

QR codes and Augmented Reality in retail stores to support a more sustainable consumption: A Neuromarketing perspective

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ABSTRACT: This study evaluates the impact of QR codes (QR) and Augmented Reality (AR) to foster sustainable consumption in retail stores. Despite growing consumer interest in sustainability, evident gaps remain in their actual purchasing behaviors, primarily due to the additional costs and effort required to access product sustainability information. This research investigates whether technological application on coffee product packaging can bridge this gap by enhancing consumer knowledge and cognitive attention. Conducted with 72 participants in a simulated retail setting, the study measures self-report levels, cognitive attention and emotional response through electroencephalography (EEG) and galvanic skin response (GSR). Results indicate that both QR and AR can improve sustainability communication, with QR showing a particularly strong effect in enhancing emotional valence and cognitive attention. The study also underlines that, to activate the full potential of QR and AR effectively, the implementation of a sustainable communication based on both informative and emotional messages, remains fundamental. Indeed in this case, higher perceptions of Green Company Orientation, Green Product Information and credibility are demonstrated.

Keywords: Sustainability, Augmented Reality, Neuromarketing, EEG, Sustainability Communication, Sustainable consumption

INTRODUCTION: This research aims to analyze the effectiveness of QR codes (QR) and Augmented Reality (AR) technologies in enhancing consumers' understanding and awareness of sustainability information during consumption decisions through their application on product packaging in retail stores. A European Commission report reveals that while consumers express interest in environmental issues and consider them relevant, they tend to act environmentally responsible only when purchases do not incur additional economic costs or cognitive effort, such as searching for product sustainability information (Joerß et al., 2021). Although some of this information is available on packaging or store shelves, space limitations often lead to communicative opacity, which is considered a barrier to sustainable consumption (Trienekens et al., 2012). Technology offers potential solutions to improve this situation. Therefore, this research hypothesizes that:

H1: The use of QR, linked to a landing page, and AR are potentially effective to support sustainability communication in improving consumers' understanding and awareness to make more sustainable consumption choices, compared to mere reality context (R) without technology.

H2: QR technology is more supportive in terms of cognitive attention, while AR in emotive valence.

LITERATURE REVIEW: Sustainable marketing strategies aim to enhance consumer awareness and understanding of the environmental, social and economical impact of purchasing decisions, fostering a culture of sustainability. Among the

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crucial elements in sustainable marketing, Green Company Orientation (GCO) (Ramirez, 2024) and Green Product Information (GPI) (Tseng, 2013) should be considered. Indeed companies that prioritize environmental responsibility tend to resonate more with eco-conscious consumers, and providing transparent and credible information about products' environmental impact, sourcing, and production processes can significantly influence purchasing decisions, mitigating at the same time concerns about greenwashing. By providing clear, accessible information about product sustainability attributes, companies can educate and empower consumers to make informed choices aligned with their values (Lakatos et al., 2021; Kumar et al., 2021). The visual and content-related aspects of sustainability communication play a crucial role in shaping consumer perceptions and behaviors, enhancing the engagement and understanding (Lin et al., 2020). In addition, the integration of emotional appeals is equally important. Consumers are more likely to connect with brands that evoke positive emotions related to environmental stewardship (Pathak, 2023; Shahlaee, 2014). This dual approach, combining informative content with emotional resonance, can significantly enhance the effectiveness of sustainable marketing efforts. This combination can be communicated effectively through the support of technologies such as QR and AR. The literature on the effectiveness of QR and AR in supporting consumers in their sustainable consumption choices in retail settings is still developing and requires further studies, however, several references provide insights into their respective roles in enhancing consumer comprehension and engagement. QR has been recognized for facilitating quick instant access to information, enhancing consumer awareness of sustainability attributes in products (Tran, 2024), and leading to more informed purchasing decisions (Latiff, 2023). AR, on the other hand, creates immersive experiences that can enhance consumer learning and understanding of sustainability by providing contextual information (Petrov & Atanasova, 2020) and evoking more emotional responses (Rauschnabel et al., 2019).

