

Article

NFC Tag Awareness and Its Visual Implementation on Food Packaging: Case Study in Slovenia

Tina Žurbi  and Diana Gregor-Sveteč * 

Faculty of Natural Sciences and Engineering, University of Ljubljana, Aškerčeva cesta 12, 1000 Ljubljana, Slovenia; tina.zurbi@gmail.com

* Correspondence: diana.gregor@ntf.uni-lj.si; Tel.: +386-12003272

Abstract: Many companies are using smart packaging to provide consumers with more information about their products. The goal of our case study is to access the Near Field Communication (NFC) tag knowledge, as well as getting insights into tag positioning in food package design for better visibility in order to develop some guidelines for future tag implementations. A preliminary survey of professionals provided an overview of NFC tag usage, followed by an online survey that assessed knowledge and visibility of tag placements. These findings were further discussed in focus groups and measured using eye-tracking technology. For placement visibility assessments, well-known and fictitious packaging designs of milk were used. The results show that, due to the NFC tag's low market penetration, consumer recognition is low, with only generations Y and Z being familiar with the NFC tag. Knowledge of the NFC tag does not significantly vary based on education level. When considering the use of NFC tags, it is crucial to define and understand the target market. If the target is younger generations, the potential to increase engagement with the product can be achieved. Additionally, to boost consumer interaction, NFC tags or other smart elements should include an activation prompt, positioned on the central right section of the packaging and distinguished by a distinct color. The influence of the design on tag visibility is essential to ensure its effectiveness.

Keywords: NFC tag; eye-tracking; packaging design; visibility



Citation: Žurbi, T.; Gregor-Sveteč, D. NFC Tag Awareness and Its Visual Implementation on Food Packaging: Case Study in Slovenia. *Appl. Sci.* **2024**, *14*, 9933. <https://doi.org/10.3390/app14219933>

Academic Editor: Alexandros A. Lavdas

Received: 25 September 2024

Revised: 14 October 2024

Accepted: 28 October 2024

Published: 30 October 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The packaging reflects the product image and identity and enables companies to communicate with consumers at retail stores [1]. As a silent salesman on supermarket shelves, the packaging has become an essential element in the marketing strategy [2]. The consumers have to decide between a variety of similar products, and a lot of product purchase decisions are made directly at the point of the sale [3,4]. The AIDA model (Attention, Interest, Desire, and Action) usually describes this cognitive process during the process of purchasing a product [5]. The packaging includes graphic and informative elements, with graphic images playing a key role in attracting consumers' attention. Younger consumers, particularly the ones from Generation Z, clearly prefer communication via images rather than via text [6]. In a visually saturated world, every detail matters when making purchasing decisions. Due to the saturation of the consumer with information as well as the increasing competition on the shelves, the inclusion of special additional elements, such as smart packaging, should attract the customer's attention even more at the unconscious stage, even before they enter the purchase decision process. Soars emphasizes the importance of visual and perceived appeal of packaging and states that the packaging must make a time window of 5 s available to the consumer's attention or even less [7,8]. Wallentin states that, in markets where smartphones are present, the website needs to be prioritized, and fast connectivity options such as smart elements offer precisely this [9]. He also emphasizes the importance of providing opportunities for the consumer to connect with the brand. At the same time, manufacturers are looking for opportunities to develop

deeper relationships with consumers by collecting data and building loyalty, leading to repeat sales. Near Field Communication (NFC) technology offers the possibility to use a fast contactless connection to electronic devices and to access to digital content. Compared to QR codes, NFC can provide much more data and can perform specific tasks. NFC is a wireless short-range communication technology based on the existing standards of the RFID infrastructure. Analysis of the development and capabilities of NFC technology evolution is available in Nikitina et al. [10].

Nowadays, NFC tags are proposed for various applications, such as smart labels for food, pharmaceuticals, and wearables. The wireless acquisition of the data from the sensors in smart labels is applied to smart packaging and modified atmosphere packaging for food monitoring [11]. RFID and NFC have been proposed to sense, obtain, and transmit information on the atmospheric conditions and identification of the package [12]. UHF RFID, paired with NFC, could be implemented to promote the traceability of the whole food chain until the product reaches the consumer [13]. Barge et al. [14] describes the weaknesses and advantages of using UHF and/or NFC systems to perform automatic identifications in the meat supply chain. Kapse et al. [15] presents the advantages of using NFC tag to determine the freshness of packaged milk. Pigni and Conti [16] point out that NFC technology has all the requirements to become the main technology for traceability in the various food sectors, with NFC-based sensors having also demonstrated how the system could enable a smartphone user to identify food deterioration at an early stage [17]. According to Malik et al. [18], the dairy industry needs an effective traceability system to ensure supply chain visibility, safety, quality, and adherence to ethical standards, while also building consumer trust, optimizing operations, and enabling end-to-end process tracking for economic benefits. Advancements in digital technologies, such as NFC as part of the Internet of Things (IoT), which connect physical objects to the digital world offer a potential solution [18]. The use of NFC combined with the IoT or blockchain can have a tremendous impact on food supply chain management [19]. In the case study by Alnahhal et al. [20] on a smart yogurt filling system, NFC, as one of the emerging technologies of Industry 4.0 (I4.0), was found to enhance customer satisfaction, reduce the expenditure of time and effort, lower error rates, and minimize waste. The advanced technologies of I4.0 are being progressively adopted in the dairy sector, making significant changes in the production of milk, cheese, and other dairy products [21].

In the digital information age, people pay more attention to the experience of interactive concepts in daily life; thus, to combine the interaction concept with packaging the needs of the consumers must also be considered in package design [22]. The graphic design of packaging involves creating visual content to convey specific information to the consumers, a strategy which is delivered through color packaging, typography, graphic shapes, and images [23]. It directly influences consumers' perception of the product through efficient communication and can influence their purchasing decision.

