Heliyon 9 (2023) e17239

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Which visual elements on packaging affect perceived credibility? A case study of in vitro diagnostic kits

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ARTICLE INFO

Keywords:
Perceived credibility
Packaging design
Visual element

ABSTRACT

With increasing public health awareness and the unprecedented global health crisis, consumers' demand for in vitro diagnostic (IVD) reagents is gradually increasing. However, consumer mistrust remains a significant barrier to purchasing and using IVD products. Pharmaceutical companies and governments prioritizing direct-to-consumer (DTC) marketing have recognized the impact of visual packaging elements on consumer perception. Thus, we researched whether visual packaging elements systematically influence consumers' perceived credibility of IVD products' credence attributes, namely, their ability to protect personal and public health. Combining previous related studies, this study was conducted experimentally with rapid diagnostic test (RDT) kits, assuming that the visual elements (i.e., typeface, color, pattern, and information) of packaging can influence consumers' perceived credibility of RDT kits and explored which elements are more credible. Questionnaires were randomly selected and assigned to 216 participants. The results indicated that all four elements influenced the participants' perceived credibility. Specifically, a sans serif typeface, realistic pattern, chromatic color, and more information made the participants feel more credible. Our research results fill a gap in the consumer perception of over-the-counter (OTC) pharmaceutical products by providing new insights into dissecting consumer perceptions. This offers a novel design strategy for online and offline marketing and promotional efforts by different companies and governmental organizations.

1. Introduction

In contrast to laboratory diagnostics, in vitro diagnostic (IVD) reagents are characterized by ease of use and rapid results [1] and are becoming an essential component of the healthcare industry. In particular, during the coronavirus disease 2019 (COVID-19) pandemic, the importance of rapid detection and early disease diagnosis has been emphasized [2]. Rapid diagnostic tests (RDTs) have become a critical component in the overall prevention and control strategy for COVID-19 and contact tracing to break chains of transmission [3]. A survey of employees of a US media company revealed that, for personal and public health protection, 71% of participants preferred daily at-home antigen testing with RDT kits to weekly PCR testing [4]. However, most participants reported that trust in the test was based primarily on trust in the institution providing the test rather than in the product [4]. The inconsistency between consumers' preferential attitudes toward IVD reagents and their behavior of reduced purchase and use due to distrust is one reason that prevents consumers from purchasing and using IVD reagents, which is not conducive to the achievement of overall prevention and control strategies.

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https://doi.org/10.1016/j.heliyon.2023.e17239
Received 1 December 2022; Received in revised form 4 June 2023; Accepted 12 June 2023
Available online 13 June 2023

Consumers' perceived credibility influences their trust and, consequently, their behavior. This study focuses on consumers' perceived credibility of the credence attributes of IVDs (e.g., protection of personal and public health [5]). According to the search, experience, and credence (SEC) framework of product or service attributes in the field of economics of information (EOI), credence attributes are characteristics that cannot be substantiated even after consumption or use [6]. IVDs are over-the-counter (OTC) medical devices, and information asymmetry due to a lack of technical expertise or practical possibilities leads consumers to be unable to substantiate their credence attributes even after consumption or use; these attributes are usually converted into search attributes in the form of extrinsic factors [5,7]. Consumers often rely on extrinsic factors such as third-party certification labels or other sources (e.g., packaging) to perceive products because they lack expertise or practical possibilities and need more information from companies [8]. However, in general, consumers are less likely to pay attention to more detailed descriptions (e.g., positive judgment values or reference intervals, product stability) and are more likely to make purchase decisions based on the small amount of information displayed on the primary display panel (PDP), such as the product name, decorative patterns, and packaging color [9,10].

Research confirms that visual packaging elements such as typeface [11,12], color [13,14], patterns [15,16], and messages [17,18] affect consumer perceptions. In addition, the expectations generated by packaging can also impact consumers' purchases; consumers reject products with low expectations, while high expectations may lead them to choose products [19]. It can be said that packaging design is an important means of companies' direct-to-consumer (DTC) marketing and is a bridge between companies and consumers [20]. Consumers are more willing to buy goods they trust and are more willing to pay premiums for them [21]. Companies need to enhance consumers' perceived credibility to maximize their benefits, which gives them confidence in corporate communications and claims.

To ensure that consumers receive accurate information about IVD reagents, national regulatory agencies strictly regulate the labeling and display of information in IVD kit packaging [22]. Compared to prescription pharmaceutical products, the promotion of OTC pharmaceutical products has a broader scope, which can be learned from the research results on fast-moving consumer goods (FMCG), food and beverage, and home and personal cases (HPC) [23]. Similarly, the packaging of IVD kits may affect consumers' perceived credibility; however, few studies have addressed the impact of OTC pharmaceutical products on perceived credibility. Specifically, this study argues that the visual elements in packaging may influence consumers' perceived credibility. Therefore, to fill the aforementioned research gaps, we investigated whether the visual elements of packaging systematically influence consumers' perceived credibility of IVD.

DTC marketing models, such as packaging design, are rapidly growing in the pharmaceutical industry (e.g., medical tests and OTC drugs) [20]. Our purpose was to contribute to the discourse on DTC marketing and communication in the pharmaceutical industry, especially in the case of IVD, by analyzing the impact of the visual elements of packaging on consumers' perceived credibility. The findings of this study can also benefit other industries and digital marketing communications (e.g., web pages and application software).

