more usable and after use because it was more usable. The opposite effect of presentation principles on HQI and HQS presumably reflects (a) users' appreciation of the more usual presentation format - when the principles were followed - of a web site that they would identify with for HQI and (b) users' experience of stimulation by an unconventional presentation format - when the principles were violated - for HQS.

*Evaluations. Beauty.* The effect of experience was significant,  $F(1, 107) = 4.43, p < .05, \epsilon^2 = .004$  - with a higher evaluation of Beauty before use (see also Table 4). *Goodness.* Only the main effects of experience,  $F(1, 107) = 6.61, p < .05, \epsilon^2 = .01$ , and presentation principles,  $F(1, 107) = 18.26, p < .001, \epsilon^2 = .10$ , were significant - with a higher evaluation of Goodness when presentation principles were followed and before use (see also Table 4).

\_\_\_\_\_ Insert Table 4 about here. \_\_\_\_\_

#### **4.2. Effect of experience on the relation among attributes and evaluations**

Associations within perceptions and evaluations were analysed and comparisons were made between associations before and those after use. The positive correlation of measurements before use of the site with those after (see Table 2) was significant for all attributes and all evaluations, all  $p < .001$ . However, the correlation was significantly higher for HQS than for PQ,  $z = 2.05, p < .01$  and the correlation was marginally significantly higher for HQI than for PQ,  $z = 1.72, .05 < p < .10$ . Furthermore, the correlation was significantly higher for Beauty than for Goodness,  $z = 1.96, p < .05$ . These results confirm Hassenzahl's hypothesis that (a) Pragmatic quality - because it is based more on experience - is less stable than Hedonic quality and that (b) Goodness - because it is more influenced by Pragmatic quality - is less stable than Beauty - because it is

more influenced by stable Hedonic quality. These results are further strengthened by those of the model tests that follow.

### **4.3. Testing models of aesthetic experience**

According to Hassenzahl (2004), Hedonic quality is related to Beauty both before and after use. Pragmatic quality and Hedonic quality are related to Goodness before use, but only Pragmatic quality is related to Goodness after use. Tests of models of aesthetic experience are presented in support of Hassenzahl's model. The models presented in Figure 1a, 1b and 1c were tested with multiple regression analysis, using mediator analysis (for a good introduction to multiple regression analysis and mediator analysis see Miles and Shevlin, 2001). The goal of a mediator analysis is to establish if the effect of a predictor on an outcome is completely or partially mediated by a third variable (the mediator). Hierarchical regression can be used to establish if the third variable is a mediator, in other words if it is still a significant predictor of the outcome after the variability explained by the predictor. Hierarchical regression can also be used to establish the type of mediation: partial mediation occurs if the predictor still explains a statistically significant amount of variability in the outcome after the variability explained by the mediator; otherwise, mediation is complete. In the mediator analyses reported in this paper, predicted (pre-use or post-use) evaluation scores (e.g. pre-use Goodness predicted from HQI, HQS and PQ) are used as a single overall measure of the corresponding set of (pre-use or post-use) perceptions (e.g. HQI, HQS and PQ).

#### *Evaluations before use*

*Beauty* (Figure 1a). Recall that presentation principles and organization principles had no effect on pre-use Beauty; furthermore, the partial correlation of pre-use PQ with Beauty was not significant. Therefore, a multiple regression analysis with Beauty as outcome and perceptions (HQI and HQS) as predictors was conducted, explaining a significant amount of variability,  $R^2 = .49$ ,  $F(2, 108) = 51.52$ ,  $p < .001$ , and both were significant predictors,  $\beta = .52$ ,  $sr^2 = .27$ ,  $t(108) = 7.49$  for pre-use HQI and  $\beta = .41$ ,  $sr^2 = .17$ ,  $t(108) = 5.95$ , for pre-use HQS, both  $p < .001$  - the higher HQI and HQS, the higher the evaluation of Beauty.

*Goodness* (Figure 1a, Table 5). A mediator analysis tested the effect of presentation principles (before use) on pre-use Goodness with pre-use perceptions as a mediator and demonstrated complete mediation. The indirect positive effect of presentation principles on pre-use Goodness after controlling for the positive effect of product attributes explained 10% ( $\approx (.10 \cdot .001) \times 100$ , from Table 5) of variability.

\_\_\_\_\_ Insert Table 5 about here. \_\_\_\_\_

#### *Evaluations after use*

*Beauty* (Figure 1c, Table 6). A first mediator analysis (Table 6a) tested the effect of pre-use perceptions on predicted post-use Beauty with pre-use Beauty as a mediator and demonstrated partial mediation. The positive indirect effect of pre-use perceptions on predicted post-use Beauty after controlling for the positive effect of pre-use Beauty explained 39% of variability ( $= (.57-.18) \times 100$ , from Table 6a). A second mediator analysis (Table 6b) tested the effect of pre-use perceptions and Beauty on post-use Beauty with post-use perceptions as a mediator and demonstrated partial mediation. The indirect positive effect of pre-use perceptions and Beauty on post-use Beauty after controlling for the positive effect of post-use perceptions explained 48% ( $= (.77-.09) \times 100$ ) of variability. Subsequent mediator analyses (Table 6c) demonstrated that post-use perceptions were a complete mediator of pre-use perceptions and a partial mediator of pre-use Beauty. The indirect positive effect of pre-use perceptions on post-use Beauty after controlling for the positive effect of post-use perceptions explained 42% ( $= (.43-.01) \times 100$ ) of variability. The indirect positive effect of pre-use Beauty on post-use Beauty after controlling for the positive effect of post-use perceptions explained 43% ( $= (.52-.09) \times 100$ ) variability.