To observe consumer behavior, eye-tracking technology is used. This technology may provide graphic representations of eye movements, such as heat maps (fixation concentration) and gaze plots (observations). It has been utilized in numerous studies to acquire a better understanding of customers' visual attention and, as a result, a better understanding of consumer behavior, information acquisition, and decision-making. For example, it has been used to verify packaging flaws prior to the product launch [24], determine the effects of packaging characteristics on consumer attention and packaging evaluation [25], identify packaging observation patterns [3], understand the effect of visual influence on in-store purchasing decisions [26], determine which characteristics attract consumer attention more [1], and to understand the attractiveness of packaging [27] and the impact of visual stimuli on consumers' decision-making strategies [28]. In the research by Oliviera et al. [29], eye-tracking was used to analyze the consumers' attention to functional food labeling of probiotic milk.

Our research focuses on NFC knowledge and on the use and placement of NFC tags to gain a better understanding of consumer knowledge and consumer interaction with NFC tags. The following research questions were of interest:

- a. Do Slovenian consumers recognize and know the meaning of NFC tags?
- b. To what extent do consumers utilize NFC tags?
- c. How does the design of NFC tags on food packaging, in terms of messaging and placement, influence consumer interaction and visibility?

2. Materials and Methods

The research started with a preliminary survey of the professional public (N = 10) to acquire an overview of NFC tag usage in the Slovenian market context. Subsequently, an online survey was conducted using the tool www.mojaanketa.si (MojaAnketa.si, Slovenia; URL accessed from 15 January till 15 February 2020) to test knowledge, usage, and NFC tag placements (Group 1—online survey: N = 164). The participants in the online survey were segmented according to age (generations) and level of education (Table 1). Generations defined by birth year included Baby Boomers (1946–1964), Generation X (1965–1980), Generation Y (1981–1996), and Generation Z (1997–2012). Three levels of education were relevant, i.e., primary school or lower (below level 5), high school or bachelor's degree (level 5 and 6/1), master's degree or higher (level 6/2 and above). To ensure a diverse audience, the survey was distributed via email with the assistance of known contacts, the contact database of the student–faculty office, and through social networks and communities (Facebook, LinkedIn). The purpose of the survey was to gather information about the knowledge and use of NFC tags in Slovenia and to evaluate the effectiveness of the design and placement of the smart element on the packaging. The questionnaire consisted of 20 questions. Questions about knowledge and recognition of NFC tag included: “do you recognize the NFC logo?”, “have you ever heard of NFC?”, “are you familiar with the NFC technology?”, “how does the NFC technology work?”, “do you have an NFC protocol on your mobile phone?”, “where have you encountered NFC tags?”, “do you use NFC technology for payment?”, “do you use NFC technology for information gathering?”, “what kind of information could be provided through the NFC tag?”. The questionnaire also included two graphic layouts: a familiar packaging design in Slovenian market (the recognized brand Alpsko) and a fictitious packaging design (Natalis) for additional and control verification. Respondents were asked about the placement of the NFC tag, whether an invitation or explanation to interact with the tag was needed, if the tag should be differentiated by color, and where the most suitable position of the NFC tag on the packaging would be.

The usage of the NFC tag was also tested with short interviews that were conducted before the eye-tracking measurements (Group 2—interviews and eye-tracking: N = 34). The purpose of the short interview was to gather information about the respondents' knowledge of NFC technology. For this purpose, we created an NFC tag sticker that linked to a website. With the functioning NFC tag, we aimed to observe how respondents reacted to the tag—whether they recognized it, whether their phones were equipped with the necessary protocol, if they actually scanned the tag, and whether they used NFC technology in general. Furthermore, the tag placement was discussed in focus groups (Group 3—focus groups: N = 50) and measured with eye-tracking system (Table 1).

In Table 1, we decided to present both groups (Group 1 and Group 2) together based on the need to highlight trends related to education and age which were similar and showed little variation between the two groups, despite the fact that different research methods were used and the number of respondents differed. Combining the groups allowed us to provide a broader, more comprehensive view of these key demographic factors and their influence on the study's outcomes.

A preliminary survey with the professional public revealed that NFC adoption in market contexts was low. Therefore, the work through focus groups, interviews, and eye-tracking assessments was conducted on students, because the younger generation

represents the sample of potential future consumers. Students were recruited with the assistance of the student–faculty office. The data collected were fully anonymized, and participants gave informed consent after being briefed about the purpose of the study and their rights. Personal data were not collected, and all responses were anonymized to protect the participants’ privacy. In the research conducted, no participants were excluded, and all available data were utilized.

Table 1. Distribution by age and education for all participants.

Groups (information retrieved)	N/Avg. age	Segmentation of Group 1 and Group 2						
		Education Level (%)			Generation (%)			
		Below level 5	Level 5 and 6/1	Level 6/2 and above	BB	X	Y	Z
GROUP 1 Online survey respondents (knowledge, design implementation)	164/32.1							
GROUP 2 Interviewees (knowledge, eye-tracking)	34/21.1	17.7	56.1	26.3	5.1	21.2	37.4	36.4
G1 + G2	198/26.6							
GROUP 3 Focus group participants (usage, design implementation)	50/22.5	Segmentation of Group 3						
			100				100	

N = number of participants, Avg. age = average age, BB = baby boomers.

A well-known brand packaging (Alpsko) and a fictitious packaging design (Natalis) of UHT milk were used to assess the visibility of NFC tag placement. Eye-tracking technology was employed to obtain non-subjective measurements of the areas of the NFC tag that received quicker and longer observations. The eye-tracking system used was the Tobii X120, manufactured by Tobii Technology AB of Sweden, capable of detecting real-time eye movements at a sampling rate of 120Hz. The packaging samples were displayed on a 52.04 × 32.60 cm HP ZR24W screen (Hewlett-Packard Inc, Palo Alto, CA, USA) with a resolution of 1920 × 1200 px and viewed from a distance of 60 (+/−1) cm. Eye movement tracking was recorded using the Tobii Studio 3.2.1 software. The measurements were performed in a quiet room with neutral matte gray walls. Prior to the measurement, each participant was allowed to adapt to the lighting conditions of the room for 5 min and underwent a 9-point screen-based calibration. All participants had normal or corrected-to-normal vision. Each participant viewed a total of 26 images of packaging designs, randomized for each participant to mitigate order effects. From 26 images of packaging designs, 16 were important for our study and were further evaluated. Each image was presented automatically on the screen to each participant for 5 s. A gray masking screen was inserted for 2 s between images to control for carryover and order effects. Participants were asked to look at the displayed image while their eye movements were recorded.

