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Context-aware optimization of mobile commerce website interfaces from the consumers' perspective: Effects on behavioral intentions

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ABSTRACT

This study focuses on the effects of user interfaces in mobile commerce (m-commerce) on the perceived ease of use and related consumer behaviors when controlled for environmental conditions (sunshine, humidity, and brightness). Effects were tested in real-time contexts (outdoor m-commerce). Specifically, three key design attributes related to commercial website interfaces were examined using a full factorial plan ($2 \times 2 \times 2$): color contrast, layout, and font type. A website selling music CDs was created for the experiment. Data were collected through an online questionnaire ($n = 560$) to investigate potential direct and interaction effects of these interface attributes. The results show that an m-commerce website with a positive color contrast (light text on a dark background) and airy line spacing with a sans-serif font (Arial) is perceived as easier to use when engaged in outdoor m-commerce. This combination of interface attributes is associated with higher intentions to purchase as well as an increase in revisits and recommendations of the website. The implications for both m-commerce research and practice are discussed.

1. Introduction

Due to the increase in the use of mobile devices, m-commerce sales accounted for 72.9 percent of all retail e-commerce in 2021. Studies examined factors that influence the actual adoption of m-commerce (e.g., Chung, 2014; Dholakia & Dholakia, 2004; Gao, Rohm, Sultan, & Pagani, 2013; Li, Dong, & Chen, 2012; Shankar, Venkatesh, Hofacker, & Naik, 2010; Varnali & Toker, 2010). The impact of factors, such as convenience, information, entertainment, and interactivity on consumers' behavioral intentions were explored (Khan, Pelet, & Zamani, 2021; Tsai, Wang, Yan, & Chang, 2017). However, there is only limited research addressing mobile website interface attributes and their effects on consumer behavior (e.g., Choi & Lee, 2012; Cyr, Head, & Ivanov, 2006; Sohn, Seegebarth, & Moritz, 2017).

Previous research has demonstrated that cues from online stores influence shoppers' emotional and cognitive states, which consequently affect their shopping outcomes (e.g., Eroglu, Machleit, & Davis, 2003; Hsieh, Hsieh, Chiu, & Yang, 2014; Hsieh, Chiu, Tang, & Lee, 2018). Researchers agree that an intuitively operable m-commerce interface is a key feature for optimal interaction with consumers (e.g., Dreyer, Olivotti, Lebek, & Breitner, 2019; Seeliger et al., 2015; Song, Sun, Wan,

Huang, & Zhu, 2019; Pao, Reben, & Rayes, 2011, May); 73% of consumers are more likely to buy when mobile transactions offer them a comfortable experience (Diorio, 2018). Specifically, it has been shown that aesthetic attributes (e.g., color, contrast, and typography) are the most important determinants of successful interactions with websites (Choi & Lee, 2012; Coursaris, Swierenga, & Watrall, 2008; Cyr et al., 2006; Holzinger, Stickel, Fassold, & Ebner, 2009; Lee & Koubek, 2010; Monzón, Angeleri, & Dávila, 2021; Seckler, Opwis, & Tuch, 2015; Wells, Valacich, & Hess, 2011). Researchers found that the effective use of websites is tied to elements such as color contrast, layout, and font style (e.g., Cyr, Head, & Larios, 2010; Gradisar & Turk, 2007, June 25-28; Hsieh et al., 2018; Lee and Koubek, 2010; Monzón et al., 2021; Pelet & Papadopoulou, 2012; Pelet & Taieb, 2018, chap. 527; Sohn et al., 2017). While some studies show that color contrast between text and background has a strong effect on user performance (e.g., Gradisar & Turk, 2007, June 25-28; Pelet & Papadopoulou, 2012; Sohn et al., 2017), Monzón et al. (2021) contend that such a color contrast does not have any beneficial effect. Lee and Koubek (2010) suggested that website layout had a greater effect on user preference than color or typography. Such conflicting results call for additional empirical research on website interfaces in an m-commerce setting.

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User interfaces in m-commerce also need to be examined in connection with the user environment (Raphaëli, Goldstein, & Fink, 2017; Stewart & Jürjens, 2018). Environmental conditions (weather, noise level, and brightness) can interfere with the use of mobile devices and compromise m-commerce processes. Current best practice technical solution, such as Responsive Web Design (RWD), fail to consider the effects which physical environmental factors (sun, rain, or temperature) may exert on mobile screen visibility. For example, a smart phone screen display is less visible when the sun shines strongly, which may make users abandon their website interactions. Sharma and Gutiérrez (2010) have argued that “*there is certainly a need to think beyond existing Internet based e-commerce business models and search for models more appropriate to m-commerce*” (p.38). More specifically, user environmental conditions should be strongly considered when designing m-commerce websites; consumers seek well-designed websites that facilitate their purchase processes regardless of their location at the time of their transaction (Clayton, Leonard, & Joseph, 2004).

Our research differs from previous studies that employed measures based on multi-item scales related to visual appearance, content, usability, and quality: the ‘Scale of the Web Analysis and Measurement Inventory’ by Kirakowski & Claridge (2001), the ‘WebQual Scale’ by Loiacono, Watson, & Goodhue (2007), as well as the ‘Scale of Visual Aesthetics of Website Inventory’ (VisAWI) by Moshagen and Thielsch (2010). These scales are rather abstract and do not contribute very much to the improvement of interface designs. Adjectives such as “ugly”, “sophisticated”, or “unpleasant” do not identify precisely which interface attributes need to be changed. Perry, O’Hara, Sellen, Brown, and Harper (2001) stated that “*when thinking about design issues in relation to mobile technologies, (...) the terms, as they stand, are too abstract to be useful. To be truly useful, it is necessary to use empirical findings (...) to unpack exactly what these terms mean*” (p. 344). Following Perry et al. (2001), we examined physical features relevant to the design of an effective mobile interface.

The present study expands the understanding of consumer interactions with m-commerce website interfaces in employing an empirical experiment under real conditions (mobile shopping outdoors). We examined three key website features: color contrast, line spacing, and font type, each of which were controlled according to physical environmental factors (luminosity, humidity, and temperature). Specifically, we sought to find out about how physical environment characteristics (i.e., luminosity, humidity, and temperature) may impact consumers’ perceptions of website interfaces, their perceived ease of use, and hence, their behavioral intentions. Research in real conditions provides a deeper understanding of usage behavior as well as both customer preferences and needs in a mobile shopping context. In the following, we present a systematic literature review on website interfaces with respect to color, layout, and font type. The experimental design and empirical testing of hypotheses are subsequently presented, followed by a discussion of the results. Finally, conclusions, implications for theory and practice, as well as limitations and suggestions for future research are given.