\_\_\_\_\_ Insert Table 6 about here. \_\_\_\_\_

*Goodness - interaction-based model* (Figure 1b, Table 7). A first mediator analysis (Table 7a) tested the effect of presentation principles on mental effort with correctness of answers as a mediator and demonstrated complete mediation. The indirect negative effect of presentation principles on mental effort after controlling for the negative effect of correctness explained 13% ( $= (.14-.01) \times 100$ , from Table 7a) of variability. A second mediator analysis (Table 7b) tested the effect of correctness on predicted post-use Goodness with mental effort as a mediator and demonstrated complete mediation. The indirect positive effect of correctness on predicted post-use Goodness after controlling for the negative effect of mental effort explained 11% ( $\approx (.11-.002) \times 100$ ) of variability. A third mediator analysis (Table 7c) tested the effect of mental effort on post-use Goodness with post-use perceptions as a mediator and demonstrated complete mediation. The indirect negative effect of mental effort on post-use Goodness after controlling for the positive effect of post-use perceptions explained 29% ( $\approx (.30-.004) \times 100$ ) of variability.

\_\_\_\_\_ Insert Table 7 about here. \_\_\_\_\_

*Goodness - perception-based model* (see Figure 1c, Table 8). A first mediator analysis (Table 8a) tested the effect of pre-use perceptions on predicted post-use Goodness with presentation principles (during use) and pre-use Goodness as mediators and demonstrated partial mediation. The indirect positive effect of pre-use perceptions on predicted post-use Goodness after controlling for the positive effect of presentation principles (during use) and pre-use Goodness explained 36% ( $= (.46-.10) \times 100$ ) of variability. A second mediator analysis (Table 8b) tested the effect of pre-use perceptions, presentation principles (during use) and pre-use Goodness on post-use Goodness with post-use perceptions as mediators and demonstrated complete mediation. The indirect positive effect of pre-use perceptions, presentation principles and pre-use Goodness on post-use Goodness after controlling for the positive effect of post-use perceptions explained 40% ( $= (.41-.01) \times 100$ ) of variability.

\_\_\_\_\_ Insert Table 8 about here. \_\_\_\_\_

*Goodness - combined model* (Table 9). A final model combined the interaction-based and perception-based models in order to improve prediction. Two hierarchical multiple regression analyses (Table 9a) demonstrated that mental effort was still a significant predictor of post-use Goodness while controlling for pre-use perceptions, presentation principles (during use) and pre-use Goodness and vice versa. A mediator analysis (Table 9b) tested the effect of mental effort, pre-use perceptions, presentation principles (during use) and pre-use Goodness on post-use Goodness with post-use perceptions as a mediator and demonstrated complete mediation; the precursors of post-use perceptions did not improve the prediction of post-use Goodness. The indirect effect of pre-use perceptions, presentation principles (during use) and pre-use Goodness on post-use Goodness after controlling for post-use perceptions explained 51% ( $= (.53-.02) \times 100$ , from Table 9b) of variability.

\_\_\_\_\_ Insert Table 9 about here. \_\_\_\_\_

## 5. DISCUSSION

This experiment had two aims to test. The first aim had not been tested previously. Regarding the second aim, models had not been formally developed and tested before and human-system interaction had not been considered. Furthermore, the current study tested models in the context of a complex type of application (web site), while previous research (Hassenzahl, 2004) had used a simpler type (MP3 player). These aims are reviewed in turn before conclusions regarding the role of causality and experience in a user's aesthetic experience of a web site and suggestions for future directions in modelling are presented.

*Aim 1.* In accordance with *Hypothesis 1*, violation of presentation principles had a negative effect on measures of the quality of interaction; compliance with presentation principles had a positive effect on PQ and Goodness and no effect on Beauty. Violation of presentation principles had a negative effect on HQI, but a positive effect on HSQ - perhaps because the pages that violated the principles possessed inherent characteristics of novelty.

*Aim 2.* In accordance with *Hypothesis 2*, Hedonic quality was a predictor of both pre-use and post-use Beauty and Goodness, but only Pragmatic quality was a predictor of pre-use and post-use Goodness and task performance and mental effort were only a predictor of post-use Goodness. The pattern of results confirmed Hassenzahl's (2004) notion that Beauty is associated with Hedonic quality-stimulation (HQS) and identification (HQI) rather than Pragmatic quality (PQ). The pattern of results for Goodness is consistent with Hassenzahl's prediction that, as a result of experience, Pragmatic quality becomes more influential and Hedonic quality-identification less so. Therefore, in accordance with *Hypothesis 3*, the relation of Beauty with perceptions was stable and not influenced by human-system interaction, but the opposite was true for Goodness. Also in accordance with *Hypothesis 3*, Pragmatic quality was less stable over time than Hedonic quality and Goodness less than Beauty: the association of PQ before use with that after use was lower than the association of HQI and HQS before use with that after use. Similarly, the association of Goodness before use with that after use was lower than the association of Beauty before with Beauty after use. The results of model tests summarised in Figure 3 are also in accordance with *Hypothesis 3*: the effects of pre-use perceptions and Beauty on post-use Beauty are partially mediated, but the effects of pre-use perceptions and Goodness on post-use Goodness are completely mediated. Furthermore, in the combined model, the precursors of post-use perceptions did not improve predictions of post-use Goodness. These findings strengthen the notion that Beauty is relatively stable and not influenced by human-system interaction, but that Goodness is relatively unstable.