When evaluating eye movements, the following measurements were taken into account:

- Time to first fixation (TFF) of the area of interest (AOI), assessing how long it takes for the observer to fixate his gaze on the active area of interest from the start of the visual display.
- Total fixation duration (TFD) with respect to an area of interest.
- A heat map, which is a graphic that can effectively reveal the center of the visual attention by showing how gazes are dispersed over the stimuli.

The data and results were statistically evaluated, and the following statistical methods were utilized:

(a) Chi-square test

Purpose: to analyze the associations between categorical variables, that is, recognition and knowledge of NFC tags based on factors like education level and generation.

Reason for use: chi-square tests were used to compare the observed frequencies (recognized vs. not recognized, known vs. not known) with the expected frequencies to determine if there were significant associations between variables and to examine if there were significant relationships among factors like education level, generation, and recognition/knowledge of NFC tags.

(b) Kruskal–Wallis test

Purpose: to compare multiple groups (different positions of NFC tags) with respect to time to first fixation and total fixation duration for non-normally distributed data.

Reason for use: this non-parametric test was used to determine if there were significant differences in fixation times among different positions of NFC tags and among differently colored tags.

(c) T-test

Purpose: when assuming that the data were normally distributed, the t-test helped determine if there were statistically significant differences between two independent groups (NFC tags with or without an invitation).

Reason for use: it was used to determine if there were statistically significant differences in time to first fixation between NFC tags with or without an invitation.

(d) Mann–Whitney U test

Purpose: suitable for ordinal, interval, or ratio data. It can be used when the assumptions of the t-test are not met. It was used to compare two independent groups (NFC tags with or without an invitation) with respect to total fixation time for non-normally distributed data, assessing if one group tended to have higher values than the other.

Reason for use: it was utilized to examine if there were statistically significant differences in total fixation time between two conditions, i.e., between NFC tags with or without an invitation, after which the *t*-test was rechecked.

3. Results

This paper summarizes the results of a case study on NFC tag knowledge, as well as insights on tag positioning in food package design for better visibility in order to develop some guidelines for future tag implementations. The statistical methods used were crucial to analyze various aspects of the study, such as recognition and knowledge of NFC tags, optimal placement on packaging, and the impact of the presence of an invitation and of color on tag visibility.

3.1. Recognition and Knowledge of NFC Tags

From the professional public ($N = 10$: product developers, marketing, R&D), it was discovered that there were practically no implementations of NFC tags on the market or that they had not yet been applied to FMCG products. To enhance familiarity with NFC tags in the online survey, graphic and substantive questions about element recognition and knowledge were included. The segmentation of the participants in all phases of the investigation is shown in Table 1 (online survey: $N = 164$, interviews and eye-tracking: $N = 34$, focus groups: $N = 50$). Simultaneously, it was possible to see how many participants recognized the NFC tag and how many knew it according to their level of knowledge or age (generation).

For the research question on whether the NFC tag was well-known among consumers, a chi-square test was conducted to assess recognition and knowledge of the NFC tag. The results indicate that 71.2% (141) of the participants recognized the displayed elements, while 28.8% (57) did not. The chi-square test shows a statistically significant difference between the groups (chi-square = 35.636; p -value = 0.000). Regarding knowledge, it was

found that 53.5% (106) of all respondents in groups 1 and 2 were familiar with the term NFC, while 46.5% (92) were not (Table 2). The results of the chi-square test show no statistically significant differences regarding knowledge of NFC tag. Based on the data shown above, it can be concluded that customers did not know the NFC tag well, but they were familiar with it.

Table 2. NFC tag knowledge in general and by group segmentation.

Knowledge and Recognition for Group 1 and Group 2								
	(in %)	Below Level 5	Level 5 and 6/1	Level 6/2 and Above	BB	X	Y	Z
Recognition of NFC	75.7	71.4	73.9	65.4	2.5	14.1	28.3	26.3
Knowledge of NFC	58.1	40.0	57.5	53.8	2.0	11.0	21.7	18.7

Regarding the relation between the respondents' education level and their recognition of NFC tags, it was observed that most respondents recognized the shown element regardless of their level of education. Recognition levels were highest in the groups with high school and bachelor's degrees (level 5 and 6/1), with 73.9% (82), followed by primary school or lower (below level 5), with 71.4% (25), and master's degree and higher (level 6/2 and above), with 65.4% (34). The results of the chi-square test of equal probability (chi-square = 1.246; p -value = 0.536) indicate no statistically significant differences in the recognition of the displayed images among the respondents based on their education level. When knowledge was taken into consideration, the result was similar. The greatest knowledge of NFC tag was found in the group with a level of education between 5 and 6/1 (57.5%/47), followed by respondents with a level of education between 6/2 and higher (53.8%/24) and by respondents with levels of education below 5 (40.0%/21). The results of the chi-square test of equal probability (chi-square = 3.338; p -value = 0.188) also show no statistically significant differences in familiarity with the term NFC among the respondents based on their level of education. Based on both calculations, it can be concluded that participants with a master's degree or higher education did not possess better knowledge of the NFC tag compared to others. Therefore, based on this analysis, we can infer that higher education (master's degree) does not necessarily make individuals more familiar with the NFC tag.

