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ORIGINAL ARTICLE

Augmented grocery shopping: fostering healthier food purchases through AR

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Abstract
Food choices are intimately related to individual health. Therefore, the food we buy should be carefully chosen. However, grocery shopping is typically done in noisy environments, and food products usually present cluttered labels with dense texts that make it hard to properly evaluate relevant nutritional data. Augmented reality (AR) allows a shopper to visualize digitally generated contents onto real objects and to interact with them. In this experiment, we investigated the effects of delivering nutritional information using AR technology on food choices. To this end, we ran a between-participants laboratory experiment in which participants were asked to choose among the products available. The experimental group received the food-related information via AR, while the control group had ordinary access to food packaging. We found that AR technology facilitated the choice of healthier food items. Additionally, participants in the experimental group reported that they based their decisions on nutritional information rather than on the appearance of the package. The present work highlights how AR can be exploited to bring to the foreground information that would otherwise be hard to spot, thereby increasing the consumer's awareness of the overall characteristics of the product.

Keywords Nutritional label · Food choices · Food facts · Augmented reality · Human–computer interaction

1 Introduction

The number of people struggling with obesity or being overweight continues to grow in Western countries (Overweight and obesity 2021). While the causes of this trend are multiple and complex, there is a growing awareness of the key role that consumers' food purchases have on their overall health and well-being (Duarte et al. 2013; Jiang et al. 2018). Indeed, public institutions are promoting clear nutritional labels in an attempt to address the issue of weight in society (Bialkova et al. 2016; Bailey and Muldrow 2019). The label on a food product can provide guidance on the nutritional value of the product itself (Hamlin and McNeill 2016), thereby potentially becoming a tool to contrast unhealthy food shopping and consumption (Inman and Nikolova 2015; Mitra et al. 2019). However, shopping decisions related to food are often made in a rush and in busy and noisy environments, and the consumer may not have enough time and cognitive resources to process the information embedded in the nutritional labels effectively (Ahn et al. 2015; Bauer and Reisch 2019). Additionally, the lack of information readily at hand hampers consumers' willingness to evaluate the ingredients carefully and make an accurate estimation of a product's healthfulness (Waltner et al. 2015; Isley et al. 2017).

Augmented reality (AR) is considered a cutting-edge technology that can improve the shopping experience and consumer engagement (Ameen et al. 2021). AR may support the purchase decision by showing digitally generated information about food items when the consumer actively seeks it, thereby reducing the information overload (Bayu et al. 2013; Chylinski et al. 2014). Several research works have addressed the development of AR apps to facilitate healthier food choices (Gutiérrez et al. 2019; Azlina Mokmin 2020; Röddiger et al. 2018; Waltner et al. 2015), but only a few of them have assessed whether these tools can actually have a positive impact on grocery shopping.

In the present study, we aim to investigate the impact of food-related information delivered using AR technology on consumers' food choices. To this end, we ran a comparative

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between-group experiment (traditional shopping vs. AR-supported shopping) and collected data including participants' food choices, time allocated to the task of choosing, and information-seeking behavior. Self-reported evaluations were collected and analyzed. Experimental findings indicated that bringing nutritional facts to the foreground facilitates the consumer to downgrade front-of-the-package claims, eventually making healthier food choices, regardless of the brand.

2 Related work

The use of augmented reality as a tool to enhance the shopping experience of different types of products has begun. Below, we report the main research investigating the impact of AR on purchases. Second, we outline the factors that influence grocery shopping. Finally, we report on the structure and content of the nutritional labels.

2.1 AR in shopping

AR apps for shopping purposes seem not to be widely spread among end users yet. Nevertheless, the users of these apps have reported satisfaction with their use, as the AR app increased their level of certainty over their purchases (Dacko 2017). This trend was also confirmed in laboratory experiments. The opportunity to explore an item using AR technology increases the perceived ownership of the product itself, and, as a consequence, the intention to buy it, as compared with touch-screen interfaces or laptops (Brengman et al. 2019). Poushneh and Vasquez-Parraga (2017) investigated the user experience (UX) and the willingness to buy accessories—namely sunglasses—using three different tools: a traditional Web site, a virtual model, and an AR app. Participants reported higher UX and intention to buy the product when using the AR app compared with the other two options. This indication proved to hold as well with other types of products—for example make-up (Watson et al. 2018)—and across different cultural settings (Pantano et al. 2017) in similar comparative experiments. AR was found to enhance the experience also when implemented in a physical store selling sports accessories, with participants stressing the amusement side of the experience and the capability of the augmentation to show the features of the product (Bonetti et al. 2019). Similarly, AR technology proved to emphasize the hidden features of home appliances, being well received by participants (Ludwig et al. 2020; Álvarez Márquez and Ziegler 2020).