2. Literature review

2.1. Interface attributes, ease of use, and consumer behavior

The interface of a website is of paramount importance for the success in e-commerce, due to its influence on customer interactions and behavior (Pelet & Papadopoulou, 2012). This has been affirmed by research on information systems, which has focused not only on the perceived quality, but also the technical characteristics, of websites as factors determining online consumer behavior (Singh, Dalal, & Spears, 2005; Torkzadeh & Dhillon, 2002). Cyr et al. (2006) argued that for the design of an m-commerce website the attributes of color, shape, font type, music, animation, etc. play an important role. Similarly, Ingraham and Bradburn (2003) mentioned three key attributes of website

interfaces that are required to develop a highly useable web page: color (color contrast between the foreground and background), layout (e.g., line spacing) and typefaces (size and font). A website interface with good visual aesthetics can improve task performance, positively influence its usability (Choi & Lee, 2012; Cyr et al., 2006; Monzón et al., 2021), or increase consumer impulsiveness (Chopdar & Balakrishnan, 2020).

In relation to mobile commerce, Sarkar, Chauhan, and Khare (2020) revealed that design attributes of interfaces may improve perceived usefulness, customization, and ease of use, and thus, strengthen customers’ trust in m-commerce. Ease of use and its effect on users’ behavioral intentions were investigated extensively in view of Human Computer Interactions (HCI) (Morris & Turner, 2001; Murray & Häuble, 2011; Venkatesh, Morris, Davis, & Davis, 2003). In m-commerce, however, there is a lack of research on the role of ease of use (Visinescu, Sidorova, Jones, & Prybutok, 2015). Along with the direct influence of website interface attributes on consumer behavior, we assume that ease of use has a mediating effect on the relationship between website interface attributes and consumer’s behavioral intentions to purchase, revisit, and recommend a website. Empirical research provides evidence for the effects of website interface attributes on consumer behavior (see Table 1). Bibliometrix¹ and R² softwares help not only to measure production rates, but also to map the structure of scientific knowledge of website interfaces in relation to color, layout, and font type. Bibliometric softwares are indispensable tools for analyzing the evolution of a particular field of science and to identify the social networks among authors, countries, scientific journals, institutions, exponential papers, and scholars. Moreover, bibliometric techniques allow researchers to make inferences about the direction of future research and reveal gaps in the extant literature to develop further studies. In addition, the use of software minimizes a potential researcher bias, which, therefore, improves the reliability of research findings (Cardoso de Santana, Bem Maracajá, & Araújo Machado, 2020).

2.2. Color: contrast matters

Color components, such as hue, brightness, and saturation (HBS) affect our perceptions, emotional reactions, and behavioral intentions (Pelet, 2010; Pelet & Papadopoulou, 2012; Valdez & Mehrabian, 1994; Wu et al., 2008). Furthermore, color influences attitudes and expectations towards brands in e-commerce (Cyr et al., 2010). Previous studies have indicated that consumers are better able to process product information if it is presented in colors and, hence, easier to read against the background (e.g. Reber & Schwarz, 1999; Shen, Jiang, & Adaval, 2010). Despite its importance, surprisingly, little is known about the influence of color in a mobile setting, particularly in the context of m-commerce, where phones are carried and used in myriad locations.

Design guidelines induced from empirical research suggest that the contrast between the foreground and background should be emphasized (Chadwick-Dias, Bergel, & Tullis, 2007; Gao, Ebert, Chen, & Ding, 2011; Hill & Scharff, 1997; Pelet, 2014, chap. 226; Pelet & Taieb, 2018, chap. 527). The color contrast on the website affects the consumer’s retention of information and intention to purchase (Pelet, 2010; Pelet & Papadopoulou, 2012). Greco, Stucchi, Zavagno, and Marino (2008) indicated that a positive color contrast, composed of a light text over a dark background, provides better legibility and readability on a computer. Pelet and Taieb (2018), chap. 527 achieved the same results in a mobile environment. It is important to note that legibility reflects how comprehensible or identifiable written characters are, based on their

¹ <https://www.bibliometrix.org/>: Bibliometrix provides all the tools to pursue a complete bibliometric analysis.

² <https://www.r-project.org/>: R is a programming language for statistical computing and graphics supported by the R Core Team and the R Foundation for Statistical Computing.

Table 1
Overview of studies on website interface attributes and their effects in e- and m-commerce.

Reference	Context	Dependent variable	Independent variable	Method	Results
Oyibo and Vassileva (2020)	m-commerce	Perceived aesthetics, enjoyment, and usefulness, intention to use	Color temperature, layout design elements	Empirical study	In tourism website design for mobile devices, a grid layout of products and services provides a better hedonic user experience than a list layout
Chopdar and Balakrishnan (2020)	m-commerce	Satisfying experience, repurchase intention	Visual attractiveness	Cross-sectional design	The effect of visual attractiveness on both consumer impulsiveness and perceived value were statistically significant
Li, Zhao, Xu, and Pu (2020)	m-commerce	Ease of use of mobile apps	Distance of Information State Transition (DIST) theory	DIST focuses on the consumption of information, which is used to reach a current state and can realize the quantitative information measurement of dynamic processes	If the information distance spent was shorter, the ease of use was better, as online consumers could reach the target state of purchasing a product with convenience and efficiency by opening the company's e-commerce app.
Patel, Das, Chatterjee, and Shukla (2020)	m-commerce	viz. general information quality, product information related quality, layout quality, and visual appeal quality	Purchase intention, perceived enjoyment, and trust	Survey	Shopping app-interface quality has no effect on perceived trust. But perceived enjoyment exerts a positive effect on perceived trust, which positively influences customer intention to purchase in using shopping apps
Cyr et al. (2006)	m-commerce	Usefulness, ease of use, enjoyment and m-loyalty	Design aesthetics of a mobile website	Experiment and survey	Design aesthetics have a significant impact on perceived usefulness, ease of use, and enjoyment
Choi and Lee (2012)	m-commerce	User satisfaction	The perception of simplicity in the smartphone interface: Visual aesthetics, information design, and task complexity	Survey	Aesthetic simplicity was evaluated thanks to the screen interface based on three items (neat, modern, and balanced). Visual aesthetics strongly contribute to the perception of simplicity in smartphone interfaces. Visual aesthetics should be adapted to the small screen of the smartphone. User satisfaction is positively impacted by the perception of interface simplicity.
Sohn et al. (2017)	m-commerce	User satisfaction, Online shop loyalty	Visual complexity of interface of mobile online shops, spatial crowding, perceived time spent on the website, and efforts invested.	Experiment and survey	A white background against a dark gray text demonstrated high contrast and represented low visual complexity; however, a light gray background contrasted less with the dark gray text and represented high visual complexity. Perceived visual complexity has a negative influence on individuals' satisfaction and loyalty to an online shop
Gradisar and Turk (2007, June 25-28)	Computer/ Web page interface	User performance, Legibility of a web page text	Color, contrast, luminance	Experimental design using fifty-six text/background color combinations	Legibility is high with yellow on black, cyan blue on black, white on blue, black on yellow, white on black, and green on black color. White color for a background resulted in lower legibility than black color for a background. Overall, a lighter text on a darker background resulted in lower legibility than a darker text on lighter backgrounds
Wu, Cheng, and Yen (2008)	e-commerce	Emotional responses and subsequent shopping behavior	Music and color on websites	Experiment using a factorial plan 2 (fast vs slow music) x 2 (warm vs cool color)	Music and color factors had a significant effect on the participants' emotional response. Warm website colors aroused and pleased participants more
Coursaris et al. (2008)	e-commerce	Perceptions of website aesthetics	Color	Experimental design manipulating the website's primary and secondary colors	More favorable perceptions regarding a website design's aesthetics when cool color combinations (blue-light blue) are used as opposed to warm color combinations (red-orange)
Monzón et al. (2021)	e-commerce	Usability User performance: task accuracy and task completion time	Visual aesthetics: contrast between text and background colors, luminance	Experiments and survey	Visual aesthetics have a positive effect on task completion time only under conditions of poor usability. In the good usability condition, visual aesthetics have no beneficial effect.
Lee and Koubek (2010)	e-commerce	User preference	Color, layout, typography	Experiment and survey	Organizational structure and website layout had a greater effect on user