From Table 2, it can be seen that there were no significant differences in recognition and knowledge between generations Y and Z. Recognition levels among members of Generation Y were 28.3%, while recognition levels reached 26.3% among members of Generation Z. Knowledge among members of Generation Y attained 21.7%, while it reached 18.7% among members of Generation Z. It is shown that 75.7% (56) of millennials recognized the NFC tag; in contrast, 24.3% (18) did not. The chi-square test results, looking only at Generation Y, showed (chi-square = 19.514; p -value = 0.000) that there were statistically significant differences in the millennial group. With regard to the knowledge of the tag, the results show that 58.1% (43) of the surveyed millennials were familiar with the concept of NFC, while 41.9% (31) were not. Chi-square tests show (chi-square = 1.946; p -value = 0.163) that there were no statistically significant differences in the group of the millennials. In this case, since knowledge is more important, it can be concluded that the NFC tag is not well-known among millennials (Generation Y).

Only 17.2% of the customers used NFC technology for payment, 15.2% for information access, and 7.6% for both. According to the data, we can confirm that NFC tags are rarely used by consumers, a fact which is also supported by the market's low application rate and by the availability of active tags on FMCG products at the moment.

3.2. Design Implementation of NFC Tags

For the design implementation of the NFC tag, various combinations were used in the online survey to analyze the trend of NFC tag placement. For the familiar packaging (Alpsko), six different displays were analyzed where the NFC tag was combined with the

existing logo (Figure 1). Respondents were asked to choose between two layouts (A and B, D and E, G and H). Further, for both the familiar packaging (Alpsko) and the fictitious packaging (Natalis), only different positions of NFC tags in the layout were evaluated (Figure 2).



Figure 1. NFC tag positions in combination with the logo on the familiar packaging: (A) NFC tag center right; (B) NFC tag bottom right; (D) NFC tag bottom right; (E) NFC tag bottom left; (G) NFC tag bottom left; (H) NFC tag center right.



Figure 2. NFC tag positions (left) and heat maps (right).

The well-known packaging (i.e., Alpsko) carries brand recognition that could influence the respondents' perceptions and reactions. By including a non-existing design (i.e., Natalis), we aimed to control for this bias and observe how participants engage with the NFC tag placement when they have no pre-existing association with the brand. This allowed for a more objective analysis of visual attention and tag recognition.

The majority of responses in the online survey indicated a preference for the bottom left position, suggesting that the research question asking whether NFC tags were more visible to consumers on the package's bottom right side may encounter challenges. Respondents most commonly chose the bottom left position (Table 3). Analyzing the heat map from the eye-tracking measurements (Figure 2), it can be seen that the most visible position for the familiar packaging was center right, while, for the fictitious packaging, it was the bottom right. In the online survey, respondents chose a position without interacting directly with the packaging, while the eye-tracking method simulated real-life engagement with the product. The survey might reflect how users are accustomed to interacting with familiar packaging (such as Alpsko), leading them to choose locations where they think the tag should be placed. While the survey captured conscious preferences, eye-tracking captured subconscious, real-time visual behavior, revealing where the attention naturally gravitated without the influence of prior expectations.

In the survey, we used a consistent layout, only changing the position of the NFC tag to minimize the effect of some parts of the screen not being equally noticeable and relying on eye-tracking technology to identify areas of interest across different packaging designs. In future studies, we plan to introduce more templates with modified layouts of the boxes

to assess whether different configurations impact the visibility and perception of NFC tags. This will provide a more comprehensive understanding of how layout influences consumer interaction with packaging.

Table 3. Choice of NFC tag position from different layout combinations from the online survey.

Packaging	Bottom Right (%)	Bottom Left (%)	Center Right (%)	Center Left (%)
Alpsko with logo and NFC tag (A and B)	67.1	/	32.9	/
Alpsko with logo and NFC tag (D and E)	41.5	58.5	/	/
Alpsko with logo and NFC tag (G and H)	/	57.9	42.1	/
Alpsko with NFC tag (Figure 2)	34.1	39.6	25.6	0.6
Natalis with NFC tag (Figure 2)	30.5	61.6	1.8	6.1

The analysis of the time to first fixation (TFF) and time of fixation duration (TFD) data show that the position “center right” consistently experienced the shortest TFF (1.83 s) and longest TFD (1.12 s) in relation to both designs, indicating that it was quickly noticed and that it held the respondents’ attention for longer. Despite the relatively high standard deviations, the Kruskal–Wallis test confirm (mean rank, Table 4) the ranking, aligning with the average values that suggested that the “center right” was the most visible and engaging position. The research question regarding the visibility of the NFC tag on the package’s bottom right side was addressed through the online survey. The findings indicate that the bottom left position was considered the most favorable location, for both the well-known and the fictitious packaging. Interestingly, the online survey results contradict the eye-tracking findings, with participants favoring the bottom left position as the most suitable for the NFC tag. However, eye-tracking and statistical analysis consistently demonstrated that “center right” was the optimal location for visibility and attention. Therefore, while participant preferences leaned toward the bottom left, objective data show that the center right was the best position for capturing visual attention, leading us to reject the initial assumption that the bottom right was optimal.

Table 4. Eye-tracking results in relation to NFC tag position.

Position	TFF					TFD				
	N	Mean (in s)	SD (in s)	Mean Rank	Rank	N	Mean (in s)	SD (in s)	Mean Rank	Rank
L bottom	129	2.37	1.65	232.92	3	136	0.79	0.55	0.55	3
R center	128	1.83	1.56	185.82	1	137	1.12	0.76	0.76	1
R bottom	138	2.18	1.43	224.59	2	138	0.81	0.57	0.57	2
L center	50	2.79	1.10	288.20	4	50	1.04	0.65	0.65	4

R—right, L—left, SD—standard deviation, s—seconds.