\_\_\_\_\_ Insert Figure 3 about here. \_\_\_\_\_

The main differences between the tested models for Beauty and Goodness are that system characteristics (presentation principles) did not have an effect on Beauty and only partial mediation occurred. However, system characteristics did influence Goodness and generally complete mediation occurred. Combined, the results of the model tests demonstrate again that Beauty is a more stable evaluation than Goodness.

## **6. CONCLUSION**

The experimental manipulation of presentation principles had an effect on objective performance, hedonic and aesthetic experience and mental workload. Beauty was predominantly related to hedonic product attributes and more so with identification than stimulation. In contrast, Pragmatic quality was not significantly related to Beauty. Goodness, however, was associated with both Pragmatic quality, even more so after System use, and Hedonic quality of web sites. There was a strong relation between Beauty and identification even though the products were web sites (a relatively complex type of application), which - by definition - are not personal possessions (such as MP3 players studied by Hassenzahl, 2004) that users would only show to significant others. Goodness was mainly associated with Pragmatic quality and identification, and - with experience - Pragmatic quality became more strongly associated with Goodness. Beauty was more stable because it was influenced by hedonic attributes derived from appearance. Goodness was less stable because - with experience - it was increasingly influenced by Pragmatic quality.

### **6.1. Causality**

There is a fundamental difference in presumed causality between Hassenzahl and Tractinsky; two major theorists researching aesthetics in HCI. According to Hassenzahl's model, Hedonic quality should influence Beauty and both Pragmatic and Hedonic quality influence Goodness - "perceptions of hedonic or pragmatic attributes can potentially lead to a positive evaluation" (Hassenzahl, 2004, pp. 322-323). At the level of an individual user, products can produce pleasure-inducing arousal fluctuations (stimulation). Fluctuations are mainly determined by comparison of stimulus elements, such as complexity, or aspects of experience, such as novelty (Berlyne, 1971). At a social level, product use operates to confirm (aspects of) a user's identity to the user and to others (Hassenzahl, 2004). Other mechanisms of the effect of products on a user's experience of Beauty include the following. First, preferences can depend on the categories to which a stimulus belongs - as judged by the perceiver - and therefore preferences for particular prototypical artefact characteristics develop (McManus and Weatherby, 1997) that can presumably be independent of usability (above a minimum required level of usability). Second, an artefact can evoke memories in users that produce an experience of Beauty (Hassenzahl, 2003; Norman, 2004). In contrast, Tractinsky assumes that Beauty influences perceived usability (Pragmatic quality), based on the principle of 'What is beautiful is good' (Dion, Berscheid and Walster, 1972). We tested and found evidence for Hassenzahl's model of aesthetic experience. Our results do not support Tractinsky's view and furthermore, previous research that claimed support for his principle suffered from methodological problems (see Hassenzahl, 2004). If at all, Tractinsky's principle 'What is beautiful is usable' is likely to hold when - *ceteris paribus* - approximately equally usable

products differ in Beauty, but not when they differ significantly in their usability.

## **6.2. Experience**

In Hassenzahl's conceptualization, experience affects Goodness through Pragmatic quality, but this should only occur if users cannot (fully) predict a product's Pragmatic quality from appearance. Otherwise, experience should not influence Goodness. Pragmatic quality should affect Goodness, but - provided a product is sufficiently usable - Hedonic quality should become more influential - in particular with asymptotic highly skilled task performance - and Pragmatic quality should become irrelevant. The concept pair of anchoring and adjustment has been applied to modelling technology acceptance (Venkatesh, 2000) and in principle this also applies to aesthetic experience. According to Venkatesh, anchors (general information in the absence of specific knowledge) strongly influence Effort expectancy (the extent to which using a system will be free of effort) initially, but over time adjustments (based on additional information that has become available as a result of direct experience with a target behaviour, for example system use) gain influence. However, anchors do not lose their influence. When modelling aesthetic experience, anchors are individual-difference variables - such as proficiency in using computers, computer anxiety and aesthetic preference - and general beliefs regarding computers based on prior experience with computers in general. Adjustments are the specific experience of hedonic and other system qualities. Immediately perceivable appearance and individual-difference variables (such as a particular consistent aesthetic preference) will not change, but users can learn more about a product's Hedonic quality with experience. A resulting change in perceived Hedonic quality is more likely in essentially hedonic products, such as computer games or hedonic web sites (Childers, Carr, Peck and Carson, 2001), than in (predominantly) utilitarian products, such as human-performance supporting software (such as utilitarian web sites or office applications). Furthermore, the mode of use (Hassenzahl, 2003; Hassenzahl and Ullrich, 2007) is likely to influence perceived product quality. Pragmatic quality will be more important when a product is used in goal mode (where users focus on achieving particular goals) than when it is used in action mode (when users focus on actions rather than goals). During action mode, hedonic product quality is likely to be more important.

## **6.3. Approach to the study of user experience and directions in modelling**

The current study is part of a framework for user experience engineering, which is similar in spirit to Liu's (2003) models of aesthetic evaluation and research process for engineering aesthetics - aiming "to achieve a comprehensive, rigorous and quantitative understanding of aesthetic response in a design context" (p.