In a grocery store, a smartphone-based AR app led consumers to purchase water bottles with a lower carbon footprint and healthier cereals, as reported by Isley et al. (2017). Additionally, the appeal of augmented food-related information affected consumers' choices, with colored Nutri-Score labels leading to a healthier selection of beverages as compared to plain white frames (Fuchs et al. 2019). AR-recommended food products were found to speed up the retrieval of foods suitable for specific health needs (Ahn et al. 2015). Chanlin and Chan (2018) developed ARFood, an AR mobile app delivering functional nutritional guidance to students eating at a university cafeteria. The app was appreciated and deemed helpful, especially by users engaging in a high level of monitoring. A different approach was taken by Gajadur et al. (2020), who proposed an AR app that emphasizes the presence of harmful ingredients in food and that was positively received by users. Finally, AR proved to be useful also in helping users estimate portion sizes both for users with backgrounds in health sciences and for naïve users (Lam et al. 2021).

2.2 Factors affecting grocery shopping

The majority of the decisions related to grocery shopping are made at the point of purchase and are driven by the exposure to stimulating environments and marketing-controlled motivators such as packaging (Luomala et al. 2018; Barakat 2019). In this context, the package plays a significant role because it is the first and the last element that the consumer sees. Additionally, the package is meant to represent the product, to gain the buyer's attention, and to influence information processing patterns (Ranjbarian et al. 2010; Duarte et al. 2013). The aesthetical features of the packaging can impact the choice of the hesitant and unmotivated consumer (Silayoi and Speece 2007; Bailey and Muldrow 2019; Maleki et al. 2019). The packaging components can be grouped into *visual* and *informational* categories. More specifically, the graphical (e.g., colors and images) and structural elements (e.g., size and shape) fall into the *visual category* and are highly related to the affective side of the decision-making process. By contrast, on-package details and package ease of use are arranged into the *informational category*, which is significantly connected to the cognitive side of the decision-making process (Silayoi and Speece 2004). The consumer typically considers the visual elements as a proxy indicator of the overall quality of the product because they are less cognitively demanding than the informational elements (Ranjbarian et al. 2010). The location of those elements also makes a difference, with labels placed on the front of the package being more easily readable and affecting grocery shopping (Kozup et al. 2003; Azman and Sahak 2014; Sumarwan et al. 2017). However, most of the labels placed on the front of the package do not display objective product-related information; rather, they report the brand, or third-party endorsements, with the rare exception of weight values and apportionment claims (Hamlin and McNeill 2016). On the other hand, informational elements such as nutritional labels are placed mainly on the back of the package, thereby reducing their visibility (Campos et al. 2011; Finkelstein et al. 2018; Bauer and Reisch 2019).

2.3 Nutritional labels

Nutritional labels have attracted considerable attention as tools capable of improving consumers' eating habits (Cannoosamy and Jeewon 2016; Bauer and Reisch 2019). By being available from the time of purchase to the time of consumption, nutritional labels have a broad reach and can serve both as sources of information for consumers and marketing tools for manufacturers (Kumar and Kapoor 2017).

Many countries have introduced specific policies requiring that food products report information about nutrient content, origin and ingredients on a dedicated nutrition information panel (NIP) (Hamlin and McNeill 2016; Mitra et al. 2019).

However, there is still no general agreement on the most informative way to report such data. As a consequence, a great variety of nutritional labeling formats placed at different locations on the package are used around the world (Hamlin and McNeill 2016), sometimes even resulting in information clutter (Bauer and Reisch 2019). More specifically, the NIP is generally placed on the back, where it has low impact and it is not readily available for reading and quick evaluations (Hamlin and McNeill 2016; Finkelstein et al. 2018). In addition, the NIPs are usually packed with extensive information written in small font, thereby hampering readability and leading to information overload (Silayoi and Speece 2007; Isley et al. 2017). Furthermore, food packages tend to include symbols and icons that are not straightforward and do not follow a single official standard (Azman and Sahak 2014; Hamlin and McNeill 2016).

3 Methodology

The research investigating the usage of AR technology to assist more aware food choices is still limited. Nevertheless, findings are promising, indicating that food-related information delivered through AR generally guides the user toward healthier choices. However, previous research has overlooked exploring the further aspects that can influence food selection. In the present study, we aimed to investigate whether the modality with which the user accesses food-related information impacts her/his selection and to understand which additional factors contribute to the decision-making process.

AR technology allows one to associate digitally generated contents to a physical object and enables the user to access and interact with those contents at her/his will (Azuma 1997). Thus, the user is not overloaded with additional information. These features make AR particularly suited for the grocery store environment, where the consumer is constantly pinged with stimuli from various sensory modalities, including visual information from billboards and packages and audio messages from ambient speakers. In this context, we expect that it will be easier for users to attend to product-related information when they actively seek it and when it is clearly displayed. Therefore, we foresee that:

> *H1*. Participants using AR will be more likely to select products with high nutritional value, than those accessing traditional information.