In the graphic layout shown in Figure 3, the NFC tag is presented with and without an invitation to interact with the tag, as well as in two colors, blue and green. In order to promote interactive behaviors, the following text was added to the label: “more about the origin of milk and its production can be found here”. Looking at the heat map of NFC tags based on color and presence or not of an invitation (Figure 3) for both packaging designs (Alpsko and Natalis), the tag in a distinctive (contrasting) color with an invitation was the most visible. The visibility of the graphic element was primarily due to the high contrast between the background and the tag. It is logical that the blue color blended with the background, making it less noticeable. Empirically, the NFC tag was also seen earlier when presented with an explanation or an invitation, at least from the perspective of our results (Table 5). With respect to the time to first fixation, the tag with the invitation was seen more

quickly, although only by 0.01 s; with respect to total fixation duration, the tag with the invite was observed for longer, i.e., 0.28 s (no invite = 0.63, invite = 0.91). By using the normal distribution test (p -value = 0.000), we proved that the tested data were not normally distributed. The results were analyzed with a t -test, which yielded a p -value = 0.389 in relation to the time to the first fixation, meaning that there were no statistical differences between NFC tags with or without an invitation for the consumer. However, in relation to total fixation time, the p -value was 0.000, and there was a difference between tags with or without an invitation. We also conducted a Mann–Whitney U test, which showed that the mean rank results were consistent (Table 5). Since the level of total fixation is of interest, based on the data, it can be confirmed that NFC tags are more visible to consumers when presented with an explanation or an invitation.



Figure 3. NFC tag with or without an invitation (left) and heat maps (right).

Table 5. Eye-tracking results in relation to the NFC tag with or without an invitation.

	TFF				TFD			
	N	Mean (in s)	SD (in s)	Mean Rank	N	Mean (in s)	SD (in s)	Mean Rank
Invite	60	1.38	0.89	56.04	60	1.53	0.78	68.88
No invite	50	1.56	1.24	54.85	50	0.86	0.52	39.44

Invite—with invitation, No invite—without invitation, SD—standard deviation, s—seconds.

Further investigation was conducted to explore the research question regarding the visibility of NFC tags to consumers when presented with an explanation or invitation and in a distinctive color. Table 6 illustrates the shortest time to the first fixation for an element without an invitation in a distinctive color (1.96 s), suggesting that the color was the crucial fixation element here. On the other hand, the element with an invitation in a distinctive color was observed for the longest duration (1.25 s), followed by the tag with an invitation (0.91 s), the tag with no invitation and in a distinctive color (0.74 s), and the tag with no invitation (0.63 s) (Table 6). The Kruskal–Wallis statistical test was utilized to determine that the fastest noticeable tag was that without an invitation and in a distinctive color (mean rank 78.4), while the longest observed tag was that with an invitation in a distinctive color (mean rank 120.48). This finding supports the research question aimed at observing the total time of fixation in relation to the element.

Table 6. Eye-tracking results in relation to the NFC tag with an invitation and in a distinctive color.

	TFF					TFD				
	N	Mean (in s)	SD (in s)	Mean Rank	Rank	N	Mean (in s)	SD (in s)	Mean Rank	Rank
No invite	30	3.17	2.10	115.18	3	30	0.63	0.40	72.37	4
No invite C	54	1.96	1.59	78.40	1	54	0.74	0.47	84.91	3
Invite C	60	2.11	1.52	84.13	2	60	1.25	0.90	120.48	1
Invite	50	3.18	1.47	123.56	4	50	0.91	0.67	98.61	2

Invite—with invitation, Invite C—invitation in a distinctive color, No invite—without invitation, No invite C—without invitation and the tag has a distinctive color, invitation SD—standard deviation, s—seconds.

Our study provides valuable insights into consumer behavior in a real-world context by examining how these design features perform in relation to familiar and unfamiliar packaging designs. With no brand-related distractions or preconceptions, the fictitious design (Natalis) allowed respondents to focus solely on the design elements, such as the placement and color of the NFC tag, ensuring that their responses were based on the tag's features rather than being influenced by their familiarity with the product.

The study demonstrates the importance of design elements, such as color and placement, when attempting to influence consumer interaction with smart packaging features like NFC tags. The combination of eye-tracking data and survey responses highlights how different aspects, including invitation prompts and color contrast, affect user engagement and tag visibility.

During the focus groups meeting, more than half of the participants (57.0%) placed the NFC tag on the packaging's side. After engaging in a debate about the acceptability of their opinions where they were given more time for contemplation and were offered, possibly, new facts and ideas, their attitude remained unchanged or even became reinforced. The focus groups also suggested that an invitation to interact with smart elements should be included to provide the user with a better understanding of why they should interact with the tag. Additionally, using NFC tags should bring benefits to the consumer, such as immediate gratification, rewards, or discounts. The visual presentation of the tag should be straightforward for quick comprehension. It was also suggested that the tag should be presented in a distinct color on the design to enhance brand engagement and the possibility of product interaction long after the purchase.

Results in brief:

- In terms of element recognition, consumers have noticed the NFC tag, but they do not know what it means.
- Based on the recognition and familiarity analysis, there is no significant difference according to the education level.
- When considering whether to use an NFC tag, approaching the generations Y and Z is recommended.
- Consumers rarely utilize NFC tags also because of their poor market penetration and the presence of few tags on products.
- The NFC tag is most readily visible and observed for the longest period when in the center right position, according to eye movement analysis and statistical processing.
- NFC tags are more visible to consumers when accompanied by an explanation or an invitation and if they are shown in a distinctive color.

4. Discussion

Smart packaging's purpose is to control and convey product quality information in-house to prolong the interaction between the consumer and the product [30]. Many businesses already use smart packaging to provide consumers with more insights into their items and make their purchases more informative. It is gaining popularity, since it allows for more effective product tracking and enhanced communication between producers and

consumers. According to Rundh [4], while exploring supermarket aisles, an individual may be exposed to up to 300 different brands, implying that a product has only a split second to entice a purchase. This is where interaction with smart elements as a means of prolonging the connection with a consumer comes into play.