(continued on next page)

Table 1 (continued)

Reference	Context	Dependent variable	Independent variable	Method	Results
Cyr et al. (2010)	e-commerce	User trust, satisfaction, and e-loyalty, with culture as a moderator	Color	Eye-tracking, survey, and interviews	preference than aesthetic aspects, such as color and typography The attractiveness of website colors is a significant determinant for trust and satisfaction in relation to websites; there are cross-cultural differences, though
Pelet and Papadopoulou (2012)	e-commerce	Consumer mood, memorization, and buying intention	Color	Experiment and survey	The interaction of hue and brightness, using chromatic colors for the background and foreground, supports memorization and buying intention, when contrast is based on low brightness. A negative mood infers a decrease in buying intention
Seckler et al. (2015)	e-commerce	Facets of aesthetic perceptions (simplicity, diversity, colorfulness, craftsmanship)	Structural factors (vertical symmetry, visual complexity) color factors (hue, saturation, brightness)	Experiment and survey	The color features had a great impact on the users' aesthetic perceptions. Especially, color saturation affected colorfulness, whereas color hue also affected the perceived simplicity and craftsmanship; color brightness influenced the perceived simplicity
Visinescu et al. (2015)	e-commerce	Cognitive absorption, ease of use, intention to buy online	2D/3D website design	Experiment and survey	3D websites incorporating more visual components and increasing the complexity of the design. Such designs required cognitive effort that led to lower perceptions of ease of use. Thus, 3D websites were perceived as less easy to use compared to 2D websites

appearance (Gradisar & Turk, 2007, June 25-28), while readability is a measure of how easy a piece of text is to read and understand. Readability built on a good contrast between the foreground and background colors enables consumers to navigate more easily. If consumers perceive the website as being easy to use, they are more likely to make positive recommendations for not only revisiting it, but also buying on it in the future. This ease of use encourages the consumers to feel more comfortable when navigating on the website, and consequently, enhances their intention to purchase. Since the right color scheme improves the interaction between consumers and websites (Cyr et al., 2010; Pelet, Durrieu, & Lick, 2020), we propose the following hypotheses:

H1. An m-commerce website interface with a positive color contrast is easier to use than an interface with a negative color contrast.

H2. An m-commerce website interface with a positive color contrast is easier to use and will result in (a) higher purchase intentions, (b) higher revisit intentions, and (c) higher intentions to recommend the website.

2.3. Layout: line spacing aerates the content

The page layout refers to the arrangement of text, images, and other elements on a page in order to customize the appearance of the website.³ The literature suggests that spacing should be provided between lines and letters (e.g., W3C; Wang et al., 2008), though not too liberally as this would require extra scrolling motions, which would decrease the ease of use, especially for older people (Wright, 2000). Further suggestions include avoiding complex menu hierarchies and repetitive movements for interactions, such as fast clicking on touch screens (Wells et al., 2011; Zaphiris, Kurniawan, & Ghiawadwala, 2006; Zhou, Rau, & Salvendy, 2013; Ziefle, 2010). Previous studies have shown that the layout of a website has an influence on consumer evaluations and behavior (e.g., Lee and Koubek, 2010; Pallud & Straub, 2014; Visinescu et al., 2015; Oyibo & Vassileva, 2020). Nevertheless, the concept of layout needs to

be explored in m-commerce. Empirical research is needed, in particular with regard to smartphone screens, which oblige the user to focus closely on a tiny surface area. The present research aims to examine the influence of an airy/dense spacing of a mobile website interface on ease of use, as well as its impact on behavioral intentions. We, therefore, suggest the following hypotheses:

H3. An m-commerce website interface with airy spacing is easier to use than an interface with dense spacing.

H4. An m-commerce website interface with airy spacing is easier to use and will result in (a) higher purchase intentions, (b) higher revisit intentions, and (c) higher intentions to recommend the website.

2.4. Typefaces: size and font type affect readability

According to Henderson, Giese, and Cote (2004), typeface is an important visual tool for creating positive impressions (pleasing, engaging, reassuring, etc.) and for making messages stand out more prominently. Research has revealed that the physical features of the typeface (font style and size) affect readability, memorizing, and responses to advertising (e.g., Amar, Droulers, & Legohérel, 2017; Childers & Jass, 2002; McCarthy & Mothersbaugh, 2002). However, only a few studies have investigated the effects of the typography in an online environment (e.g., Bernard et al., 2001; Cyr et al., 2006). On computer screens, sans-serif fonts, such as Arial, are perceived as more readable than serif fonts, such as Times New Roman (Davidov, 2002; List, 2001). A 12- or 14-point font size is mostly recommended for on-screen media (Bernard et al., 2001). Having said that, typography has never been investigated in m-commerce or on mobile devices. Thus, the present research examines how font types influence ease of use and relevant consumer behavior. We propose the following hypotheses:

H5. An m-commerce website interface with a sans-serif font is easier to use than an interface with a serif font.

H6. An m-commerce website interface with a sans-serif font is easier to use and will result in (a) higher purchase intentions, (b) higher revisit intentions, and (c) higher intentions to recommend the website.

³ Collins Dictionary (2017).