In the typical shopping experience, consumer's choices are driven mainly by the overall aesthetics of the packaging. Indeed, besides serving a key protection function, packaging conveys important information about the product, for instance, factual information about the product (yet usually written in small font and dense style). More importantly, the package needs to make the product pop out from the shelf, grabbing the consumer's attention. Moreover, the package conveys an immediate feeling about the quality of its content, and a poor-looking box will be associated with a low-quality product (Silayoi and Speece 2004; Maleki et al. 2019). Therefore, given the purposeful impact that food packaging is meant to have on consumers, we expect that:

> *H2*. Participants receiving nutritional information through regular food boxes will be more likely to base their choices on package aesthetics.

3.1 Selection of the food products

To investigate the hypotheses outlined above, a preliminary test was run to identify the food products to be included as experimental stimuli. We decided to focus on food products that were widespread and familiar among young men and women. In addition, we chose to exclude basic food groups such as vegetables; rather, we targeted the so-called *fun food* class. This type of food is primarily purchased on impulse for emotional satisfaction and with little concern for nutritional value (Inman and Nikolova 2015; Duarte et al. 2013). Indeed, consumers tend to rely on specific claims suggesting a health benefit to justify their purchase, regardless of the actual nutritional content (Enax and Weber 2015; Bailey and Muldrow 2019).

We selected two groups of products—cold breakfast cereals and granola bars. All of the types of products selected belonged to a similar price range and had packages of similar size and weight. In addition, all of the boxes reported typical front-of-package claims pertaining to nutrient contents such as *"light," "palm oil-free," "organic," "high in fiber"* and *"high in vitamin content,"* or to healthfulness such as "*powering you."*

Table 1 Characteristics of the products that have been considered to group them into high and low nutritional value food items

	Product 1	Product 2	Product 3	Product 4
Granola bars				
Energy (Cal)	83	105	85	83
Sugar (g)	6.4	7.9	6	8.3
Saturated fat (g)	0.6	1.4	1	1
Protein (g)	1.2	1.7	1.5	1.3
Salt (g)	0.11	0.1	0.13	0.2
Fiber (g)	1.1	0.9	2.1	0.3
Healthy ingredients	Iron Vitamins Fiber Wheat germ	Iron Vitamins Fiber	Iron Vitamins	Iron Vitamins Fiber
Unhealthy ingredients	Artificial aromas High in sugar Cocoa butter	High in sugar High in saturated fat Cocoa butter	High in sugar High in saturated fat Artificial aromas Dangerous food additives Non-hydrogenated oils Cocoa butter	Artificial aromas High in sugar High in saturated fat Palm oil Cocoa butter
Overall nutritional value	High	High	Low	Low
Breakfast cereals				
Energy (Cal)	185	157	178	174
Sugar (g)	8.1	6.4	7.4	5.6
Saturated fat (g)	1.7	2.2	2.4	1.1
Protein (g)	3.5	3	3.6	4.6
Salt (g)	0.15	0.12	0.04	0.3
Fiber (g)	2.7	1.6	3	5.6
Healthy ingredients	Organic Vitamins Low in salt	Iron Vitamins Fiber Calcium Low in fat	Organic Fiber	Fiber Wheat germ
Unhealthy ingredients	High in sugar High in saturated fat Cocoa butter	Artificial aromas High in sugar Cocoa butter	Artificial aromas High in sugar High in saturated fat Cocoa butter	Artificial aromas Food additives High in salt Palm oil Cocoa butter
Overall nutritional value	High	High	Low	Low

For each product, the macronutrient contents are reported, together with lists of healthy and unhealthy ingredients. Finally, the overall nutritional value is reported

A total of eight products were selected, four in each food category. Both categories included the products of popular brands (two for each category) and the products of grocery brands (two for each category). The products in each category were divided into two subgroups: products with high and low nutritional value. The attribution of nutritional quality was based on both the macronutrient content—for example, the quantity of sugar, saturated fat, or protein—and on the number of healthy and unhealthy ingredients. Healthy ingredients included fiber or the addition of iron, calcium, and vitamins. In contrast, unhealthy ingredients included a high content of saturated fat, salt, sugar, and artificial aromas. The selected products had generally similar macronutrient contents, but contained different quantities of healthy and unhealthy ingredients. More specifically, the products with high nutritional value had more healthy than unhealthy ingredients. Conversely, the products with low nutritional value had more unhealthy than healthy ingredients (Table 1).