Because of the low market penetration of the NFC tag, recognition among customers is also low, with just 53.5% in our research recognizing it. Given the low NFC recognition, the most popular smart element, such as QR codes, could be used in conjunction with traditional labels to familiarize consumers with the smart packaging technology, such as NFC, in order to increase trust in products and suppliers [31]. There are still some struggles regarding the perception of NFC benefits to the product packaging and the overall interest in initiating the interaction, although a strong correlation between the NFC sign identification and the overall interest in initiating the interaction exists [32].

Knowledge of NFC does not differ significantly depending on the participants' degree of education, meaning that there are no statistically significant differences among them. According to the findings, members of Generation Y are the most familiar with the NFC tag, accounting for 58.1% of their generation and 21.7% of the total, with Generation Z not far behind, accounting 18.7% of the total. As a consequence, we may conclude that the NFC tag is predominantly known by the younger generations when it comes to NFC technology, as Generation Z is less concerned with privacy than Generation X [33].

When deciding to use the mentioned tag, first, the decision "who is the targeted public" must be made, as well as "what type of activity should be hidden behind the NFC tag", keeping in mind that the consumer prefers instant gratification. Furthermore, various markets have varying levels of understanding and utilization. One example of market disparities is that the Chinese market is more mature for QR codes and NFC tags than the rest of the world; therefore, such technologies are more accepted [34].

The results of our research show that instructions for the visual location of smart elements, such as an NFC tag, are also observed. The position on the side received 57.0% of the votes in the focus groups. Additionally, according to online surveys and measured eye movements, it is recommended to use an activation invitation, which, in the case of an NFC tag, is on the right in the middle of the packaging and in a distinctive color. The research on packaging design revealed that variations in function and color could substantially impact the consumer [35]. According to Ares et al. [36], for consumers seeking particular information such as brand, ingredients, and nutritional information, any visual "pop out" element, such as an NFC tag in a distinctive color, would constitute a purchasing motivation regardless of product type or label design. Furthermore, package designs should be focused on making packaging graphics bright, vibrant, and appealing in order to catch customers' attention and, ultimately, encourage them to buy those goods [37], as data show that the tag being presented in a distinctive color is advantageous. According to the theory of flow, the fringe of consciousness includes vague contextual feelings at the periphery of the focus of attention [38]. In addition to the perception of fluency, consumers will find objects appealing if they are easy to perceive and understand [39], as also pointed out in our focused group where it emerged that invitations to engage with the tag need to be simple and quick to understand. According to Htun et al. [31], smart elements on packaging are perceived as a possibility to add extra information to the conventional information display. A significant relationship between the identifying sign for the NFC and user initiation of the interaction was found by Karpavičė et al. [32], with participants initiating their interaction with printed NFC symbols substantially more quickly than with the blank ones.

NFC technology can be used in food packaging to provide consumers with information about the product, such as nutritional facts, product ingredients, and expiration date. According to Young et al. [34], both QR codes and NFC tags that stimulate a deeper customer involvement with the product are regarded as an emerging supply chain possibility that was mentioned as a 'good to have' [31]. By using NFC technology, food manufacturers can ensure that the information on their packaging is accurate and up to date. Additionally, NFC can be used to track the product's journey from the factory to the store, allowing

companies to monitor the food freshness and quality. Finally, NFC can provide consumers with coupons and other promotional offers related to the product.

Despite the fact that NFC technology is still in its early stages of development, its use will likely increase in the future, particularly in relation to higher value-added products and services. NFC can be utilized for data sharing, data interchange, and information exchange between two NFC-enabled devices, helping demonstrate product authenticity while also promoting customer trust and loyalty.

This study provides empirical data on the low consumer awareness of NFC tags, particularly in the context of food packaging, and highlights generational differences in knowledge (with generations Y and Z being more familiar with the technology). This finding helps clarify market penetration challenges for smart packaging and the need for consumer education in this area. By using eye-tracking technology and focus group discussions, the study identifies the most effective placement of NFC tags on packaging for maximum visibility. This adds practical knowledge to the field of packaging design, offering evidence-based recommendations (e.g., positioning tags in the center right section of the packaging and using distinct colors) to enhance tag visibility and consumer interaction. It also addresses the design considerations necessary for effective tag activation which is valuable for future research and industrial application.

5. Conclusions

NFC technology is gaining popularity owing to its ease of use and features. The results of this study offer valuable insights into the use of NFC tags and their visual implementation which can be advantageous for food manufacturers aiming to improve customer engagement. In terms of NFC recognition and knowledge, participants recognized the element but showed little understanding of what it signifies; also, the segmentation among educational levels showed no significant differences. The generations Y and Z are most likely to use it, a finding which provides an understanding of which consumer group the manufacturer should focus on (segmentation based on age and educational attainment). Consumer awareness and usage still need to be higher, as NFC tags are rarely implemented on products. In order to increase consumer engagement with NFC tags, their logo on food packaging should be in a visually distinct color with a quickly understandable invitation to direct the consumer to use the tag and give them immediate satisfaction. The results of the research recommend placing the element in the center of the right side of the packaging and using the invitation to further stimulate its usage.

Although NFC technology is still in its early stages, the results can be utilized to shape future applications, which are predicted to rise in the future, particularly in relation to products with added value. The study adds to the scientific understanding of consumer behavior related to smart packaging technologies, offering practical insights into NFC tag visibility and providing a framework for future research and industry application. This study provides actionable guidelines for packaging designers and contributes to the body of knowledge on smart packaging technologies by offering evidence-based strategies to improve consumer interaction and awareness of NFC tags, particularly for younger audiences.

RESEARCH LIMITATIONS AND FUTURE RESEARCH

In order to collect as much information and data for research, different approaches that were possible to implement were considered (online survey, interviews, focus groups, eye-tracking measurements). However, due to low market presence, the confirmation of familiarity with NFC tags was limited. When potential participants approached to take part in the study, they were provided with general information about the scope and study objectives, resulting in some declining to participate in the eye-tracking measurement study and in the interviews due to time constraints. The research was restricted to the Slovenian territory. In the future, we would like to conduct a wider-scale poll, geographically, and also look at how the NFC tag performs on other types of packaging.

