Design simplicity influences patient portal use: the role of aesthetic evaluations for technology acceptance

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ABSTRACT

Objective This study focused on patient portal use and investigated whether aesthetic evaluations of patient portals function are antecedent variables to the Technology Acceptance Model.

Methods A cross-sectional survey of current patient portals users (N = 333) was conducted online. Participants completed the Visual Aesthetics of Website Inventory, along with items measuring perceived ease of use (PEU), perceived usefulness (PU), and behavioral intentions (BIs) to use the patient portal.

Results The hypothesized model accounted for 29% of the variance in BIs to use the portal, 46% of the variance in the PU of the portal, and 29% of the variance in the portal’s PEU. Additionally, one dimension of the aesthetic evaluations functions as a predictor in the model – simplicity evaluations had a significant positive effect on PEU.

Conclusion This study provides evidence that aesthetic evaluations – specifically regarding simplicity – function as a significant antecedent variable to patients’ use of patient portals and should influence patient portal design strategies.

Keywords: eHealth, patient portals, web aesthetics, technology acceptance model
BRIEF COMMUNICATION

Aesthetic evaluations are often made on their actual use of the technology, beyond its usability. Web aesthetics are sensory experiences of pleasure or beauty resulting from an interface design. Aesthetic evaluations are often made quickly; hold constant; and impact the perceived (as well as actual) usability of the technology, the users’ satisfaction, and their intentions to revisit a website. Grounded in interactionist aesthetics, in which the objective properties of a website are reflected in users’ subjective appraisals of the website, the four validated facets of VisAWL – simplicity, diversity, colorfulness, and craftsmanship – have been empirically shown to affect website usability.

Simplicity is the perception that a website exhibits orderliness, balance, and clarity – the concepts of figural goodness defined by Gestalt psychology. Higher levels of perceived simplicity are positively associated with increased fluency, ease of processing, and improved task performance. Diversity is the perception of the complexity, visual richness, and dynamics of the website. Although diversity provokes users’ interest, too much diversity can create tension or negative arousal. Colorfulness is an evaluation of the coherence of color selection and placement in a website’s design. Craftsmanship reflects the users’ perceptions of the skill and care used in the creation of the website. Therefore, we pose the following hypotheses and a research question about the less-studied facets of VisAWL.

Hypothesis 3 (H3): Simplicity will have a positive effect on PEU.

Hypothesis 4 (H4): Diversity will have a negative effect on PEU.

Research Question 2 (RQ2): Does colorfulness or craftsmanship have a positive effect on PEU?

METHODS

Procedure
A cross-sectional survey of patient portal users was conducted online, as approved by the relevant institutional review board. Participants were recruited through a link on a regional clinic’s patient portal website landing page. All participants were enrolled users of a regional clinic’s patient portal and had the ability to regularly use the portal and view its aesthetics. Over 38,000 patients were enrolled portal users prior to the study. Data were collected over 6 months, during which time approximately 8000 users in the study enrolled each month. After giving informed consent, the study participants responded to items measuring TAM variables and completed VisAWL. Lastly, demographic information about the study participants was collected. The items used in this study were part of a larger data collection activity.

The patient portal, introduced in July 2013, has a prototypical design with a navigation bar on the left side of the screen, the main content in the center of the screen, and information about the clinic and log-in information in the top banner, exhibiting mid-level visual complexity. The top banner also displays images of a laptop and mobile phone with the patient portal loaded. Current news, updates, and tips are displayed at the top of the main content area. Users can send messages, make appointments with their healthcare providers, view their medical records, or check billing and insurance information, all of which are tasks that can be selected from a text-based navigation bar on the left side of the screen or by clicking large buttons, containing text and icons, in the main content area. The site is primarily white, gray, and purple – the clinic’s brand colors. No updates were made to the portal’s design during the data collection activities for this study.