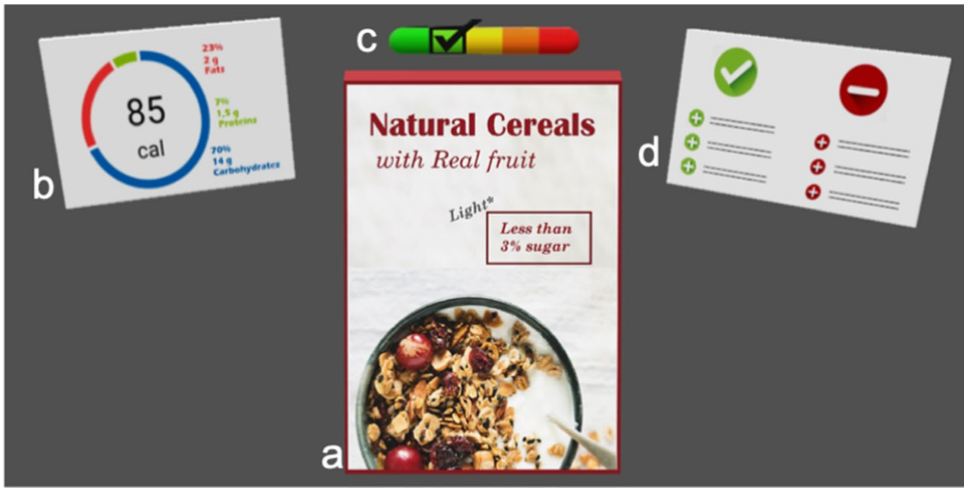

Fig. 1 An example of a label delivered with AR technology. **a** An exemplary product package, **b** a pie-chart view of the Nutritional Information Panel, **c** the overall assessment of product healthiness, **d** the more (green) and less (red) healthy ingredients contained (colour figure online)

3.2 Development of the AR app

A dedicated AR app running on Microsoft HoloLens was developed. The 3D models of the objects were created using the Microsoft 3D Builder application, and high-definition photographs of each product were applied as textures. Subsequently, the files were exported from .obj to .fbx format to run on Unity 3D. Indeed, the Unity 3D game engine was deployed to develop the application and handle information visualization and location estimation. More specifically, the virtual augmented reality environment was created through Unity 3D, and the HoloToolkit library was used for integration with HoloLens smart glasses. In this environment, a virtual camera was set up to track the position and movement of the user. 3D objects were instantiated at a fixed distance from the camera's original position so that the objects' placement in the space could be defined from the user's initial location. By doing this, we were able to instantiate the objects within the shelf without using spatial tracking. Graphical information on nutritional values was linked to the 3D objects, and a gestural input system such as Air Tap was set up to interact with the virtual products. Unity 3D was finally used to deploy the AR app into the Microsoft HoloLens head-mounted display.

The information regarding nutritional values comprised calories, macronutrients, vitamins, fiber, sodium content, and food additives, in line with previous findings (Campos et al. 2011). The information on the macronutrients reported on the nutritional information panels (NIPs) of each product was processed and displayed on an AR label as a pie chart. Alongside this, a hybrid-type label reported the more and less healthy components contained in each food product. An additional evaluative-type label provided an overall assessment of the products' healthiness. It was represented by a colored pill-shaped band ranging from solid green, i.e., high healthiness value, to red, i.e., low healthiness value. The hybrid- and evaluative-type labels were based on the products' NIPs, the Nutri-Score© calculator algorithm,[1] and the food classification based on the presence of unhealthy ingredients and overall composition (Fig. 1).

The AR app displayed the models of the products arranged on the physical shelves set up in the laboratory. No additional information was readily presented. To access further details of a product, the user had to gaze at it and perform the *air tap* gestural command, by bending the index finger. As a result, the package would move out of the shelf and the food-related information would show as a pop-up (Fig. 2).

4 Materials and methods

4.1 Experimental design

The experiment followed a between-participant design. The between-participant factor corresponded to the modality of information delivery. The experimental group used the AR app, while the control group explored the boxes as an ordinary shopping experience.

4.2 Questionnaires

Participants filled in four questionnaires in total, two before the experimental session and two after it. The pre-experiment questionnaires were meant to collect information about the participants' demographics (name, age, gender, living status), and their familiarity with grocery shopping. It also included a list of food brands, and

[1] https://www.santepubliquefrance.fr/determinants-de-sante/nutrition-et-activite-physique/articles/nutri-score.