1282). Following Liu's approach, the top-down part of our framework aims to identify the main components of user experience (such as Hedonic quality-stimulation, -identification and -evocation), to measure them and model their causal structure. Following Liu's approach, the bottom-up part of our framework aims to elucidate users' sensitivity to variations in components of user experience, users' absolute and relative detection thresholds, users' abilities to perceive and judge levels, changes and variability in design parameters, and users' preferences for levels of design parameters. The current study addressed measurement and modelling (top down) as well as preference for levels of design parameters (bottom up). Our framework for user experience engineering is more general than Liu's because Liu focuses on aesthetics whereas our framework extends to other aspects of user experience as well. The resultant knowledge base - in the form of models of user experience can be used to produce design guidance in the form of design patterns to facilitate comprehension and application by designers (see Zajicek, 2004; van Schaik et al., 2005).

In order to provide a more complete understanding of how the overall quality or the 'goodness' of an interactive product is formed, given pragmatic and hedonic aspects and underlying needs, future research should develop and test models based on existing theoretical notions and measurement instruments in the field of user experience (including hedonic and other factors) (e.g. Hassenzahl, 2004; Tractinsky et al., 2000; Lavie and Tractinsky, 2004), empirical evidence and predictions from the present study and other psychological theories. In order to be relevant for the success of interactive systems, acceptance should be explicitly modelled (see e.g. Cyr, Head & Ivanov, 2006). However, there may be further important final outcomes of user experience, such as well-being (Kahneman, Krueger, Schkade, Schwarz and Stone, 2004) and effectiveness of communication (Hoffman and Krauss, 2004). Future modelling work should also address the effect of mode of use (Hassenzahl, 2003; Hassenzahl and Ullrich, 2007) on aesthetic experience. The advancement of these models should enhance our understanding of user experience and inform system design.

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#### APPENDIX - QUESTIONNAIRE ITEMS

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*Pragmatic quality* - I judge the web pages to be

- 1 Technical - Human
- 2 Complicated - Simple
- 3 Impractical - Practical
- 4 Cumbersome - Direct
- 5 Unpredictable - Predictable
- 6 Confusing - Clear
- 7 Unruly - Manageable

*Hedonic quality-identification* - I judge the web pages to be

- 1 Isolating - Integrating
- 2 Amateurish - Professional
- 3 Gaudy - Classy
- 4 Cheap - Valuable
- 5 Noninclusive - Inclusive
- 6 Takes me distant from people - Brings me closer to people
- 7 Unpresentable - Presentable

*Hedonic quality-stimulation* - I judge the web pages to be

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- 1 Typical - Original
- 2 Standard - Creative
- 3 Cautious - Courageous
- 4 Conservative - Innovative
- 5 Lame - Exciting
- 6 Easy - Challenging
- 7 Commonplace - New

*Beauty* - I judge the web pages overall to be

Ugly - Beautiful

*Goodness* - I judge the web pages overall to be

Bad - Good

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Modelling user experience with web sites

Table 1. Factor analysis of questionnaire items.

Item	Factor					
	Pre-use			Post-use		
	1 Pragmatic quality	2 Hedonic quality- stimulation	3 Hedonic quality- identification	1 Pragmatic quality	2 Hedonic quality- stimulation	3 Hedonic quality- identification
PQ2	.70			.98		
PQ3	.82			.92		
PQ4	.81			.83		
PQ5	.49			.71		
PQ6	.87			.89		
PQ7	.71			.78		
HQS1		.55			.84	
HQS2		.77			.87	
HQS3		.84			.76	
HQS4		.83			.89	
HQS5		.50	.43		.66	
HQS7		.79			.81	
HQI2			.72			-.59
HQI3			.80			-.79
HQI7			.72			-.52
Eigenvalue	5.19	4.50	3.11	5.93	4.17	3.55

Note. Extraction method: principal axis factoring; rotation method: direct oblimin. Figures per item are factor loadings from the pattern matrix. PQ: Pragmatic quality; HQS: Hedonic quality-stimulation; HQI: Hedonic quality-identification.

Table 2. Reliability, descriptives and correlations.

	ICR	Mean	SD	HQI (1)	HQS (1)	PQ (1)	B (1)	G (1)	HQI (2)	HQS (2)	PQ (2)	B (2)
HQI (1)	.83	3.74	1.42									
HQS (1)	.88	3.33	1.29	.11								
PQ (1)	.90	4.94	1.32	***.48	***-.47							
B (1)	NA	3.17	1.50	***.57	***.47	.12						
G (1)	NA	4.14	1.65	***.74	.12	***.49	***.64					
HQI (2)	.89	3.68	1.46	***.75	.11	***.41	***.54	***.64				
HQS (2)	.92	3.27	1.25	.14	***.83	***-.33	***.50	.19	** .28			
PQ (2)	.95	4.03	1.57	***.48	*-.24	***.61	.16	***.47	***.69	.02		
B (2)	NA	2.97	1.34	***.57	***.39	.17	***.72	***.58	***.68	***.52	***.41	
G (2)	NA	3.76	1.68	***.56	.10	***.41	***.42	***.55	***.76	** .30	***.76	***.63

Note. ICR: internal consistency reliability (Cronbach's alpha). Mean: arithmetic mean. SD: standard deviation. Remaining figures are correlations among constructs. PQ: Pragmatic quality; HQI: Hedonic quality-identification; HQS: Hedonic quality-stimulation; B: Beauty; G: Goodness. (1) Pre-use; (2) post-use.

\*  $p < .05$  \*\*  $p < .01$  \*\*\*  $p < .001$

Table 3. Interaction outcomes as a function of experimental manipulations.