2.5. Processing fluency: interactions among color contrast, layout, and typeface

Previous investigations have asserted that processing fluency is a function of multiple interface stimuli, such as visual objects, clarity, and contrast (e.g., Choi & Lee, 2012; Lavie & Tractinsky, 2004; Moshagen & Thielsch, 2010). A website with a visually optimal interface is usually processed more fluently, since 80% of the information processed by an Internet user depends on sight (Mattelart, 1996). Users' initial impressions upon visiting a website are crucial since the first few seconds of interaction help them to decide whether or not to continue navigating (Nielsen & Tahir, 2002; Tractinsky, Cokhavi, Kirschenbaum, & Sharfi, 2006). Lindgaard, Fernandes, Dudek, and Brown (2006) contend that users' first impressions (on a computer in an indoor setting) are built in about 50 milli-seconds and appear to remain stable over time. Indeed, a website which is perceived as user friendly, easily navigable, and well-organized fosters the intention to revisit it (Hausman & Siekpe, 2009; Li et al., 2012; Parasuraman, Zeithaml, & Malhorta, 2005; Seckler et al., 2015; Suh, Ahn, & Pedersen, 2013). Thus, according to the processing fluency theory, the ease with which interface attributes of the mobile website are processed might elicit positive evaluations. We posit that an m-commerce website interface combining light text on a dark background (positive contrast), airy spacing, and a sans-serif font is processed more easily and can lead to positive responses (purchase, revisit, and recommendation). We, therefore, suggest the following hypotheses:

H7. An m-commerce website interface with a positive color contrast, airy spacing, and a sans-serif font is easier to use than an interface with a negative color contrast, dense spacing, and a serif font.

H8. An m-commerce website interface with a positive color contrast, airy spacing, and sans-serif font is easier to use and will result in (a) higher purchase intentions, (b) higher revisit intentions, and (c) higher intentions to recommend the website.

We propose the following model which shows how the mobile website interface, characterized by the color contrast between background and foreground, line spacing, and font type, can raise consumers' intention to 1) purchase, 2) revisit, or 3) recommend based on the buyer's perception of the ease of use of the m-commerce website (Fig. 1).

3. Methodology

3.1. Experimental interface stimuli

Website development. A website selling music CDs was created for the experiment, based on Parboteeah, Valacich, and Wells (2009). Following Kang and Yoon (2008) as well as Pelet and Papadopoulou (2012), we developed a fully static website with no animation or complex menu. Thirty CDs were available in 10 categories (three CDs per category). For each CD, the cover, album title, artist's name, and other items of information were visible, including the music category, online store price, music company price, sales figures, delivery time, state (new or used), and delivery charges. This detailed information would be displayed whenever a subject clicked on the cover image or title of a CD. In addition, the information included a CD description of 100 characters (around 20 words) next to the CD cover (see Table 2 for a presentation of the graphic charts used in the experiment).

Stimulus design. The design of the experimental interface stimuli on the website was based on a color scheme driven by research on readability, a characteristic which is not culture-dependent (Greco et al., 2008; Hill & Scharff, 1997). These authors demonstrated the importance of contrast (foreground color versus background color) in website design. We used the color scheme that, according to Hill and Scharff (1997), produced the best readability rate, i.e. yellow font on green background. This positive feature was compared against its inverse

coupling, green font on yellow background (Table 2). In keeping with the readability literature (e.g., Bernard et al., 2001; Bernard, Chaparro, Mills, & Halcomb, 2003; Davidov, 2002; List, 200), two font types were selected: Arial (sans-serif font) and Times New Roman (serif font). In addition, two-line spacing options (airy = 30 pt and dense = 12 pt) were chosen (Wang et al., 2008). The three attributes of the website interface were manipulated in using a full factorial plan $2 \times 2 \times 2$: color contrast between the foreground and background (yellow-on-green as a positive contrast versus green-on-yellow as a negative contrast), layout (airy spacing versus dense spacing) and font type (serif Times New Roman versus sans-serif Arial). Eight Cascade Style Sheets (CSSs⁴) representing eight experimental versions of the web page were created.

Manipulation check. The manipulation of color contrast, line spacing, and font was examined by means of a pre-test. Forty-two respondents were asked to evaluate the various levels of treatment through three-item semantic differential scales on a 5-point Likert scale. For example, "The color contrast of this website is: good (5)/bad (1)". The results showed statistically significant differences between mean scores for the color contrast ($M_{\text{positive contrast}} = 3.46$, $M_{\text{negative contrast}} = 2.83$; $t = 3.88$, $p < .001$), significant differences between mean scores for the line spacing ($M_{\text{airy}} = 3.60$, $M_{\text{dense}} = 2.87$; $t = 3.92$, $p < .001$) and significant differences between mean scores for the font type ($M_{\text{sans-serif}} = 3.40$, $M_{\text{serif}} = 2.83$; $t = 3.36$, $p < .001$), indicating that respondents successfully perceived the manipulation of the experimental variables as intended by the researchers (see in Table 2 the different graphic charts of the experimentation).

3.2. Internal validity

In order to obtain a valid experimental design, a natural experimental treatment was used, due to its "ability to produce valid causal inferences through statistical adjustments for initial non-equivalence between treatment and control groups" (Shadish, Cook, & Campbell, 2002, p. 17). Respondents were asked to participate in our survey in their natural habitat at an outdoor location. Two smartphones were used for the experiment: An Apple iPhone running on iOS and a Samsung running on Android Operating System (OS). Interface parameters of the smartphones were adjusted in response to ambient conditions, such as humidity. The reason was that, generally, a smartphone screen does not react in the same way when it is wet due to the humidity of the environment, and this, in turn, affects the way it is handled by the user (Heineman, 2016)⁵. In addition, it has been shown that the lighting of the environment is important for consumers when shopping online (Pelet & Papadopoulou, 2012). Therefore, brightness levels were also controlled for each respondent before they commenced the experimental task.

In accordance with Perry et al. (2001), we measured the ambient lighting, temperature, and humidity of the physical setting to neutralize their effects. These measurements were taken with specific tools, such as apps installed on the smartphone used during the survey. This enabled us to assess existing values (luminosity, temperature, and humidity) and

⁴ CSS = Cascading Style Sheets is a style sheet language used for describing the presentation of a document written in a markup language such as HTML (W3C, 2020).

⁵ "When you touch your finger to the screen, it sucks out some of the charge" (Gradisar & Turk, 2007, June 25-28; a mobile-technology consultant, former touch technologist at Intel), because our body is made mostly of water, which is extremely conductive. The touchscreen locates the finger on the grid by measuring how much the charge drops between two intersecting electrodes. This process is called "mutual capacitance." Those drops of sweat or rain can reduce the charge too by providing another conduit between the electrodes. This is why touchscreen engineers have solved the water problem by drawing on a different mode of touch sensing called "self-capacitance." But touchscreens are still very sensitive with the rainwater, which affects the Human Machine Interaction.