Author Contributions: Conceptualization, T.Ž. and D.G.-S.; methodology, T.Ž. and D.G.-S.; validation, D.G.-S.; formal analysis, T.Ž.; investigation, T.Ž.; writing—original draft preparation, T.Ž.; writing—review and editing, D.G.-S.; visualization, T.Ž.; supervision, D.G.-S.; funding acquisition, D.G.-S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Slovenian Research and Innovation Agency [Program P2-0213].

Institutional Review Board Statement: Ethical review and approval were waived for this study, due to the study was conducted in accordance with the Declaration of Helsinki. This study involved the use of focus groups and online questionnaires to gather participants' insights into a non-sensitive topic. Both methods that were used were non-invasive and posed minimal risk to participants. This study also involved the use of eye tracking, a non-invasive and minimal-risk technology, to monitor gaze patterns during task performance. Eye tracking does not involve physical contact or pose any harm to participants. Informed consent was obtained from all participants before their involvement, and they were fully informed of the study's purpose, procedures, and their right to withdraw at any time. Personal data were not collected, and all responses were anonymized to protect the participants' privacy. According to institutional and legal guidelines, ethical approval was not required for this minimal-risk research, but all efforts were made to ensure ethical standards were upheld, including data security and participant confidentiality.

Informed Consent Statement: Informed consent was obtained from all subjects involved.

Data Availability Statement: Publicly available datasets were analyzed in this study. This data can be found here: <https://repozitorij.uni-lj.si/IzpisGradiva.php?id=147064&lang=eng> (accessed on 24 September 2024).

Conflicts of Interest: The authors declare no conflicts of interest.

References

- Georgakarakou, C.; Riskos, K.; Tsovakas, G.; Yfantidou, I. What features of green products packaging are more eye catching; an eye-tracking exploratory study about organic agricultural products. *J. Technol. Mark.* **2020**, *14*, 93–124. [CrossRef]
- Gofman, A.; Moskowitz, H.R.; Fyrbjork, J.; Moskowitz, D.; Mets, T. Extending rule developing experimentation to perception of food packages with eye tracking. *Open Food Sci. J.* **2009**, *3*, 66–78. [CrossRef]
- Rebollar, R.; Lidón, I.; Martín Vallejo, F.; Puebla, M. The identification of viewing patterns of chocolate snack packages using eye-tracking techniques. *Food Qual Prefer.* **2015**, *39*, 251–258. [CrossRef]
- Rundh, B. The multi-faceted dimension of packaging: Marketing logistic or marketing tool? *Br. Food J.* **2005**, *107*, 670–684. [CrossRef]
- Keillor, D.B. *Marketing in the 21st Century: New World Marketing*; Praeger: Westport Conn, CT, USA, 2007.
- Mruk-Tomczak, D.; Jerzyk, E.; Wawrzynkiewicz, N. Consumer engagement and the perception of packaging information. *Olsztyn Econ. J.* **2019**, *14*, 195–207. [CrossRef]
- Soars, B. Driving sales through shoppers' sense of sound, sight, smell and touch. *Int. J. Retail. Distrib. Manag.* **2009**, *37*, 286–298. [CrossRef]
- Stephenson, A. Effective Packaging. Explorer Research. 2016. Available online: <https://explorerresearch.com/optimize-your-package/> (accessed on 2 March 2021).
- Wallentin, L. Surprise, or You Will Not Be Seen. Tank. 2017. Available online: <http://www.packagingsense.com/?s=smart+packaging&op.x=0&op.y=0> (accessed on 11 October 2017).
- Nikitina, K.; Melnikova, M.; Biliatdinov, K. Analysis of NFC technology evolution. *Int. J. Open Inf. Technol.* **2024**, *12*, 49–54.
- Escobedo, P.; Bhattacharjee, M.; Nikbakhtnasrabadi, F.; Dahiyaa, R. Flexible Strain Sensor with NFC Tag for Food Packaging. In Proceedings of the 2020 IEEE International Conference on Flexible and Printable Sensors and Systems (FLEPS), Manchester, UK, 16–19 August 2020; pp. 1–4. [CrossRef]
- Fathi, P.; Member, S.; Karmakar, N.C.; Member, S. Potential Chipless RFID Sensors for Food Packaging Applications: A Review. *IEEE Sens. J.* **2020**, *20*, 9618–9636. [CrossRef]
- Badia-Melis, R.; Mishra, P.; Ruiz-Garcia, L. Food traceability: New trends and recent advances: A review. *Food Control* **2015**, *57*, 393–401. [CrossRef]
- Barge, P.; Biglia, A.; Comba, L.; Ricauda Aimonino, D.; Tortia, C.; Gay, P. Radio frequency identification for meat supply-chain digitalisation. *Sensors* **2020**, *20*, 4957. [CrossRef]
- Kapse, S.; Kedia, P.; Kumar, A.; Kausley, S.; Pal, P.; Rai, B. A non-invasive method for detection of freshness of packaged milk. *J. Food Eng.* **2023**, *346*, 111424. [CrossRef]
- Pigini, D.; Conti, M. NFC-based traceability in the food chain. *Sustainability* **2017**, *9*, 1910. [CrossRef]