		Presentation principles					
Organization		Followed		Violated		Overall	
	principles						
Correctness	Followed	75.67	(14.78)	56.92	(24.13)	66.96	(21.65)
	Violated	71.33	(16.97)	69.20	(18.24)	70.36	(17.42)
	Overall	75.67	(14.78)	56.92	(24.13)	66.96	(21.65)
Efficiency (incorrect answers)	Followed	2.10	(0.49)	2.47	(1.03)	2.28	(0.80)
	Violated	2.11	(0.60)	2.58	(1.05)	2.33	(0.85)
	Overall	2.11	(0.54)	2.52	(1.03)	2.30	(0.83)
Mental effort	Followed	26.04	(12.48)	39.11	(19.84)	32.11	(17.44)
	Violated	28.09	(14.43)	39.81	(17.43)	33.42	(16.78)
	Overall	27.07	(13.41)	39.45	(18.51)	32.76	(17.05)

Note. Mean values are presented with standard deviations in brackets.

Table 4. Perceptions of quality and evaluations.

	Pragmatic quality (PQ)			Hedonic quality-identification (HQI)			Hedonic quality-stimulation (HQS)			Beauty			Goodness		
	Time			Time			Time			Time			Time		
	Pre-use	Post-use	Overall	Pre-use	Post-use	Overall	Pre-use	Post-use	Overall	Pre-use	Post-use	Overall	Pre-use	Post-use	Overall
Presentation principles															
Followed	5.60 (0.81)	4.83 (1.26)	5.21 (0.94)	4.32 (1.13)	4.34 (1.03)	4.33 (1.00)	2.77 (1.01)	2.90 (1.06)	2.83 (0.98)	3.15 (1.25)	3.12 (1.19)	3.13 (1.13)	4.62 (1.40)	4.30 (1.52)	4.46 (1.33)
Violated	4.16 (1.38)	3.08 (1.37)	3.62 (1.13)	3.06 (1.44)	2.91 (1.51)	2.98 (1.35)	3.99 (1.28)	3.72 (1.33)	3.85 (1.24)	3.20 (1.77)	2.80 (1.48)	3.00 (1.52)	3.57 (1.76)	3.12 (1.64)	3.34 (1.40)
Overall	4.94 (1.32)	4.03 (1.57)	4.48 (1.30)	3.74 (1.42)	3.68 (1.46)	3.71 (1.35)	3.33 (1.29)	3.27 (1.25)	3.30 (1.22)	3.17 (1.50)	2.97 (1.34)	3.07 (1.32)	4.14 (1.65)	3.76 (1.68)	3.95 (1.47)

Note. Mean values are presented with standard deviations in brackets.



Table 5. Mediator analysis of pre-use Goodness.

Outcome	R <sup>2</sup>	F	df <sub>1</sub>	df <sub>2</sub>	Predictor	β	sr <sup>2</sup>	t
Predicted pre-use	.18	***24.01	1	109	Presentation principles			
<i>Goodness</i>								
Pre-use Goodness	.10	***12.19	1	109	Presentation principles			
	.49	***43.14	3	106	Pre-use PQ			
					Pre-use HQI			
Pre-use Goodness					Pre-use HQS			
	.59	***32.36	3	107	Pre-use PQ	.30	.04	***3.40
					Pre-use HQI	.58	.21	***7.36
				Pre-use HQS	.19	.02	*2.45	
	< .001	< 1			Presentation principles			

\*  $p < .05$  \*\*\*  $p < .001$

Modelling user experience with web sites

Table 6. Mediator analysis of post-use Beauty.

Outcome	R <sup>2</sup>	F	df <sub>1</sub>	df <sub>2</sub>	Predictor	β	sr <sup>2</sup>	t			
(a) Predicted post-use <i>Beauty</i>	.57	***72.15	2	108	Pre-use HQI	.60	.35	***9.42			
					Pre-use HQS	.40	.16	***6.33			
					Pre-use <i>Beauty</i>	.03	**7.27	1	107		
Predicted post-use <i>Beauty</i>	.42	***77.73	1	109	Pre-use <i>Beauty</i>						
					Pre-use HQI	.18	***24.42	2	107		
					Pre-use HQS						
(b) Post-use <i>Beauty</i>	.57	***37.33	3	107	Pre-use HQI	.26	.04	***3.28			
					Pre-use HQS	.12	.01	1.63			
					Pre-use <i>Beauty</i>	.52	.14	***5.85			
					Post-use HQI	.11	***17.61	2	105		
					Post-use HQS						
					Post-use <i>Beauty</i>	.59	***76.58	2	108	Post-use HQI	.59
Post-use <i>Beauty</i>	.09	***9.81	3	105	Post-use HQS	.36	.12	***5.54			
					Pre-use HQI						
					Pre-use HQS						
Pre-use <i>Beauty</i>					Pre-use HQI						
					Pre-use HQS						
					Pre-use <i>Beauty</i>						
(c) Post-use <i>Beauty</i>	.43	***40.85	2	108	Pre-use HQI						
					Pre-use HQS						
Post-use <i>Beauty</i>	.52	***118.82	1	109	Pre-use <i>Beauty</i>						
Post-use <i>Beauty</i>	.59	***756.58	2	108	Post-use HQI						
					Post-use HQS						
					Pre-use HQI	.01	1.88	2	106		
Post-use <i>Beauty</i>					Pre-use HQS						
					Post-use HQI	.59	***756.58	2	108		
					Post-use HQS						
Post-use <i>Beauty</i>	.09	***29.89	1	107	Pre-use <i>Beauty</i>						

\*\*  $p < .01$  \*\*\*  $p < .001$

Modelling user experience with web sites

Table 7. Mediator analysis of post-use Goodness - interaction-based model.