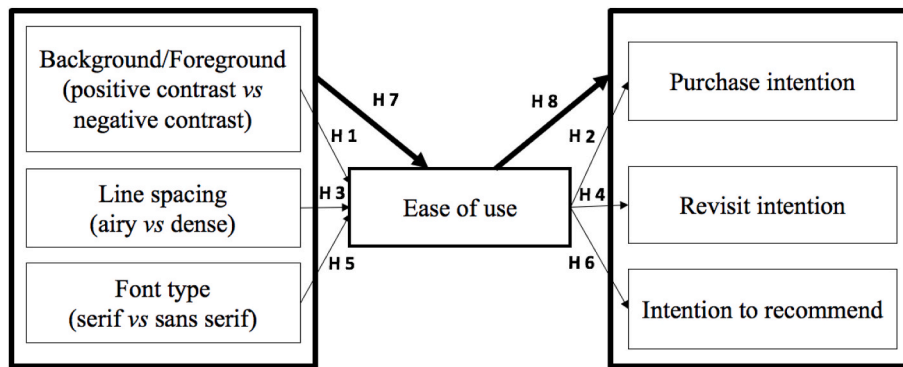


Fig. 1. Research model.

adjust interface settings to standardize test conditions for each respondent before starting the experiment. Every participant was also tested for color blindness using the highly reliable Ishihara test⁶ (Lanthy, 2005). The sample included people with no color blindness to guarantee the validity of the experiment, see Table 3 for a presentation of each app.

3.3. Experimental procedure

We defined seven experimental cells with a control group in order to examine the direct effects as well as the interaction effects of the manipulated variables, namely color contrast, line spacing, and font type. Table 4 describes the experimental cells assigned to the different treatments. Cells 1 and 2 were designed to treat the main effects of the color contrast by maintaining the same levels of line spacing and font type. Cells 3 and 4 concern the main effects of line spacing, and cells 5 and 6 concern the main effects of font. Cell 7 was designed to examine the interaction effects of all variables (see Table 4).

Each participant was randomly assigned to one of the seven experimental cells. As indicated in Table 4, each cell was exposed to two CSSs within a period of 20 min. For example, Cell 1 was exposed initially to the interface with a positive contrast, dense line spacing, and a serif font, followed by the interface with a negative contrast, dense line spacing, and a serif font. This allowed us to measure intra-subject effects. Formatted pages were prepared for the fictitious website in order to establish acceptable delays between exposure and evaluation, enabling the webpage to be shown for a particular amount of time - as delays have been shown to critically determine the strength of the repeated exposure effects (Bornstein, 1989). A control group was assigned to each cell in order to compare inter-subject effects, but also to avoid a possible bias due to repeated exposure.

When participants visited the assigned web page, they were asked to select a music category from the menu; this enabled them to view the three CDs belonging to that category. Participants were requested to read the details of at least two CDs of their choice, regardless of the CD category. They could look at more than two CDs from any category if they wished to do so and then they had to add them to their shopping cart. But they could not make any real purchases. After viewing the details of at least two CDs, an easy-to-distinguish link appeared on the interface of the website and respondents were asked to complete a questionnaire.

⁶ The Ishihara test is the most common color-blindness test in use today. It consists of a number of Ishihara plates (24 or 38), each containing a circle of dots, which appear in random colors and sizes. Within the circle, the dots form a number, which should be clearly visible to viewers with normal color perception and hard to see, or invisible, for viewers who are affected by color-blindness. To pass the test, participants should recognize the number on every plate.

3.4. Data collection

Data were collected in France, as this country has emerged as one of the most important mobile markets in Western Europe. Indeed, 43% of all commerce transactions in France, including app transactions, are completed in using mobile devices, with sales through mass market retailers growing by 52% during 2017 (Criteo, 2018). We collected data in the street, e.g., café terraces, sidewalks, and parks, where potential respondents were more willing to share a moment of their free time with us. First of all, people were asked whether they were accustomed to buying products or services on mobile devices. The survey was then conducted only with respondents who confirmed that they had already made purchases on mobile devices, notably on smartphones. As an incentive, the participants were also informed that, at the end of the survey, they had the chance to win a voucher to buy a product on an m-commerce website. Forty participants were randomly assigned to each cell and forty subjects were assigned to the control group. A total of 560 respondents participated in this study: 51% were male; the average age was 34 years.

3.5. Survey development

A questionnaire was developed to measure the dependent variables and included adapted items from prior research. These were ease of use (five items) from Bressolles (2006), purchase intention (four items) from Limayem and Rowe (2006), revisit intention (three items) from Mukherjee and Nath (2007) and intention to recommend (three items) from Goyette, Ricard, Bergeron, and Marticotte (2010). Each item was measured on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). Demographic questions were included at the end of the questionnaire.

3.6. Reliability and validity of the measurement model

All constructs showed high levels of reliability; the Cronbach's alpha (α) and Jöreskog's rho values (ρ) were greater than 0.9 for all scales. The Discriminant and convergent validity of the scales were additionally examined. The average variance extracted (AVE) values of the constructs were greater than 0.5 for all constructs. The square roots of the AVEs were compared with the correlations between a given construct and others in the model. The discriminant validity was also fulfilled (see Table 5). The overall fit of the measurement model was assessed: RMSEA = 0.07, TLI = 0.97, CFI = 0.98; $\chi^2/df = 2.86$, $p < .001$, which demonstrated a good fit of the proposed model to the data.

Table 2
Graphic charts of the experimentation.

Cascade Style Sheet 0 (style_0.css)		Cascade Style Sheet 4 (style_4.css)	
Layout	Airy line spacing (line-height = 30 pt)	Layout	Airy line spacing (line-height = 30 pt)
Color contrast	Positive contrast: yellow (#FFFFAC) on green (#006500)	Color contrast	Positive contrast: yellow (#FFFFAC) on green (#006500)
Font type	Sans-serif font (Arial)	Font type	Serif font (Times New Roman)

Cascade Style Sheet 1 (style_1.css)		Cascade Style Sheet 5 (style_5.css)	
Layout	Dense line spacing (line-height = 12 pt)	Layout	Dense line spacing (line-height = 12 pt)
Color contrast	Negative contrast: green (#006500) on yellow (#FFFFAC)	Color contrast	Negative contrast: green (#006500) on yellow (#FFFFAC)
Font type	Serif font (Times New Roman)	Font type	Sans-serif font (Arial)

(continued on next page)

Table 2 (continued)

Cascade Style Sheet 0 (style_0.css)		Cascade Style Sheet 4 (style_4.css)		
Cascade Style Sheet 2 (style_2.css) Layout Dense line spacing (line-height = 12 pt) Color contrast Positive contrast: yellow (#FFFFAC) on green (#006500) Font type Serif font (Times New Roman)			Cascade Style Sheet 6 (style_6.css) Layout Dense line spacing (line-height = 12 pt) Color contrast Positive contrast: yellow (#FFFFAC) on green (#006500) Font type Sans-serif font (Arial)	
Cascade Style Sheet 3 (style_3.css) Layout Airy line spacing (line-height = 30 pt) Color contrast Negative contrast: green (#006500) on yellow (#FFFFAC) Font type Serif font (Times New Roman)			Cascade Style Sheet 7 (style_7.css) Layout Airy line spacing (line-height = 30 pt) Color contrast Negative contrast: green (#006500) on yellow (#FFFFAC) Font type Sans-serif font (Arial)	

Table 3

Apps used to control environmental conditions, both on iOS and Android (smartphones used for the experimentation).