Measures
The following previously validated measures were used. Item wording was adapted to reflect the use of the “patient portal.” PEU measured, with three items, whether the portal was easy “to use,” “to do what I want,” and was “clear and understandable.” Three items measured PU, by offering the study participants the chance to agree/disagree that the portal would “improve,” “enhance,” or be “useful” for managing one’s healthcare. Three items measured BIs by asking study participants about their intentions, predictions, and plans to use the patient portal in the next month. Aesthetic evaluations were measured with VisAWL’s 18 items. All of the items were measured with a Likert-type scale, ranging from strongly disagree (1) to strongly agree (7), and were reverse-coded if they were negatively framed, so that positive numbers represent higher levels of agreement. A single item measured the study participants’ past use of the patient portal, ranging from not at all (1) to very often (5).

Data Analysis
Structural equation modeling was used to test the hypotheses and investigate the research questions, because this analytical procedure offers a more robust test of effect decompositions, estimates of model fit, and controls for error than traditional path modeling. The structural equation modeling analysis was conducted with an a priori specified path model (Figure 1) in Mplus v6.12. In the model, hypotheses are represented as solid arrows and research questions as dotted arrows, for ease of interpretation.

RESULTS

Descriptive Statistics of the Sample
A total of 333 enrolled patient portal users participated in this study. Participants ranged from 18–87 years (mean = 51.91, standard deviation [SD] = 14.20) and were mostly (72%) female. Education levels included high school to some college (29%), bachelor’s degree (35%), master’s degree (27%), and doctoral or professional degree (9%). Participants identified as white (84%), African American (4%), Asian (3%), or multiracial/other (8%). Most participants (82%) rated their general health as good to excellent; fewer indicated their health was fair (14%) or poor (3%). Participants reported having used the patient portal for <3 months (56%), 3–6 months (24%), 6–9 months (13%),

"Downloaded from https://academic.oup.com/jamia/article-abstract/23/e157/e158/2379907 by guest on 15 December 2018"
or > 9 months (8%). Most participants (56%) reported occasional use of the patient portal, and others claimed rare (13%), often (26%), or very often (5%) use of the patient portal.

Model Testing
The hypothesized model (Figure 1) fits the data quite well, according to common fit statistics, when controlling for past use – isolating relationships beyond those from this predictor of repetitive future intentions (likelihood ratio $\chi^2 = 11.323$, $df = 8$, $P = .184$; Akaike information criterion [AIC] = 2712.312; comparative fit index [CFI] = 0.994; root mean square error of approximation [RMSEA] = 0.035; standardized root mean square residual [SRMR] = 0.029). Standardized correlations are shown in Table 1. The model accounts for 29% of the variance in the criterion variable of BIs for patient portal use, 46% of the variance in PU, and 29% of the variance in PEU, without controlling for past use (and inflating the values). The variance when controlling for past use is 41% for BIs, 48% for PU, and 34% for PEU.

Three of the four hypotheses (H1, H2, and H3) were supported with our model, when controlling for past use. Our findings indicated that PU had a significant positive effect on BIs ($b = 0.403$, $P < .001$) and that PEU had a significant positive effect on PU ($b = 0.641$, $P < .001$), as predicted. Importantly, aesthetic appraisals functioned as a significant predictor for one of the proposed relationships. Users’ evaluations of simplicity had a significant positive effect on PEU ($b = 0.624$, $P < 0.001$). H4 was unsupported.

The model did not yield support for either research question. The PEU of the patient portal was not significantly related to BIs (RQ1). Furthermore, neither the aesthetic evaluation of colorfulness nor of craftsmanship was a significant predictor of PEU (RQ2).