Outcome	R <sup>2</sup>	F	df <sub>1</sub>	df <sub>2</sub>	Predictor	β	sr <sup>2</sup>	t
(a) Correctness <sup>a</sup>	.19	***12.65	1	54	Presentation principles			
Mental effort <sup>a</sup>	.14	**8.95	1	54	Presentation principles			
	.31	***29.72	1	53	Correctness			
Mental effort <sup>a</sup>	.44	***42.57	1	54	Correctness			
	.01	< 1			Presentation principles			
(b) Mental effort	.38	***66.22	1	109	Correctness			
Predicted post- use Goodness	.11	***13.16	1	109	Correctness			
	.24	***38.67	1	108	Mental effort			
Predicted post- use Goodness	.34	***56.51	1	109	Mental effort			
	.002	< 1			Correctness			
(c) Post-use Goodness	.30	***45.93	1	109	Mental effort			
	.42	***51.97	3	106	Post-use PQ Post-use HQI Post-use HQS			
Post-use Goodness	.71	***87.78	3	107	Post-use PQ	.52	.13	***6.40
					Post-use HQI	.35	.05	***4.45
					Post-use HQS	.19	.03	***3.45
	.004	1.55	1	106	Mental effort			

<sup>a</sup> Subsample of conditions, with organization principles followed.

\*\*  $p < .01$  \*\*\*  $p < .001$

Modelling user experience with web sites

Table 8. Mediator analysis of post-use Goodness - perception-based model.

Outcome	R <sup>2</sup>	F	df <sub>1</sub>	df <sub>2</sub>	Predictor	β	sr <sup>2</sup>	t
(a) Predicted post-use <i>Goodness</i>	.46	***30.31	3	107	Pre-use PQ	.35	.10	***3.46
					Pre-use HQI	.44	.18	***4.85
					Pre-use HQS	.20	.05	*2.26
	.08	***8.44	2	105	Presentation principles (during use) Pre-use <i>Goodness</i>			
Predicted post-use <i>Goodness</i>	.44	***42.24	2	108	Presentation principles (during use) Pre-use <i>Goodness</i>	.31	.09	***4.10
					Pre-use <i>Goodness</i>	.49	.22	***6.50
	.10	***7.16	3	105	Pre-use PQ Pre-use HQI Pre-use HQS			
(b) Post-use <i>Goodness</i>	.41	***14.39	5	105	Pre-use PQ Pre-use HQI Pre-use HQS Presentation principles (during use) Pre-use <i>Goodness</i>	.24	.03	*2.11
					Pre-use HQI	.18	.01	1.40
					Pre-use HQS	.27	.03	*2.44
					Presentation principles (during use) Pre-use <i>Goodness</i>	.20	.02	1.96
					Pre-use <i>Goodness</i>	.20	.02	1.70
	.31	***38.01	3	102	Post-use PQ Post-use HQI Post-use HQS			
Post-use <i>Goodness</i>	.71	***87.78	3	107	Post-use PQ Post-use HQI Post-use HQS	.52	.13	***6.40
					Post-use HQI	.35	.05	***4.45
					Post-use HQS	.19	.03	***3.45
	.01	< 1			Pre-use PQ Pre-use HQI			

## Modelling user experience with web sites

Pre-use HQS

Presentation principles

(during use)

Pre-use *Goodness*

---

\*  $p < .05$  \*\*\*  $p < .001$

Modelling user experience with web sites

Table 9. Mediator analysis of post-use Goodness - combined model.

Outcome	R <sup>2</sup>	F	df <sub>1</sub>	df <sub>2</sub>	Predictor	β	sr <sup>2</sup>	t
(a) Predicted post-use Goodness	.53	***24.09	5	105	Pre-use PQ	.26	.03	*2.55
					Pre-use HQI	.18	.01	1.58
					Pre-use HQS	.33	.05	**3.40
					Presentation principles (during use)	.34	.06	**3.73
					Pre-use Goodness	.19	.01	1.80
	.12	***35.29	1	104	Mental effort			
Predicted post-use Goodness	.34	***56.51	1	109	Mental effort			
	.31	***18.59	5	104	Pre-use PQ			
					Pre-use HQI			
					Pre-use HQS			
					Presentation principles (during use)			
					Pre-use Goodness			
(b) Post-use Goodness	.53	***19.04	6	104	Mental effort	-	.12	***5.18
						.39		
					Pre-use PQ	-	.02	*2.02
						.39		
					Pre-use HQI	.21	<.01	0.40
							1	
					Pre-use HQS	.05	.04	**2.92
					Presentation principles (during use)	.28	.01	1.45
					Pre-use Goodness	.14	.02	*2.20
	.20	***24.47	3	101	Post-use PQ			

Modelling user experience with web sites

					Post-use HQI			
					Post-use HQS			
Post-use <i>Goodness</i>	.71	***87.78	3	107	Post-use PQ	.52	.13	***6.40
					Post-use HQI	.35	.05	***4.45
					Post-use HQS	.19	.03	***3.45
	.02	< 1			Mental effort			
					Pre-use PQ			
					Pre-use HQI			
					Pre-use HQS			
					Presentation principles (during use)			
					Pre-use <i>Goodness</i>			