METHODOLOGY: *Sample, Materials and Instruments:* The research involved 72 participants, coffee consumers, balanced by gender and age (20-55 years). They were randomly assigned to one of three experimental conditions: R, QR, or AR. The study was conducted in accordance with the Declaration of Helsinki and the General Data Protection Regulation. An experimental setting was recreated to simulate a real supermarket for analyzing the purchase of roasted coffee. The IULM NeuroRetail Lab set up shelves to maintain consistent product quantity, arrangement, positioning, and price (Waterlander, 2019). Coffee has been selected as the product of analysis since, compared to others, consumers are more careful about its sustainability when making purchase decisions (Bartoloni et al., 2022). The experiment used three real brands as stimuli, selected based on their sustainable communication: Lavazza (L); Kimbo (K); Vergnano (V). For each condition, all three stimuli were shown to the participant, each in a separate phase during which the participant was asked to interact with it. The electroencephalography (EEG) was used to analyze the brain waves signals in reaction to interaction with products in the three conditions. For the experiment, the NVX-36 device was allowed to obtain a direct measure of brain activity and its functions during the performance of a task. The GSRsSens sensor was used to obtain skin conductance (SC) and heart rate (HR) data allowing us to gain insights into the

participant's emotional experience while exploring products on the shelf. The questionnaires, focused on GCO (Ramirez, 2024), GPI (Tseng, 2013) and Credibility (Hoffman et al., 2022), and adapted for each condition, were presented to the participants via computer and the answers were collected using a Likert scale from 1 (not at all agree) to 6 (totally agree). At the beginning of the experimental protocol, the researchers welcomed the participants and accompanied them to the laboratory. At the end of a first briefing phase and after signing the informed consent, the neurophysiological sensors were applied to the participant, who was then carefully stowed in a previously worn, lightweight backpack. This procedure allowed the participant to move freely within the laboratory. When the baseline signal calibration and instrument setup for the subject was completed, the researcher gave a task to the participant, identical for all three conditions of the experiment, to immerse the participant in the context of a familiar supermarket for a realistic shopping simulation. Once the task was completed, the participant trial was divided into three sequential tasks per each packet of coffee. In Task 1, the participant stood in front of a coffee shelf for 10 seconds. In Task 2, the participant interacted with the product according to the assigned experimental condition, gathering as much information as possible within a 5-minutes limit. Task 3 involved completing a 7-minute questionnaire, with researchers swapping the stimuli between phases. At the end of completing the questionnaire, the participant was taken back to the shelves to start the task again from the beginning. This procedure was repeated three times until all three analysis packages had been shown. After the experimental phase, participants completed a final questionnaire. The entire procedure took 1 hour per participant.

RESULTS: Given that multiple observations were collected from the same individuals, a repeated measures ANOVA was employed for the analysis. Before conducting the analysis, the assumption of sphericity was evaluated using Mauchly's test. In cases where the assumption was violated, the Greenhouse-Geisser correction was applied. Post hoc t-tests were adjusted for multiple comparisons using Holm's method. The results showed a significant main effect in the interaction between conditions and questionnaire scores: $F(10.273;364.681)=7.901$; $p<0.001$; $\eta^2=0.080$; $\omega^2=0.056$. The post-hoc analysis results showed statistically significant GCO differences between the AR and QR conditions compared with the R one within the various brands. As shown in **Table 1**, the L and V brands showed significantly higher GCO scores in the AR and QR conditions than in the R.

TABLE 1: Post-hoc analysis of ANOVA for repeated measures of GCO by brand and condition

*Post Hoc Comparisons - Conditions * GCO*

BRAND	CONDITIONS	Mean Difference	SE	t	Cohen's d	Pholm	
LAVAZZA	AR -> R	1.296	0.283	4.574	1.295	0.003	**
	QR -> R	1.510	0.289	5.226	1.508	<.001	***
KIMBO	AR -> R	0.925	0.283	3.265	0.924	0.325	
	QR -> R	1.052	0.289	3.640	1.051	0.096	
VERGNANO	AR -> R	1.270	0.283	4.481	1.268	0.004	**
	QR -> R	1.688	0.289	5.838	1.685	<.001	***