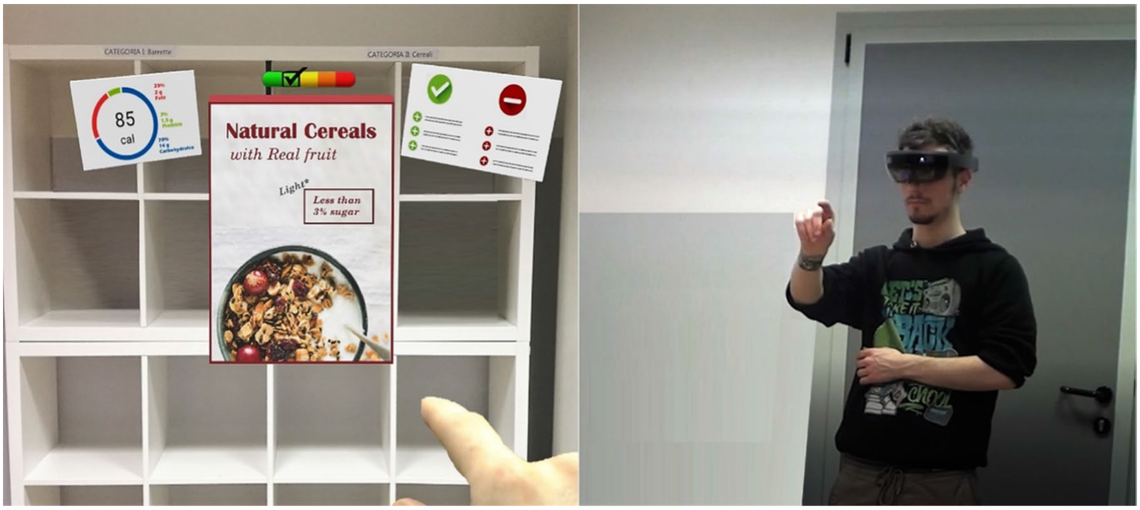

Fig. 2 A participant selecting a 3D product and the related pop-up information displayed

participants were asked to indicate which one(s) they already knew. A further questionnaire was meant to investigate participants' technological orientation (12 items, adapted from the National Technology Readiness Survey, NTRS and the Technology Readiness Index, TRI; Parasuraman 2000; Walczuch et al. 2007) and their shopping tendencies [8 items, adapted from Ĉivić and Ćilimković (2017)]. Additionally, participants' inclination to engage in exploratory buying behavior for making the purchase decision was assessed. More specifically, we investigated the extent to which participants valued the product price, quality, and brand reputation to make a food choice.

The post-experimental questionnaire consisted of 12 items and investigated respondents' experience and the motivations behind their behaviors. In particular, the survey comprised four dimensions: the importance attributed to the visual features of the package, e.g., colors and images (2 items; Ranjbarian et al. 2010), the brand and front-of-package claims (2 items; Krystallis et al. 2008), nutritional information, including product nutritional labels, and food composition (6 items; Steptoe et al. 1995; Krystallis et al. 2008), and, lastly, the hedonic attributes of the experience (2 items; Babin et al. 1994). We asked participants to indicate their level of agreement on a 5-point Likert scale.

We further investigated the choice made by participants by asking them to report the extent to which the perceived healthfulness, the overall aesthetics of the package, and the quantity of the product (i.e., the amount of food in the package) influenced their decision. They had to answer on a 5-point scale (1 = *not at all important,* 5 = *extremely important).* All questionnaires were administered in the native language of the respondents using Google Forms and were displayed on a desktop computer.

4.3 Data collected

Product choice The final product decision was written by participants on a dedicated answer sheet.

The choices made by the participants in the two groups were compared to investigate the effect of information presentation modes on the decision.

Exploratory behavior Participants could gather additional information on the product by either grasping the box or by air-tapping the 3D model. Participants' handling of the product was assessed through the video analysis of the recorded experimental session and was considered a proxy of individual willingness to explore additional information before making the decision.

The *total amount of time* allocated to make the purchase decisions—hereafter termed "time on task"—was measured by the experimenter with a stopwatch. The time started when the experimenter told the participants that they could begin, and it stopped when they said that they had made their choice, or after 6 min. Time on task was compared between groups to assess whether the information delivery mode was related to different selection times.

Self-report ratings The scores that the participants provided on the questionnaires were compared between groups. By doing this, we meant to assess the effect of the information presentation modality on the participants' perception of the experience. The answers given to the pre-experiment questionnaires were compared to ensure the homogeneity of the groups.

4.4 Setting

The experiment was conducted in a dedicated laboratory. The laboratory was purposefully furnished with a shelf

Table 2 Demographic characteristics of participants in the experimental and control groups

Group	*N*	Gender		Frequency of grocery shopping		Living status	
		Male	Female	Sometimes	Often	With flatmates	With family
Experimental group	25	13	12	7	18	12	13
Control group	25	11	14	10	15	15	10
Total	50	24	26	17	33	27	23

Table 3 Means, medians, and values of the Mann–Whitney *U* test of the experimental and control groups for the pretest questionnaires with regard to the study variables

	Group	*M* (SD)	Mdn	*U*	*p*
Technology readiness	Experimental group	2.93 (0.31)	3	320	0.89
	Control group	2.91 (0.35)	2.91		
Exploratory behavior: quality	Experimental group	4.16 (0.77)	4	352.5	0.43
	Control group	4.02 (0.63)	4		
Exploratory behavior: price	Experimental group	3.04 (0.48)	3	224.5	0.084
	Control group	3.29 (0.52)	3.33		
Exploratory behavior: brand image	Experimental group	3.16 (0.43)	3.33	385.5	1.149
	Control group	3.05 (0.57)	3		

unit. In both information delivery modes, the food products were displayed on the shelf in a random order, either as real boxes or as 3D models. The products had no price labels to limit potential confounding effects (Freedman and Connors 2010; Koenigstorfer et al. 2013).

A well-visible dot was drawn on the floor to indicate the starting position, so that all participants were at the same distance from the shelf at the beginning of the experimental session. Participants were free to move in the room during the experiment. A desk and a chair were also present in the room to allow participants to comfortably complete the questionnaires.