---

\*  $p < .05$  \*\*  $p < .01$  \*\*\*  $p < .001$

## Figure captions

Figure 1. Models of user experience

- a. Aesthetic experience before or without *System use*
- b. Interaction-based model of aesthetic experience with *System use*
- c. Perception-based model of aesthetic experience with *System use*

Figure 2. Typical web pages used in the experiment

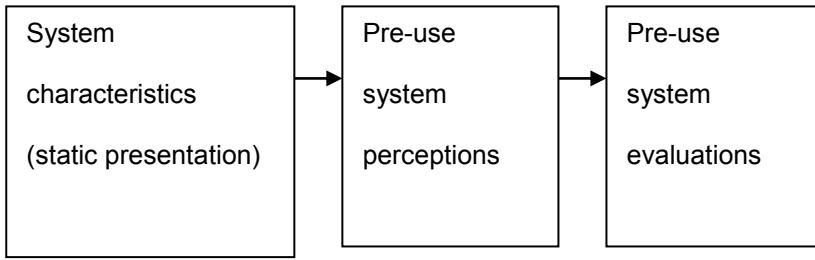
- a. Presentation principles followed, organization principles followed
- b. Presentation principles followed, organization principles violated
- c. Presentation principles violated, organization principles followed
- d. Presentation principles violated, organization principles violated

Figure 3. Relationships confirmed in model tests

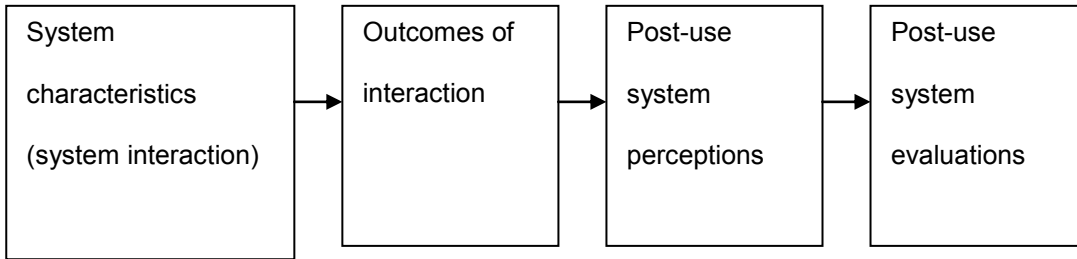
- a. Beauty
- b. *Goodness* - interaction-based model
- c. *Goodness* - perception-based model



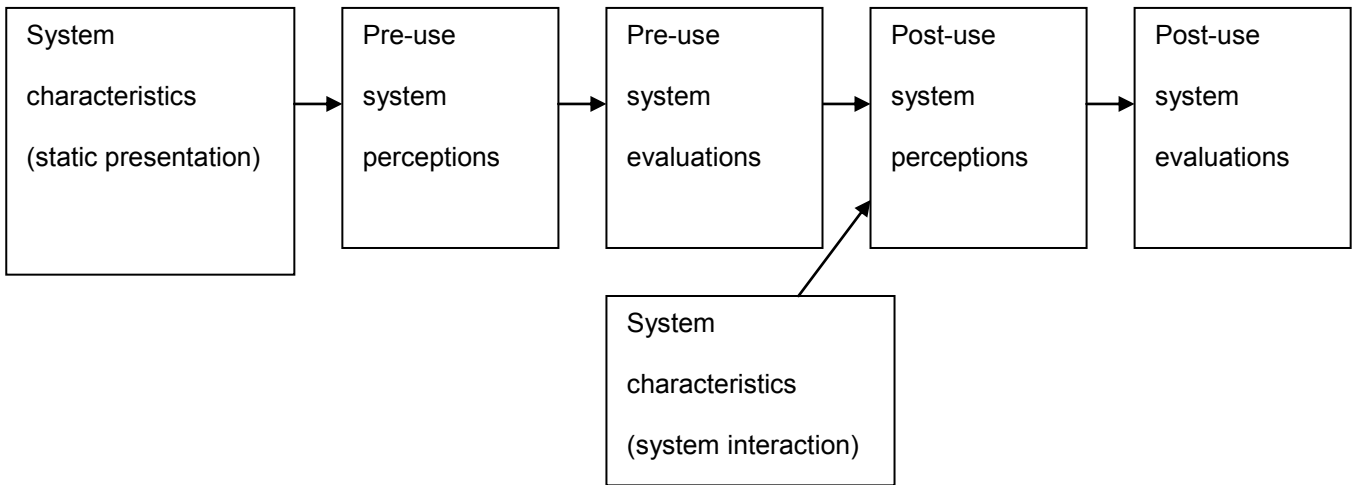
Modelling user experience with web sites



a.



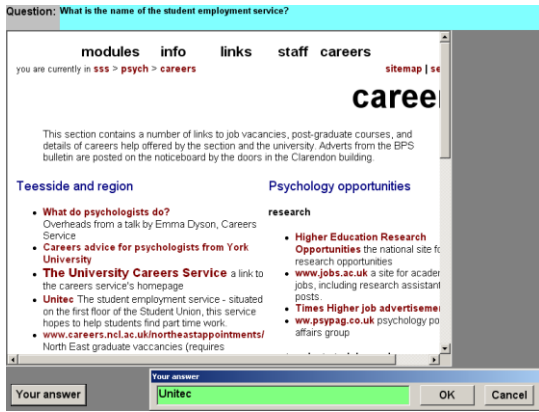
b.