17. Escobedo, P.; Bhattacharjee, M.; Nikbakhtnasrabadi, F.; Dahiya, R. Flexible Strain and Temperature Sensing NFC Tag for Smart Food Packaging Applications. *IEEE Sens. J.* **2021**, *21*, 26406–26414. [\[CrossRef\]](#)
18. Malik, M.; Gahlawat, V.K.; Mor, R.S.; Singh, M.K. Unlocking dairy traceability: Current trends, applications, and future opportunities. *Future Foods* **2024**, *10*, 100426. [\[CrossRef\]](#)
19. Bieganska, M. Intelligent packaging as a tool in supply chain traceability in the food sector. In *Current Trends in Quality Science—Consumer Behavior, Logistic, Product Management*; Smigielska, H., Ed.; Institute of Quality Science Poznan University of Economics & Business: Poznan, Poland, 2021; pp. 226–236.
20. Alnahhal, M.; Saleem, W.; Salah, B. The impact of emerging technologies of industry 4.0 on sustainability dimensions. *J. Eng. Res.* **2024**; *in press*. [\[CrossRef\]](#)
21. Hassoun, A.; Garcia-Garcia, G.; Trollman, H.; Jagtap, S.; Parra-López, C.; Cropotova, J.; Bhat, Z.; Centobelli, P.; Aït-Kaddour, A. Birth of dairy 4.0: Opportunities and challenges in adoption of fourth industrial revolution technologies in the production of milk and its derivatives. *Curr. Res. Food Sci.* **2023**, *7*, 100535. [\[CrossRef\]](#)
22. Li, Y. Analysis of Visual Communication Packaging Design Based on Interactive Experience. *J. Phys. Conf. Ser.* **2021**, *1852*, 022074. [\[CrossRef\]](#)
23. Horská, E.; Nagyová, L.; Šedík, P.; Kielbasa, B.; Krasnodębski, A. Evaluation of Cheese Packaging Graphics Design Using Eye Tracking and Consumer Survey Research. *Int. J. Manag. Cases* **2020**, *22*, 38–45.
24. Fazio, M.; Reitano, A.; Loizzo, M.R. Consumer preferences for new products; eye tracking experiment on labels and packaging for olive oil based dressing. *Proceedings* **2021**, *70*, 59. [\[CrossRef\]](#)
25. Husić-Mehmedović, M.; Omeragić, I.; Batagelj, Z.; Kolar, T. Seeing is not necessarily liking; advancing research on package design with eye-tracking. *J. Bus. Res.* **2017**, *80*, 145–154. [\[CrossRef\]](#)
26. Clement, J. Visual influence on in-store buying decisions; an eye-track experiment on the visual influence of packaging design. *J. Mark. Manag.* **2007**, *23*, 917–928. [\[CrossRef\]](#)
27. Kovačević, D.; Brozović, M.; Možina, K. Do prominent warnings make packaging less attractive? *Saf. Sci.* **2018**, *110*, 336–343. [\[CrossRef\]](#)
28. Orquin, J.L.; Mueller Loose, S. Attention and choice; a review on eye movements in decision making. *Acta Psychol.* **2013**, *144*, 190–206. [\[CrossRef\]](#) [\[PubMed\]](#)
29. Oliveira, D.; Machín, L.; Deliza, R.; Rosenthal, A.; Walter, E.H.; Giménez, A.; Ares, G. Consumers' attention to functional food labels: Insights from eye-tracking and change detection in a case study with probiotic milk. *LWT-Food Sci. Technol.* **2016**, *68*, 160–167. [\[CrossRef\]](#)
30. Alizadeh, A.M.; Masoomian, M.; Shakooie, M.; Zabihzadeh Khajavi, M.; Farhoodi, M. Trends and applications of intelligent packaging in dairy products: A review. *Crit. Rev. Food Sci. Nutr.* **2021**, *62*, 383–397. [\[CrossRef\]](#) [\[PubMed\]](#)
31. Htun, N.N.; Wiśniewska, A.; Nocella, G.; Santa Cruz, E.; Peracaula-moner, A.; Vehmas, K.; Hakola, L.; Liczmanska-Kopcewicz, K.; Bridgett, D.L.; Vebert, K. Smart tag packaging technologies: A qualitative investigation of consumers' needs and expectations. *Packag. Technol. Sci.* **2023**, *36*, 595–613. [\[CrossRef\]](#)
32. Karpavičė, J.; Hafith, I.A.; Tambo, T.; Chinello, F.; Venytė, I.; Gegeckienė, L. Experimental approaches to NFC-enabled packaging for UX/CX of physical artefacts: A technology maturity study. *Procedia Comput. Sci.* **2023**, *219*, 577–585. [\[CrossRef\]](#)
33. Agárdi, I.; Alt, M.A. Do digital natives use mobile payment differently than digital immigrants? A comparative study between generation X and Z. *Electron. Commer. Res.* **2024**, *24*, 1463–1490. [\[CrossRef\]](#)
34. Young, E.; Miroso, M.; Bremer, P. A conceptual model for food industry views on the commercialisation of active and intelligent packaging. *Packag. Technol. Sci.* **2023**, *36*, 905–925. [\[CrossRef\]](#)
35. Hidayatno, A.; Komarudin, E. Eye-tracking research methodology for the planograms of supermarket shelf that draw shopper's visual attention: Case study in shampoo packaging. In *Proceedings of the Proceeding, International Seminar on Industrial Engineering and Management, Bali, Indonesia, 10–11 December 2009*; pp. A12–A19.
36. Ares, G.; Giménez, A.; Bruzzone, F.; Vidal, L.; Antúnez, L.; Maiche, A. Consumer Visual Processing of Food Labels: Results from an Eye-Tracking Study. *J. Sens. Stud.* **2013**, *28*, 138–153. [\[CrossRef\]](#)
37. Adam, M.A.; Ali, K. Impact of Visual Packaging Elements of Packaged Milk on Consumers Buying Behavior. *Interdiscip. J. Contemp. Res. Bus.* **2014**, *5*, 1–45.
38. Csikszentmihalyi, M.; Csikszentmihalyi, I.S. *Optimal Experience: Psychological Studies of Flow in Consciousness*; Cambridge University Press: Cambridge, UK, 1988.
39. Reber, R.; Schwarz, N. The hot fringes of consciousness: Perceptual fluency and affect. *Conscious. Emot.* **2002**, *2*, 223–231. [\[CrossRef\]](#)

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.