4.5 Equipment

Participants used a desktop computer with a 23″ monitor to display and complete the questionnaires. To visualize and interact with the 3D models of the presented food products, they used Microsoft's HoloLens mixed-reality smart glasses.

Participants' interactions were video-recorded using a Sony HDR-CX240E handheld HD camcorder. The performance of those wearing the HoloLens smart glasses was also recorded in real-time using the Microsoft HoloLens application running on a laptop connected through the Wi-Fi network.

4.6 Participants

A total of 50 participants ($F = 26$) took part in the experiment. Participants were undergraduate students, and their average age was 22.6 years (SD = 2.15). No statistically significant differences emerged between the groups for any of the variables collected in the pre-experiment questionnaires (Tables 2, 3). Participants were randomly assigned either to the experimental ($N = 25$; $F = 12$) or to the control group ($N = 25$; $F = 14$). None of the participants in the experimental group reported having previous experience with the HoloLens head-mounted display. They were all recruited by word of mouth and received no compensation for their participation.

4.7 Procedure

Participants were first welcomed in the laboratory, signed an informed consent form, and received a general explanation of the experiment. Before starting with the experimental session, participants filled in the pre-experiment questionnaires. Next, participants were trained for the task. The experimenter assisted the participants in the experimental group to calibrate the device to improve the quality of the 3D visual elements. Participants were trained to use the AR app with the built-in Learn Gestures app by Microsoft, which lasted about 5 min. They could repeat the training until they felt confident in executing the gestures. Participants in the control group were given a body care product with similar features (detailed information with a small font and very dense writing style on the backside) to handle and explore. Once participants felt confident, they received detailed instructions on the actual experimental task. Both groups were presented with eight food products arranged on the shelf unit in random order and were given a maximum time of six minutes to choose one product in each food category (uncertain responses were not admitted). They were allowed to manipulate, handle and explore the products freely to gather relevant information.

Table 4 Frequencies of the products chosen by participants in the experimental and control groups

Category of the product	Nutritional value	Group	Frequencies of choices
Granola bars	High	Experimental group	22
		Control group	9
	Low	Experimental group	3
		Control group	16
Cold breakfast cereals	High	Experimental group	23
		Control group	12
	Low	Experimental group	2
		Control group	13

On that account, participants in the experimental group were presented with 3D models of the food products and explored them using related gestural commands. In addition, they could access further product-related information through AR by selecting the package (as described in Sect. 5). Individuals assigned to the control group could explore the real products, reading the relevant information on the packages. Once they had made their product decisions, participants were then asked to report their choices by ticking the corresponding images on the answer sheet and completing the post-experiment questionnaire. The experimental session ended when the participants reported their decisions. In case they had not communicated any choice after 6 min, the experimenter would end the session and ask them to make a decision. Overall, the experiment lasted approximately 15 minutes.

4.8 Data analysis

To investigate the effect of the information delivery modes on participants' choices, we conducted a Fisher's exact test. More specifically, we compared the nutritional value (high vs. low) of the products that the participants in the two groups chose. In addition, we compared the scores related to the importance of product healthiness, aesthetics, and quantity between groups using the nonparametric Mann–Whitney test (Shapiro–Wilk test $p < 0.05$). We also used the Mann–Whitney test to compare the scores assigned to the visual features of the package, the brand and the front-of-package claims, the nutritional information, and the hedonic attributes of the experience. Finally, we used the Student's t test for independent samples (Shapiro–Wilk test $p > 0.05$) to investigate differences in the task duration between groups.

5 Results

The Fisher's exact test indicated that participants in the experimental group significantly more often chose the products having high nutritional value compared to the control group (both Fisher's test $p < 0.001$). This effect emerged for both product categories, i.e., the granola bars and the cold breakfast cereals (Table 4).

As for the factors that affected participants' choices, the quantity of the product in the package was considered more important ($U = 202.5$, $p = 0.03$) for participants in the control group (MeanRank = 29.90, Mdn = 3; $M = 3.08$; SD = 1.41) than participants in the experimental group (MeanRank = 21.10, Mdn = 2; $M = 2.20$; SD = 1.15), as shown in Fig. 3. By contrast, no statistically significant differences were found with respect to a products' aesthetics ($U = 235$, $p = 0.122$; experimental group: Mdn = 2, $M = 2.64$, SD = 1.32; control group: Mdn = 4, $M = 3.24$, SD = 1.36) and healthiness (U = 409, p = 0.052; experimental group: Mdn = 4, $M = 4.16$; SD = 0.99; control group: Mdn = 3, $M = 3.28$, SD = 1.57).