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

The V brand scored higher in the GPI in the QR condition than in the R condition (MD= 1.267; SE = 0.289, $t(39) = 4.382$, $p = 0.006$, $d = 1.265$). In addition, the V brand showed a higher score in the Credibility dimension in the QR condition than in the R

condition (MD= 1.125; SE = 0.289, $t(39) = 3.892$, $p = 0.039$, $d = 1.124$). The repeated measures ANOVA showed a significant main effect in the interaction between conditions and EI ($F(2;65)=5.102$; $p = 0.009$; $\eta^2=0.113$; $\omega^2=0.040$) and CI ($F(2;62)=5.075$; $p=0.009$; $\eta^2=0.125$; $\omega^2=0.041$). The neurophysiological data did not show a statistically significant effect for the AR condition. However, a higher score was found in the QR condition than in the R condition for both EI (MD= 0.378; SE = 0.120, $t(39) = 3.145$, $p = 0.008$, $d = 0.859$) and CI index (MD= 0.747; SE = 0.235, $t(39) = 3.177$, $p = 0.007$, $d = 0.788$) in all the three brands.

CONCLUSIONS: This study examined the effectiveness of QR and AR in supporting consumers in understanding sustainability information and raising awareness about sustainable consumption choices through product packaging in retail stores. The research findings reveal that both QR and AR generally enhance GCO, suggesting their potential to improve sustainability communication. However, the effectiveness of these technologies is contingent upon the brand's sustainable communication. Notably, brands with impactful, clear, and direct communication, such as Vergnano, demonstrated higher GCO, GPI and credibility scores, especially when using QR and AR compared to traditional packaging. Compared to the literature review, this aligns with previous research indicating that companies prioritizing environmental responsibility tend to resonate more with eco-conscious consumers (Ramirez, 2024). Conversely, brands relying on a more technical communication, heavily based on eco-labels and certifications, like Kimbo, saw less benefit from these technologies. The research also indicates that QR interactions significantly increase consumer attention compared to both AR and traditional package exploration, supporting previous studies on QR ability to enhance consumer awareness of sustainability attributes (Tran, 2024; Latiff, 2023). This heightened attention correlates with a stronger emotional valence during the digital exploration process, surpassing also in this case AR and traditional packaging experiences in this regard, aligning with research on the importance of emotional appeals in sustainability communication (Pathak, 2023; Shahlaee, 2014). These findings suggest that both QR and AR are more effective in educating consumers in retail stores compared to the mere traditional packaging (H1), with QR levels of effectiveness higher than AR. Moreover, to effectively activate the full potential of these technologies, the implementation of a sustainable communication based on storytelling, and both informative and emotional messages, remains fundamental. This dual approach has been identified as key to enhancing sustainable marketing efforts (Lin et al., 2020). Finally, in terms of cognitive attention and emotive valence, differently from the first hypothesis (H2), QR performs once again more effectively than AR in both areas. To justify this specific result, it is crucial to consider the retail store context such as a supermarket, where consumers often make their purchases under stressful conditions and have little time to spare. In such circumstances, quick access to information through the use of QR, which is still a more familiar technology than AR, becomes a more convenient tool for the user. Moreover, it is relevant to note the limitations of this study. The research focused solely on food products since it aimed to investigate this specific sector, and it was conducted in a simulated environment, not a real retail store. For future research, it is recommended to expand the analysis to other sectors,

such as fashion, to test the applicability of these findings across different industries, and if possible in real environments. Additionally, investigating the implementation of more advanced AR technologies, such as AR glasses, could provide valuable insights into the evolving landscape of consumer consciousness in retail environments. This research contributes to both theoretical and managerial understandings. It enhances the relatively limited literature on comparing the effectiveness of QR and AR in sustainability communication and marketing. Furthermore, it offers practical recommendations to brands seeking to enhance their sustainability communication through technology, in retail environments and within the food sector in order to increase their levels of sustainability information engagement, accessibility, clarity and transparency.

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