The Effects of Augmented Reality Modality and User-Product Interaction Design on Consumers' Product Evaluation: A Cognitive-Experiential Self-Theory Perspective

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Introduction. Augmented reality (AR) refers to an interactive technology that provides an integrated view of virtual products and real environment (Azuma, 1997). Researchers have started employing AR in digital retailing to help consumers' imagination while shopping for products to enrich their shopping experience with the enhanced interaction between consumers and products (Suh & Lee, 2005). AR is particularly beneficial to digital retailers as it enhances consumers' ability to experience and evaluate products and overcome the limitation in examining products via only visual images or verbal specifications (Katawetawaraks & Wang, 2011). Despite the increasing adoption of AR among digital retailers, research has been scant on how to design AR to optimize product interaction experiences for consumers and to positively affect consumers' product evaluation. For example, AR may be designed with varying *modalities*, such as single modality (visual-only) or dual modality (visual + auditory). Further, a retailer may design AR to allow the user to interact with the (virtual) product (i.e., *user-virtual product [VP] interaction*) or to show only the product in the real-world environment (i.e., no user-VP interaction). However, little research has examined potentially differential effects of these AR design approaches in shaping consumers' product evaluation. Thus, this research examined the effects of these two AR design factors (i.e., AR Modality and User-VP Interaction) on consumers' processing of product information and product attitude, particularly in a mobile shopping context.

Theoretical Framework. Cognitive-experiential self-theory (CEST) posits that an individual processes information using two systems: a *rational system* and an *experiential system* (Epstein, 1991). The rational system operates in a logical way, while the experiential system operates in an emotional-oriented way (Kirkpatrick & Epstein, 1992). Both systems may play roles as consumers process product information using an AR-based mobile shopping app, and the AR design factors may affect the roles of these two systems play in the formation of consumers' product attitude. Specifically, with regard to the rational system, cognitive learning theory (CLT) posits that an individual needs to pay great attention to relevant materials to effectively process the information cognitively (Sweller et al., 2011); while literature on the modality effect suggests that the use of dual modality (vs. single modality) improves cognitive processing of information as it allows a greater amount of mental capacity (Brünken et al., 2004). Therefore, in AR-based mobile shopping, we hypothesize that AR designed with *dual modality* (visual + auditory), as compared to *single modality* (visual only), attracts consumers' higher *cognitive attention* to the provided product information (H1), which in turn leads them to perceiving (learning) a higher *utilitarian value* of the product (H2).

With regard to the experiential system of information processing, according to the experiential learning theory (ELT), effective learning can be produced through an immersive experience of an activity (Kolb, 1984). Applying this in AR-based mobile shopping, as compared to when consumers cannot see themselves in the AR display (*no user-VP interaction*), when AR allows consumers to view themselves interact with the product virtually (*yes user-VP interaction*), they are likely to experience a higher *sense of presence* (i.e., feeling like they are physically using the product) (H3), which in turn enhances their perceived experiential or *hedonic value* of the product (H4).

Finally, previous research found that an individual's product attitude can be greatly influenced by their perceived product values (e.g., Chi & Kilduff, 2011; Yim et al., 2017). Thus, it is predicted that consumers' perceived (a) utilitarian and (b) hedonic product values positively influence their *product attitude* during mobile shopping with an AR app (H5).

Method. An online experiment was conducted employing a 2 (AR Modality: single vs. dual modality) × 2 (User-VP Interaction in AR Display: yes vs. no interaction) × 2 (Product: watch vs. flower vase) mixed design with product as a within-subjects factor, user-VP interaction and AR modality as between-subjects factors. A total of 480 U.S. consumers (18-54 years old), recruited from a consumer research firm, were randomly assigned to one of the four AR Modality × User-VP Interaction conditions. They first viewed a video portraying a mobile shopping session on an AR-based mobile shopping app, corresponding to their assigned experimental condition, for the first product and completed the manipulation check measures and dependent measures for the product. The participants repeated the process for the second product. The order of the two products was randomized. All measures were adapted from literature and used 5-point Likert-type scale formats.

Results. The manipulation of the AR Modality and User-VP Interaction factors was successful. Confirmatory factor analysis (CFI = .96, TLI = .96; RMSEA = .036) results ensured the validity and reliability of all measures (AVEs > .50; AVEs > SVs; CR > .50; Cronbach's αs > .80). Results of three-way multivariate analysis of variance (MANOVA), followed by univariate ANOVAs, with cognitive attention and sense of presence as the dependent variables showed that all between-subjects effects, including the main effects of AR modality and user-VP interaction and the effect of an interaction between these two factors, were non-significant, rejecting H1 and H3. However, further within-subjects effects analysis revealed a significant User-VP Interaction × Product interaction effect for sense of presence ($p < .05$). Specifically, for watch, sense of presence was higher in the yes user-VP interaction condition ($M = 3.496$) than in the no interaction condition ($M = 3.283$; $p < .05$), as predicted by H3; but this effect was non-significant ($p = .71$) for flower vase. Further, results of structural equation modeling with maximum likelihood estimation (CFI = .94, TLI = .93; RMSEA = .071) revealed that cognitive attention positively influenced perceived utilitarian product value for both watch ($\gamma = .55$, $p < .001$) and flower vase ($\gamma = .61$, $p < .001$), supporting H2; while sense of presence positively explained perceived hedonic product value for both watch ($\gamma = .72$, $p < .001$) and flower vase ($\gamma = .77$, $p < .001$), supporting H4. Consumers' perceived utilitarian and hedonic product values both

positively influenced product attitude for both products ($.39 < \beta < .60$, all *p*s < .001), supporting H5.

Implications. This study empirically examined the role of the two AR design factors in impacting consumers' decision-making by aiding their product evaluations. Findings of this study provide insights that could help retailers evaluate the value of adopting the AR technology for their m-commerce platforms. Our findings suggest that incorporating user-VP interaction in AR app design may help enhancing consumers' immersive shopping experience through boosted sense of presence, for certain products (e.g., watch); but it may not be as effective for other products (e.g., flower vase). This differential effectiveness may be due to the proximity of the product to the consumer's body when in use (e.g., a watch is worn on a consumer's wrist whereas a flower vase is used away from the consumer's body). Future research is recommended to delve into potential product type moderating effects for the usefulness of user-VP interaction design for AR apps. Further, the findings suggest that when retailers adopt AR, it is critical to carefully design their AR technology to enhance consumers' cognitive attention and sense of presence, which are shown to help consumers recognize the product's utilitarian and hedonic values, leading to a positive product attitude.

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