- LuxMeter Pro**
Description: LuxMeter Pro emulates a lux meter to measure light intensity. LuxMeter is used to measure the lighting level of environments in reference tables that indicate the LUX value required for the specific type of environment.
- Thermometer**
Description: Thermometer is the market leader, undoubtedly one of the most useful utility apps available. The temperature can be recorded in a second without having to set up anything and in any location.
- Hygrometer**
Description: Check your humidity!
- Ishihara's test**
Description: Are you color blind? Do you know somebody who is color blind?

4. Results

4.1. Hypothesis testing

The hypotheses were tested using the analysis of variance method (ANOVA) including main effects and all possible two- and three-way interactions of color contrast, layout, and font. Control groups were used only to evaluate inter-subject perceptions for each cell and were not included in the ANOVA analysis for hypothesis testing. The ease of use mean scores for the color contrast, layout, and font conditions are shown in Table 6.

As expected, the positive contrast (yellow-on-green) produced higher scores for ease of use than the negative contrast (green-on-yellow) when

Table 4
Description of the seven experimental cells assigned to the different treatments.

	Color contrast		Layout		Font	
	Positive (yellow-on-green)	Negative (green-on-yellow)	Airy (line spacing = 30pt)	Dense (line spacing = 12pt)	Sans-serif (Arial)	Serif (Times New Roman)
Cell 1	×			×		×
		×		×		×
Cell 2	×		×		×	
		×	×		×	
Cell 3	×		×		×	
	×			×	×	
Cell 4		×	×			×
		×		×		×
Cell 5	×		×		×	
	×		×			×
Cell 6		×		×	×	
		×		×		×
Cell 7	×		×		×	
		×		×		×

Note: Red color (manipulated variable) - Grey color (variable not manipulated)

Table 5
Reliability and validity of the measurement scales.

	Number of items	Mean	SD	α	Jöreskog's ρ _h	Ease of use	Purchase	Revisit	Recom-mend
France (N = 560)									
Ease of use	5	3.32	.81	.96	.98	.90			
Purchase	4	3.11	.89	.97	.98	.55	.93		
Revisit	3	3.10	.86	.95	.97	.58	.77	.93	
Recommend	3	3.35	.78	.96	.99	.47	.62	.65	.98
Fit indices	$\chi^2/df = 2.86$, RMSEA = .07 CFI = .98, TLI = .97								

Notes: Values on the diagonal (in bold italic) are AVEs; values below the diagonal are the correlations between constructs.

Table 6
Ease of use mean as a function of the experimental manipulations.

	Color contrast	Font	Layout	Ease of use Mean score (SD)	Mean score differences Δ
Main effect of color contrast	Negative	Serif	Dense spacing	2.83 (.77)	.62
	Positive	Serif	Dense spacing	3.45 (.71)	
	Negative	Sans-serif	Airy spacing	3.22 (.88)	.24
	Positive	Sans-serif	Airy spacing	3.46 (.66)	
Main effect of layout	Negative	Serif	Dense spacing	2.87 (.81)	.55
	Negative	Serif	Airy spacing	3.42 (.72)	
	Positive	Sans-serif	Dense spacing	3.20 (.99)	.39
	Positive	Sans-serif	Airy spacing	3.59 (.69)	
Main effect of font	Negative	Serif	Dense spacing	2.83 (.77)	.57
	Negative	Sans-serif	Dense spacing	3.40 (.74)	
	Positive	Serif	Airy spacing	3.45 (.79)	-.85
	Positive	Sans-serif	Airy spacing	2.60 (.80)	
Color contrast*layout*font manipulated simultaneously	Negative	Serif	Dense spacing	2.83 (.71)	.59
	Positive	Sans-serif	Airy spacing	3.42 (.66)	

the variations of layout and font were isolated: $M_{\text{positive contrast}} = 3.45$ versus $M_{\text{negative contrast}} = 2.83$, when the line spacing is dense and the font is serif, and $M_{\text{positive contrast}} = 3.46$ versus $M_{\text{negative contrast}} = 3.22$, when the line spacing is airy and the font is sans-serif. MANOVA results indicate significant differences between color contrast levels, regardless of layout and font conditions ($F(1, 78) = 12.50, p < .001$). Thus, **H1** is statistically supported.

As shown in **Table 6**, ease of use is higher when the interface has airy rather than dense spacing, regardless of the font and color contrast conditions. The mean score differences are significant for ease of use ($\Delta = 0.55$ and $\Delta = 0.39$). This was verified by Univariate F-tests indicating a significant direct effect of layout levels ($F(1, 78) = 12.20, p < .001$), which provides statistical support for **H3**.

With respect to the main effect of the font, ease of use is higher for the sans-serif font when the interface has a negative contrast and dense line spacing ($M_{\text{sans-serif}} = 3.40$ versus $M_{\text{serif}} = 2.83$) but not for the interface with a positive contrast and airy line spacing ($M_{\text{sans-Serif}} = 2.60$ versus $M_{\text{serif}} = 3.45$). Moreover, MANOVA results reveal a non-significant main effect for the font ($F(1, 78) = 0.48, p > .05$). Hence **H5** is not supported. Nonetheless, differences between font levels are significant when interacting with color contrast and layout. Finally, all conditions were tested by simultaneously varying the color contrast, font, and layout. As hypothesized, ease of use was higher for the interface with a positive color contrast, airy line spacing and sans-serif font ($M = 3.42$) when compared to the interface with a negative color contrast, dense line spacing and serif font ($M = 2.83$). The three-way interaction of color contrast, layout and font was significant ($F = 12.47, p < .001$). These results support **H7**.

Hypotheses 2, 4, 6 and 8 assumed the mediating effect of ease of use in the relationship between behavioral intentions as well as color contrast, layout, and font, respectively. The mediation analysis was

Table 7
Mediational analysis for purchase intention.