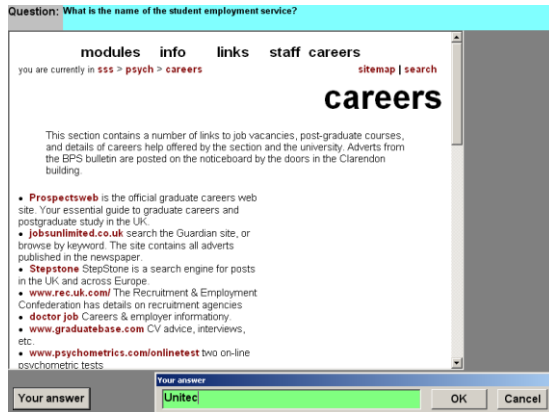
c.

Figure 1.

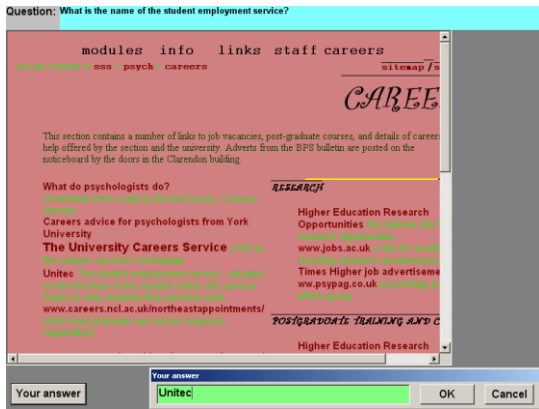
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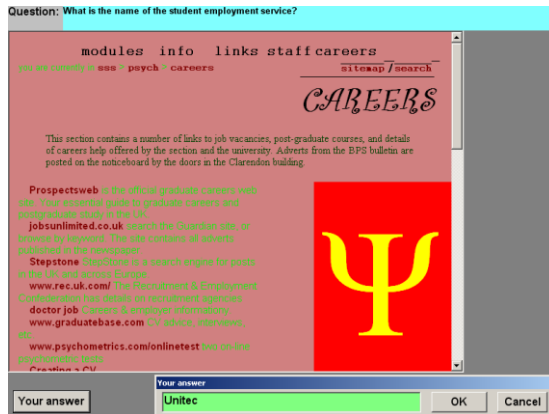
a.



b.



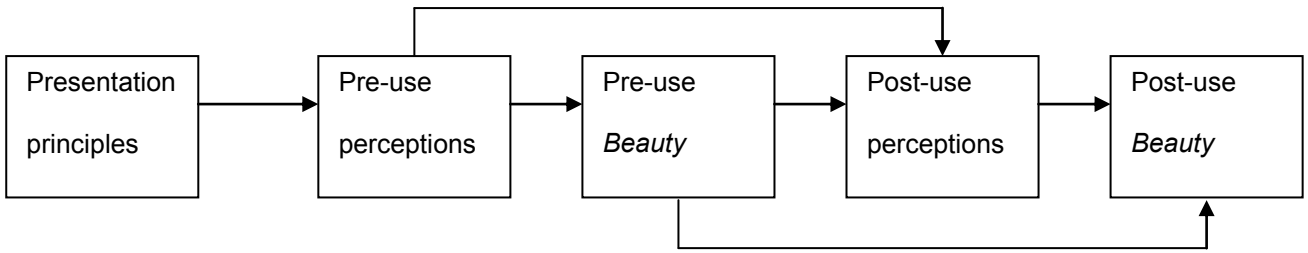
c.



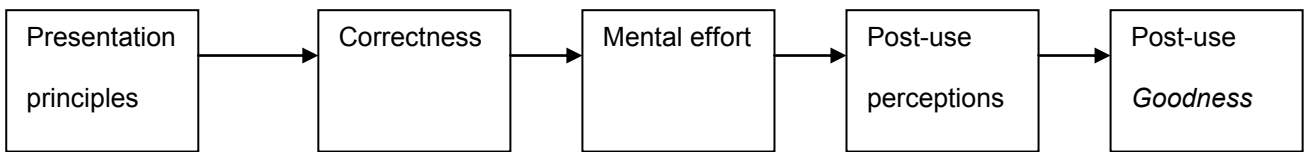
d.

Figure 2

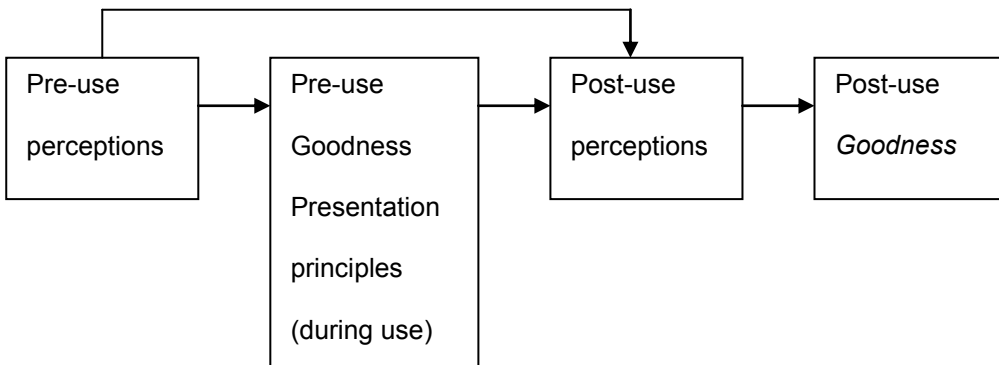
Modelling user experience with web sites



a.



b.



c.

Figure 3