The visual features of the package were considered more important ($U = 180$, $p = 0.009$) by the control group (MeanRank = 30.80, Mdn = 4; $M = 4.08$; SD = 0.62) than by participants in the experimental group (MeanRank = 20.20, Mdn = 3.5; $M = 3.36$; SD = 0.93). Differently, participants in the experimental group (MeanRank = 29.02, Mdn = 4.33; $M = 4.16$; SD = 0.61) attached greater importance ($U = 421$, $p = 0.034$) to the nutritional information of the products than participants in the control group (MeanRank = 21.98, Mdn = 3.83; $M = 3.76$; SD = 0.70). No statistically significant differences between groups emerged for brand and FOP claims ($U = 265.5$,

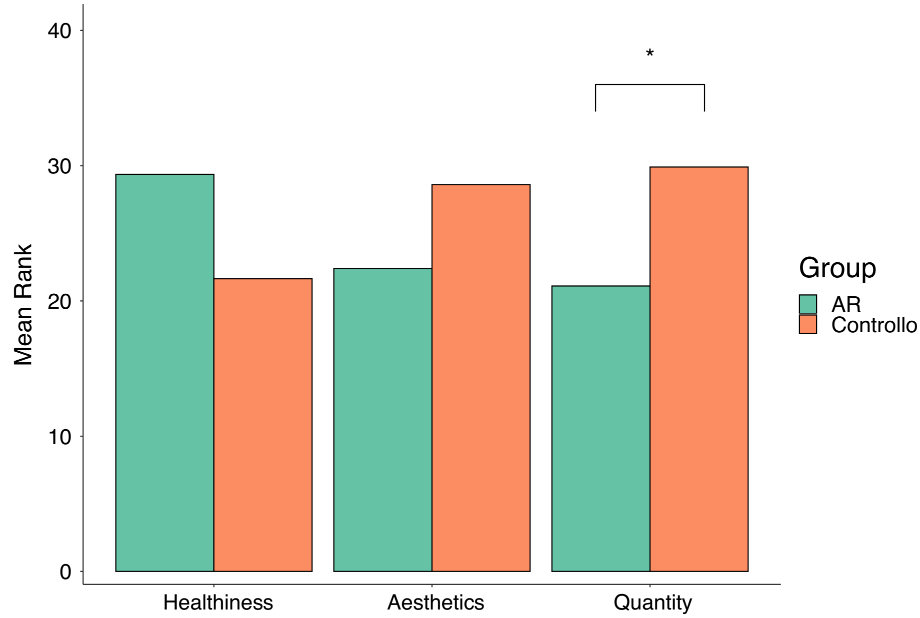

Fig. 3 The mean rank of the scores related to the importance of healthiness, aesthetics, and quantity of the product for the experimental and control groups. $*p<0.05$

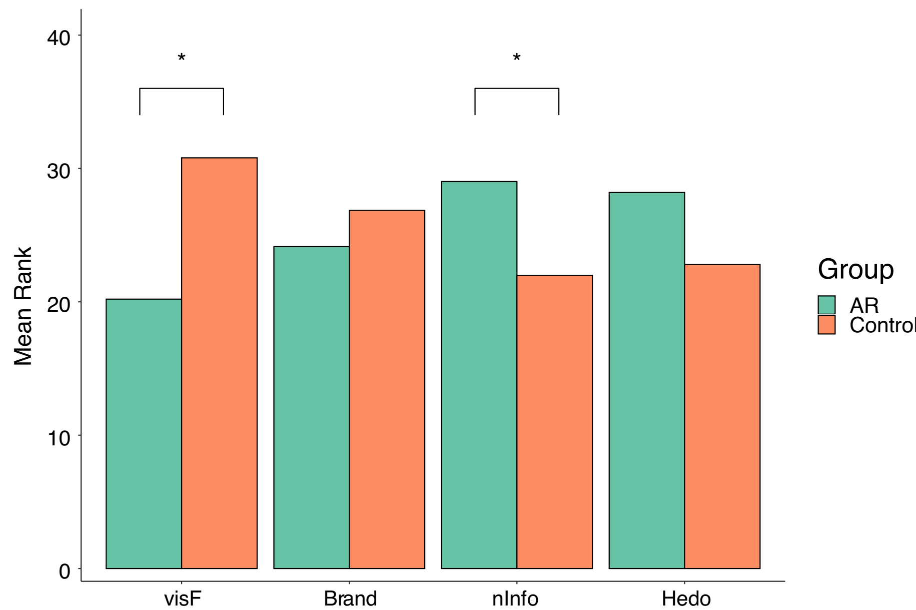

Fig. 4 The mean ranking scores for the evaluation related to visual features (visF), brand and front-of-the-package claims (Brand), nutritional information (nInfo), and hedonic attributes (Hedo). $*p<0.05$

$p=0.35$; experimental group: Mdn = 3, $M=2.96$, SD = 1.06; control group: Mdn = 3, $M=3.26$, SD = 0.84) and hedonic attributes (U = 265.5, $p=0.173$; experimental group: Mdn = 4.5, $M=4.46$, SD = 0.59; control group: Mdn = 4, $M=4.14$, SD = 0.81; Fig. 4).