	Dependent variable	Independent variable	Standard beta	t-value	Sobel test Z	Mediation
1. Direct effect	Intention to purchase	Color contrast	.53	3.86**		
2. Direct effect	Ease of use	Color contrast	.42	3.46**		
3. Mediating effect of ease of use	Intention to purchase	Color contrast	.22	2.05*	3.28**	Partial
		Ease of use	.73	10.58**		
1. Direct effect	Intention to purchase	Layout	.51	3.49**		
2. Direct effect	Ease of use	Layout	.83	14.87**		
3. Mediating effect of ease of use	Intention to purchase	Layout	.12	1.28	3.32**	Full
		Ease of use	.74	11.78**		
1. Direct effect	Intention to purchase	Font	.01	.08		
2. Direct effect	Ease of use	Font	.17	1.12		
3. Mediating effect of ease of use	Intention to purchase	Font	-.11	-1.21	1.11	No
		Ease of use	.74	13.29**		
1. Direct effect	Intention to purchase	Contrast*layout*font	.48	2.72*		
2. Direct effect	Ease of use	Contrast*layout*font	.59	3.53**		
3. Mediating effect of ease of use	Intention to purchase	Contrast*layout*font	.00	.00	3.34**	Full
		Ease of use	.82	10.61**		

Notes: *p < .05; **p < .001.

Table 8
Mediational analysis for revisit intention.

	Dependent variable	Independent variable	Standard beta	t-value	Sobel test Z	Mediation
1. Direct effect	Revisit intention	Color contrast	.49	3.74**		
2. Direct effect	Ease of use	Color contrast	.42	3.46**		
3. Mediating effect of ease of use	Revisit intention	Color contrast	.18	1.81	3.31**	Full
		Ease of use	.74	11.78**		
1. Direct effect	Revisit intention	Layout	.43	3.05**		
2. Direct effect	Ease of use	Layout	.46	3.41**		
3. Mediating effect of ease of use	Revisit intention	Layout	.05	.51	3.33**	Full
		Ease of use	.84	16.22**		
1. Direct effect	Revisit intention	Font	.05	.37		
2. Direct effect	Ease of use	Font	.17	1.12		
3. Mediating effect of ease of use	Revisit intention	Font	-.07	-.78	1.12	No
		Ease of use	.69	13.46**		
1. Direct effect	Revisit intention	Contrast*layout*font	.41	2.49*		
2. Direct effect	Ease of use	Contrast*layout*font	.59	3.53**		
3. Mediating effect of ease of use	Revisit intention	Contrast*layout*font	-.03	-.27	3.32**	Full
		Ease of use	.75	10.23**		

Notes: *p < .05; **p < .001.

performed following Baron and Kenny’s approach (1986). In addition, we also applied the Sobel test using PROCESS macro (v3.4) developed by Hayes (2013). Ease of use emerged as a mediator of purchase intention when the interface has a positive color contrast, airy line spacing, and a sans-serif font. As shown in Table 7, mediation effects were also demonstrated for both color contrast and layout ($p < .001$), but not for font ($p > .05$). It should be noted that mediation is complete for layout and partial for color contrast (Table 7). When ease of use is

introduced as a mediator, the direct effect of layout on purchase intention is not significant ($t = 1.28, p > .05$), but the direct effect of the color contrast is still significant ($t = 2.05, p < .05$). Mediation results were supported by the Sobel test ($p < .001$).

Similar results were produced by the mediation analysis for the intention to revisit (Table 8) and recommend the m-commerce website (Table 9). These findings also indicate that consumers appreciate the ease of use of the website interface with a positive color contrast, airy

Table 9
Mediational analysis for intention to recommend.

	Dependent variable	Independent variable	Standard beta	t-value	Sobel test Z	Mediation
1. Direct effect	Intention to recommend	Color contrast	.43	3.41**		
2. Direct effect	Ease of use	Color contrast	.42	3.46**		
3. Mediating effect of ease of use	Intention to recommend	Color contrast	.15	1.49	3.27**	Full
		Ease of use	.67	10.46**		
1. Direct effect	Intention to recommend	Layout	.35	2.63*		
2. Direct effect	Ease of use	Layout	.46	3.41**		
3. Mediating effect of ease of use	Intention to recommend	Layout	.01	.08	3.31**	Full
		Ease of use	.74	14.00**		
1. Direct effect	Intention to recommend	Font	.03	.25		
2. Direct effect	Ease of use	Font	.17	1.12		
3. Mediating effect of ease of use	Intention to recommend	Font	-.07	-.90	1.11	No
		Ease of use	.55	12.58**		
1. Direct effect	Intention to recommend	Contrast*layout*font	.31	2.00*		
2. Direct effect	Ease of use	Contrast*layout*font	.59	3.53**		
3. Mediating effect of ease of use	Intention to recommend	Contrast*layout*font	-.09	-.77	3.28**	Full
		Ease of use	.67	9.30**		

Notes: *p < .05; **p < .001.

Table 10
Results of hypothesis tests.

Paths	Hypothesis	Supported
Direct effects	H1. positive color contrast → ease of use	Yes
	H3. airy line spacing → ease of use	Yes
	H5. sans-serif font → ease of use	No
	H7. positive color contrast*airy line spacing*sans-serif font → ease of use	Yes
Indirect effects	H2a. positive color contrast → ease of use → purchase intention	Yes
	H2b. positive color contrast → ease of use → revisit intention	Yes
	H2c. positive color contrast → ease of use → intention to recommend	Yes
	H4a. airy line spacing → ease of use → purchase intention	Yes
	H4b. airy line spacing → ease of use → revisit intention	Yes
	H4c. airy line spacing → ease of use → intention to recommend	Yes
	H6a. sans-serif font → ease of use → purchase intention	No
	H6b. sans-serif font → ease of use → revisit intention	No
	H6c. sans-serif font → ease of use → intention to recommend	No
	H8a. positive color contrast*airy line spacing*sans-serif font → ease of use → purchase intention	Yes
	H8b. positive color contrast*airy line spacing*sans-serif font → ease of use → revisit intention	Yes
	H8c. positive color contrast*airy line spacing*sans-serif font → ease of use → intention to recommend	Yes

line spacing, and a sans-serif font, which leads to a strong intention to revisit and recommend the m-commerce website ($p < .001$). The results do not indicate indirect or direct effects of font type on the intention to revisit or recommend the website ($p > .05$), but there is evidence for complete mediation of ease of use for color contrast and layout (Tables 8 and 9), which is further supported by the Sobel test ($p < .001$). Hence H6 is not supported, but H2, H4, and H8 receive statistical support.

The results of the hypothesis tests are summarized in Table 10.

5. Discussion and implications

This empirical research examined the effects of the interface attributes of m-commerce websites, namely color contrast, layout, and font type, on the ease of use in outdoor mobile shopping contexts, when controlling environmental cues (sunshine, humidity and brightness). The results show that an interface with a positive color contrast (light text on a dark background) and an airy line spacing with a sans-serif font is perceived as easier to use than an interface with a negative color contrast (dark text on a light background), when conducting shopping transactions outdoors on a mobile phone. This result differs from Hill and Scharff's (1997) conclusions with respect to a large screen setting (not on a mobile). They argued that "according to a manual by AT&T; (1989), the direction of the contrast (dark on light, or light on dark) might also affect legibility. When light text is placed on a dark background the text may seem to glow and become blurred; this is referred to as halation, and it may make the text harder to read." On a mobile, this halation effect does not impact the readability and ease-of-use, according to the results we have obtained. The perceived ease of use facilitates smartphone access to commercial websites, which leads to higher intentions to purchase, revisit, and recommend.