**DISCUSSION**
Patient portals, building on decades of development in telemedicine and e-health research and practice, have the potential to be a cornerstone of patient-centered care in coming years. Indeed, the Healthy People 2020 initiative includes objectives related to increasing the proportion of patients who use the Internet to keep track of personal health information and communicate with their healthcare providers.26 To actually deliver on this promise, however, patient portals must be designed so that patients perceive them to be both useful and easy to use, because repeated use of patient portals is imperative to reduce demands on healthcare providers’ resources.18 Although patient portals, similar to other websites, are displayed in a browser, meaning that patients’ aesthetic appraisals are susceptible to all the variations of individual displays (eg, window size, scrolling requirements), healthcare providers have an additional challenge when trying to increase users’ engagement with patient portal – healthcare providers must often depend on patient portal design and functionality that is set by third-party developers. Thus, this study is an important step toward determining how aesthetic evaluations of patient portals contribute to patients’ intentions for continued use of the portals, filling a gap in the literature with evidence that can be shared among providers and portal developers to determine best practices for the design and development of patient portals.27

This study integrated multifaceted aesthetic evaluations with the TAM to understand predictors of patient portal use. We found support for the well-established PEU–PU–BIs relationship, further demonstrating the applicability of this model for understanding the adoption of e-health technologies.12,17,18 No direct relationship between PEU and BIs was found, which provides evidence that this relationship is likely mediated through PU; this is, perhaps, a consequence of the increased prevalence of digital technology and users’ increased aptitude for computer use.28

More importantly, our findings showed that simplicity aesthetics are an antecedent to the TAM, mirroring the evidence of generic portal use. The four facets of aesthetics explained almost 30% of the variance in PEU, with simplicity having the greatest impact on this aspect of the TAM. The simplicity evaluations elicited from the study population provide empirical corroboration that designing patient portals to increase users’ perceptions of orderliness and clarity can indirectly influence patient portal BIs.

These findings provide clear guidance for the focus of patient portal user testing – perceptions of simplicity. Above all other aesthetic appraisals, perceptions that the design of the patient portal is

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**Figure 1:** Final model with parameter estimates of the paths while controlling for past use (PAST).

[Diagram showing the model with parameter estimates]

**FIT Statistics**
- $\chi^2 = 11.323$, $P = .184$, $df = 8$
- AIC = 2712.312
- CFI = 0.994
- RMSEA = 0.035
- 90% CI, RMSEA = (.000, .079)

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

Standardized Beta coefficients are reported.
well-structured, cohesive, and easy to understand are influential indicators for patient portal BIs and could likely be influential factors for improving the adoption of other e-health technologies. Isolating simplicity as a crucial aspect of patient portal design also provides a clear next step for identifying objective structural design features that lead to positive user evaluations of patient portals. Research and practice should base user testing and actionable design strategies around these findings. Structural features, such as graphic elements, lines, or color breaks that visually distinguish content, are simple design techniques that should be explored as ways of increasing users’ simplicity ratings of patient portals and, hence, improving the perceived usability of and the likelihood of actual use of patient portals.

Using a well-known model to test the relationship between aesthetic evaluations of patient portal design and other factors influencing patient portal use was a logical first step. Future research should expand our results by examining objective design features as well as patients with different health literacy levels or computer experience. Although the negative relationship between diversity and PEU was not significant in our model, our study’s population of current users might have suppressed this relationship, because this population was not deterred by the site’s current objective visual complexity. Investigations of how visual complexity – both feature complexity and design complexity – influences users’ perceptions of patient portals and actual patient use of patient portals would illuminate whether the amount of information (feature complexity) or the organization of information (design complexity) are barriers to patient portal use.30 On the one hand, additional information (including cues for functionality) presented in well-designed layouts with a sophisticated use of color, graphics, and typography may emphasize information hierarchy, distinguish content, and increase PU and ease of use at-a-glance. Conversely, additional information that is not well organized, or is visually unappealing to a user, may overwhelm and deter use. Although some researchers have linked objective design features, such as design structure and color, to positive aesthetic evaluations, others have been unable to replicate these findings.31 Indeed, the non-significant relationship for colorfulness may indicate that tailoring the patient portal to a clinics’ brand colors does not greatly affect users’ aesthetic evaluations – a positive finding that means that designers can make the branding of a site easily identifiable without sacrificing the quality of the users’ aesthetic evaluations. Future studies should also explore how factors that are likely context- and population-specific, such as the perceived relevance of imagery and mental models for structural designs (eg, prototypicality), influence users’ perceptions of and engagement with patient portals.32