Considering the time on task, participants in the experimental group ($M=3'15''$; SD = 60.9 s) spent a longer time to complete the task ($t=2.41$; df = 48; $p=0.02$) than participants in the control group ($M=2'28''$; SD = 87.2 s). Nevertheless, it should be noted that participants in the experimental group explored the products more frequently than those in the control group. More specifically, 80% of participants in the experimental group handled all products, with 72% of them doing so repeatedly. Meanwhile, only 52% of participants in the control group handled all the products, 36% of whom did it more than once. In addition, 16% of participants in the control group did not show any product manipulation at all. The remaining participants in both groups (respectively 20% in the experimental group and 32% in the control group) manipulated a few products, but not all of them.

6 Discussion

The present study extended previous research on the use of AR in grocery shopping by assessing the actual impact of the technology on participants' food choices. To this end, an AR app running on Microsoft HoloLens was developed to display the nutritional information of specific food products. We found that having access to augmented information facilitated the choice of healthier food items. Participants in the experimental group were indeed more likely to choose the products with a higher nutritional value, as compared to their counterparts in the control group, confirming our first hypothesis (*H1*). In addition, participants in the experimental group motivated their choices by referring to the actual nutritional information provided. In line with previous findings (Chylinski et al. 2014; Isley et al. 2017), AR-delivered contents allowed participants to make a more aware decision. In other words, AR technology emphasized the factual and less visible characteristics of the product, thereby supporting the decision-making process (Bonetti et al. 2019; Pantano et al. 2017; Álvarez Márquez and Ziegler 2020). On the other hand, participants in the control group motivated their product choices referring to the visual features of the package. This finding is consistent with *H2* and supports previous research (Silayoi and Speece 2007; Maleki et al. 2019). Indeed, captivating packaging biased individuals' assessments and intentions, leading poorly designed products to lose appeal regardless of their actual nutritional characteristics. In addition, we found that participants in the experimental group took a longer time to examine and handle the products and make their choices, in line with Bonetti et al. (2019). Higher interaction times when using AR can be explained, at least in part, by the fact that for participants, the technology was novel, and even if they were trained to use it before the experiment, they could not be considered experts. Furthermore, the excitement of using an unfamiliar technology may have also contributed. Still, more time dedicated to exploring the product makes the consumer address food items more carefully, thereby spending more resources on evaluating the quality of the food.

The integration of AR into the daily shopping routine is a likely scenario, if we consider that consumers are already in the habit of using their personal devices while making purchases in stores (Mclean and Wilson 2019). Moreover, it responds to young consumers' expectations of smart technology assistants that help them identify suitable items for them (Priporas et al. 2017; Chanlin and Chan 2018). AR-shopping assistants can be conceived of as a tool to magnify the product features that are particularly relevant for the consumer—for example, nutritional restrictions—or that the producer would like to promote, such as a sustainable manufacturing process. In the very context of grocery shopping, augmenting nutritional values can attract the consumers' attention to actual product-related facts rather than to the claims or packaging appeal.

It should be acknowledged that in the present experiment, participants did not make a real purchase and they had no price information regarding the products. Nevertheless, the price was found to be a relevant variable in product choice (Inman and Nikolova 2015; Barakat 2019). Further experiments should address how price-related information impacts the perception of value and intention to buy. In the present study, participants were not screened for potential eating disorders. However, it should be acknowledged that some groups of individuals are particularly careful at inspecting food labels during grocery shopping (e.g., individuals with orthorexia nervosa tendencies; Yardımcı and Demirer 2022), and in our experiment they may have behaved differently from our sample. Future work should investigate how individuals with eating disorders interact with nutritional information presented via AR and whether they could benefit from such a presentation. The literature shows that the acceptance of wearable technology depends on the context in which it is deployed (Spagnolli et al. 2015). In the present experiment, we did not assess participants' acceptance of the HMD enabling the visualization and interaction with augmented objects. Future studies should address the technology acceptance of such devices in the long term and specifically for grocery shopping purposes. Finally, future studies should compare the impact of product-related information delivered through AR technology with other visual media, such as video clips, on the user's purchase intention. Indeed, users, especially some target groups, like older adults, may feel more confident with traditional media, thereby considering them more trustworthy.

7 Conclusion

In the present study, we showed that AR technology facilitates the access to nutritional facts in packaged food products, thereby fostering a more aware choice. Not only can AR easily bring nutritional data to the foreground, but it can also provide readily available insights into the products' overall quality. More importantly, it enables the consumer to gather information only on the food of his/her interest. In this respect, AR can also be a valuable means of reducing information clutter while shopping, while at the same time emphasizing specific product features.

Our findings support the exploitation of AR as an active information filter for grocery shopping. By enabling the consumer to select only the products consistent with his/her nutritional needs—for example, gluten-free or low glycemic index food—he/she would have access only to the products suitable for his/her diet, thereby reducing the efforts related to purchasing choice.

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Declarations

Conflict of interest All authors declare that they do not have any conflicts of interest.

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