As reported by Sohn et al. (2017), whether or not a customer uses a mobile device to make purchases depends on the perceived psychological costs (i.e., visual complexity and satisfaction) which rely on the color contrast between background and foreground. The latter increases or decreases the legibility and view of details, notably on images presenting a product. Furthermore, a well-designed user interface reduces the perceived system complexity and enhances customer engagement and trust in relation to the website (Lee & Chung, 2009; Stewart & Jürjens, 2018). The interface design of a website is a key driver of

perceived performance (Dickinger & Stangl, 2013), which results in stronger behavioral intentions. This most likely leads consumers to engage in long-term relationships and develop consumer loyalty (Agrebi & Jallais, 2015; Cyr et al., 2006; Liang & Chen, 2009; Parker & Wang, 2016; Tan, Kheng, & Meng, 2015).

The present research has several managerial implications. First, m-retailers need to focus on all the variables of interface design: colors, fonts, and layout. In particular, designers need to consider users' situational environments rather than focusing only on the static elements of background and foreground colors. The ubiquitous nature of mobile devices means that m-commerce may be expected to take place anywhere (Barnes, 2002; Scharl, Dickinger, & Murphy, 2005). Color contrast can vary according to the environment where the user is located. In addition, Sun, Li, and Ronnier Luo (2016) have indicated that "the orientation of background pattern and the size of stimuli are not that important. However, background size, background luminance, and surround luminance influence the appearance considerably" (p. 440). Hence, shopping apps should be augmented with features, for example, a brightening functionality, to adjust the interface and to accommodate a variety of environmental conditions that might otherwise impede legibility and readability. It is possible to foresee how easily the smartphone might be able to adapt the legibility and readability of the interface to enhance the ease of use for users, based on powerful GPUs (Graphic Processing Units). The adaptation of colors, line spacing, and font type could be integrated into the interface attributes of the website in order to respond to the specific environmental settings. Improvements in screen information accessibility can help users to feel more comfortable with m-commerce and can support transactions any-time/anywhere, which will increase consumer buying intentions.

Mobile applications are not always designed for easy use in real-time contexts, i.e., considering the location of the user and the type of task or service requested (Pengnate, Sharda, Biros, Hass, & Shimp, 2011). One solution is to have the smart phone adjust itself. Corrections to improve screen information accessibility could be made automatically by getting the smartphone lens to provide information about environmental conditions to the smartphone, which then enhances visibility and readability on the screen and, therefore, ease of use. Alternatively, developers could build m-commerce platforms that offer more control for users and allowing them to adjust mobile interface features (color contrast between foreground and background, line spacing, and font type), according to their needs and aesthetic preferences. Murray and Häuble (2011) argue that a user's freedom of choice may affect interface preferences: "Greater freedom of choice while learning to use an incumbent interface actually has a positive influence on users' eventual preference for that interface" (p. 958). Specifically, being constrained to use a particular interface designed by a company reduces the perceived ease of use and preference for that interface.

The ability to modify the smart phone interface and its HMI can increase consumers' hedonic pleasure in using shopping apps and m-commerce websites. It would be interesting to provide users and consumers with the potential to modify the color scheme, font type, or layout of the web page on any m-commerce website in the future. Refer to the website entitled "CSSzengarden" (2020) for an example of what can be accomplished through CSS-based design. Offering consumers this potential may contribute to the building of positive attitudes and inducing stronger behavioral intentions.

6. Conclusion, limitations, and avenues for further research

Mobile phones have become essential telecommunication devices, highly valued by their users and in many countries widely used as an effective and convenient means to access the Internet, buy, sell, as well as to make and receive payments (Uribe, 2007). The ease of use of the website interface was identified in HCI as a key variable affecting the user's behavioral intentions (Murray & Häuble, 2011; Venkatesh et al., 2003). Our findings show that the interface of m-commerce websites is

of paramount importance in determining behavioral outcomes, especially in outdoor shopping.

For the present study an experiment was conducted under real conditions and designed to reflect everyday shopping situations. However, certain limitations must be mentioned. Firstly, only one fictitious m-commerce website selling CDs with eight interface versions and combining color contrast, line spacing, and font type was investigated. The use of a real m-commerce website might lead to other results than the use of a fictitious website especially produced for an experiment. Secondly, our experiment was conducted in France, which has a temperate climate. In future, a range of varied climates in different countries should be studied to expand the understanding of this topic.

Ubiquity is one of the most important characteristics of mobile devices (Okazaki & Mendez, 2013). Future research on m-commerce could look to smartphones which are more responsive to both consumers' personal reactions and the surrounding physical environments. For example, the smartphone camera could track the user's facial reactions to capture emotions felt by the user and adapt the interface accordingly. If users are cold, because the ambient temperature is uncomfortably low, their faces might feature cues which show that they are cold and, consequently, the smartphone could modify the colors, layouts, and fonts of the interface to make these users feel more comfortable. Alternatively, the user's voice generally reflects their mood, which may influence their consumer behavior, as demonstrated by Pelet and Papadopoulou (2012). According to Canziani and MacSween (2021), "developments in voice-activated technology have wide-ranging implications for brands, consumers, and academic research". Taking these facial and vocal cues into account during an experiment conducted in real conditions may contribute to the stream of research on consumer interaction with mobile shopping interfaces.

Previous findings have also indicated that older users of mobile devices are more inclined to research products online before buying them than younger consumers (Jastrzembski & Charness, 2007). Given that eyesight decreases after 45 years of age (Mutti & Zadnik, 2000), the Baby Boomer generation and Generation X have a higher prevalence of visual impairment in comparison to other age groups (Tielsch, Sommer, Witt, Katz, & Royall, 1990). Therefore, the information on an m-commerce website is more difficult to access for these groups. With an ever-increasing aging population, the matter of making website interfaces on mobile devices universally accessible to all types of people needs to be investigated much more extensively.

Finally, given our finding that a positive contrast (light text color on dark background color) increases the ease of use and behavioural intentions and previous work showing that it saves energy (Ding, Huyen Tran, & Halfond, 2014, pp. 527–538), e-commerce website designers can offer consumers a more 'ethical' and, therefore, more 'sustainable' interface through their designs that save batteries. In view of our findings and the, hopefully, ensuing vivid discussions in this area, we encourage both academicians and practitioners to seek ways to enhance users' experiences with mobile devices in the future.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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