There are limitations in this study that must be acknowledged when considering our results’ implications for research and practice. The study sample was recruited from current users of a patient portal, who might be different, in systematic ways, from nonusers (eg, they are more likely to adopt new technology), it is difficult to know how these two groups might vary in terms of their aesthetic evaluations of the patient portal, but future research could investigate this by inviting non-portal users to look at or use the patient portal for the first time and provide evaluations of the portal at that time. The clinic involved in this study is the largest private healthcare provider in a major metropolitan city and thus likely reasonably represents the health conditions and status of the broader population; still, future research should directly assess how users’ health status may relate to their evaluations of a patient portal. Additionally, although the TAM provides a parsimonious framework to isolate the influence of aesthetics on patients’ use of patient portals, more robust iterations of this theory, such as the Unified Theory of Acceptance and Use of Technology, that account for voluntariness15 may be more useful for studying the influence of aesthetics on patient portals and other e-health applications used by healthcare practitioners.

Table 1: Descriptive Statistics, Reliabilities, and Standardized Correlations among Constructs

<table>
<thead>
<tr>
<th>Construct</th>
<th>SIMP</th>
<th>DIV</th>
<th>CO</th>
<th>CRA</th>
<th>PEU</th>
<th>PU</th>
<th>BIs</th>
<th>PAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplicity (SIMP)</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Diversity (DIV)</td>
<td>0.74***</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Colorfulness (CO)</td>
<td>0.76***</td>
<td>0.72***</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Craftsmanship (CRA)</td>
<td>0.85***</td>
<td>0.77***</td>
<td>0.75***</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived ease of use (PEU)</td>
<td>0.53***</td>
<td>0.36***</td>
<td>0.34***</td>
<td>0.42***</td>
<td>1.00</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Perceived usefulness (PU)</td>
<td>0.38***</td>
<td>0.30***</td>
<td>0.30***</td>
<td>0.34***</td>
<td>0.68***</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral intentions (BIs)</td>
<td>0.27***</td>
<td>0.28***</td>
<td>0.27***</td>
<td>0.25***</td>
<td>0.40***</td>
<td>0.53***</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Past use (PAST)</td>
<td>0.21***</td>
<td>0.17**</td>
<td>0.21***</td>
<td>0.16**</td>
<td>0.33***</td>
<td>0.33***</td>
<td>0.52***</td>
<td>1.00</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>5.41 (0.94)</td>
<td>4.73 (1.02)</td>
<td>5.10 (0.93)</td>
<td>5.24 (0.98)</td>
<td>5.89 (1.14)</td>
<td>5.93 (1.25)</td>
<td>5.98 (1.25)</td>
<td>3.22 (0.77)</td>
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<tr>
<td>Cronbach’s $\alpha$</td>
<td>0.86</td>
<td>0.85</td>
<td>0.81</td>
<td>0.82</td>
<td>0.92</td>
<td>0.95</td>
<td>0.98</td>
<td>N/A</td>
</tr>
</tbody>
</table>

SD, standard deviation, NA, not applicable **Significance at $P < .01$. *** $P < .001$. 

CONCLUSION

As technology becomes more ubiquitous, evaluations of beauty and pleasure may continue to have a stronger relationship with users’ initial and long-term decisions to use a piece of technology. This study provides evidence that aesthetic evaluations – specifically of simplicity – function as a significant antecedent variable for patients’ portal use. These findings provide an empirical evaluation of one dimension of aesthetic appraisal, which developers and process experts should focus on to improve patient portal designs and increase patient use of patient portals.

CONTRIBUTORS

A.J.L., I.W., M.S.M., H.S., B.X., and K.S. conceptualized and designed the study; A.J.L., I.W., M.S.M., and H.S. collected the data; A.J.L., I.W., and M.S.M analyzed the data and wrote the initial draft manuscript; B.X. and K.S. assisted with data analysis and interpretation; and all authors contributed to the manuscript revisions.
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COMPETING INTERESTS
None.

REFERENCES

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