2. Theory

2.1. Consumers' perception of IVD

The literature on the economics of information (EOI) describes the SEC framework, which classifies the attributes of a product or service into search, experience, and credence [24,25]. Studies have shown that consumer decisions are closely related to perceptions, and evaluations of these attributes are perceived and evaluated [26]. Credence attributes are related to health, welfare, safety, and environmental issues; therefore, consumers cannot verify the presence of these attributes even after actual use or consumption (e.g., beneficial to personal and public health) [27]. Trust is a key factor in decision-making because it allows us to rely on the information we receive [28]. Doubts about the credence attributes of products may be greater when consumers perceive uncertainty about the efficacy or safety of products and when they have limited knowledge or experience with the products [29]. For example, the public's reluctance to use IVD reagents may be related to their distrust of the test, which includes a lack of trust in the results [30] and a lack of benefits that can be perceived [31]. However, the test results aid the user's judgment of whether to take precautionary measures. When the user takes precautionary measures, it benefits individual and public health.

Different factors can influence consumers' perceived credibility of IVD. Generally, perception can be considered as an individual's mental impression of a stimulus object (i.e., product or service) and includes four attributes: selectivity, organization, perception depending on the stimulus element, and perception influenced by personal factors [32]. Owing to these four attributes of perception, the information available to consumers about a product or service before purchase varies for different consumers. Information asymmetry causes consumers to require more information before making decisions. Particularly, when the government provides more information on the ability of rapid antigen testing to reduce COVID-19 morbidity and mortality, the public is more likely to undergo RDTs [33]. Some scholars conceptualized the credence attribute as a health benefit of vaccination in previous studies on the perceived credibility of vaccination [29]. In this study, we conceptualize the credence attribute of RDT reagents as the benefit of protecting one's own and public health.

2.2. Consumer's perception of the visual elements on the packaging

Existing consumer experience or information creates expectations, which, together with external factors such as packaging, create expectations that influence consumer perceptions and judgments [19]. Previous research and policy efforts have focused on optimizing the presentation of pharmaceutical product details at the back of the package. In contrast, the front of the retail package label, often

referred to as the PDP, has received less attention, and policies have been far less restrictive than the detailed information on the back of the package. Typically, consumers are less likely to pay attention to detailed descriptions (e.g., positive judgment values or reference intervals, product stability) and are more likely to make purchase decisions based on the small amount of information displayed on the PDP, such as product name, decorative patterns, and package color. Some studies have confirmed that information on PDP significantly increases the likelihood that consumers will end their information search, allowing them to view only information on PDP [34]. Consumers seem to use potentially irrelevant signals from the packaging when judging the attributes of a specific product [35,36]. This phenomenon has previously been described as the "halo effect" associated with consumer products. When certain attributes of a product are unknown, consumers tend to assume that they are similar to the known attributes of the product [37]. This allows consumers to draw conclusions without requiring significant additional resources to collect missing attributes.

Cue utilization theory, further studied and explained for consumer perceptions, was first proposed by Ref. [38] and further refined by Olson & Jacoby (1972), who divided cues into intrinsic and extrinsic cues. Intrinsic cues originate from the product itself and are attributes related to its intrinsic characteristics, including size, shape, material, and taste, which hardly change. Extrinsic cues are extrinsic characteristics related to, but not part of a product, such as the price, brand name, store name, and country of origin. Packaging is a familiar extrinsic cue. Although intrinsic cues are generally weighted heavier because they are deemed more diagnostic and useful, consumers have neither infinite time horizons nor incentives to perform thorough comparative studies before purchase [39]. Extrinsic cues, such as packaging, play an important role when intrinsic information is scarce [40]. In the next section, we discuss some of the extrinsic cues in packaging that consumers may use to determine the IVD's credence attributes.

Packaging is viewed as an item composed of structural, graphic/iconic, and linguistic/informational elements [40] that consumers use as cues. Among these are structural elements such as material, shape, size, weight, and texture; graphic/iconic elements such as colors, graphics, and patterns; and linguistic/informational elements, including all textual information available on the package and usually related to product information (e.g., flavor, nutritional content, brand name) [40]. This study focused on RDT reagents sold in kits and did not investigate the effect of package shape on the participants' perceptions. As the experiment for this study was completed online, it was difficult to describe the package materials and sizes; thus, this information was not shown. Furthermore, the impact of branding on the participants' perceptions, including brand names and logos, was not considered because this study was not intended to examine individual RDT kits. Our primary focus is on four key visual elements: typeface, color, pattern, and information. These four elements constitute a typical RDT kit packaging, as seen in Fig. 1, which includes headlines, decorative patterns, relevant information, and primary colors.

Consumers typically believe that a product's attributes are inherent in the product itself, such that high-quality products always provide top-notch services regardless of appearance [41]. However, a significant body of research has shown that consumer perception is influenced by information beyond the product itself, such as packaging design, brand name, price, and so on [42–44]. Indeed, a product's extrinsic cues can significantly affect consumer perceptions. These extrinsic cues consist of information that is not physically part of the item but is related to the product. Research on consumer perception should be conducted in a broader context and consider factors beyond the quality of the product itself.

We focus on visual cues in packaging and, based on previous research by scholars, combined with the current study's division of visual elements in the packaging of RDT kit. This paper will discuss four visual packaging elements: typeface, color, pattern, and information. These four elements may affect consumers' perceptions.

2.2.1. *Typeface*

Most typefaces used in print and display screens fall into two categories: serif and sans-serif. Serif typefaces have short decorative lines at the beginning or end of letter strokes, whereas sans-serif typefaces lack decorative lines. In graphic and interface design, one of the most important issues regarding these two typefaces, in terms of user perception, is their impact on readability and legibility. Research has shown that serif typefaces have better readability and legibility in print than sans-serif typefaces [45]. However, on display screens, this advantage of serif typefaces is weakened, and sans-serif typefaces exhibit higher readability and legibility than serif typefaces [46]. However, some studies found that differences in user perception between these two typefaces are minimal, with no statistically significant differences between them [47,48]. These findings may be attributed to factors such as the user's age [47],

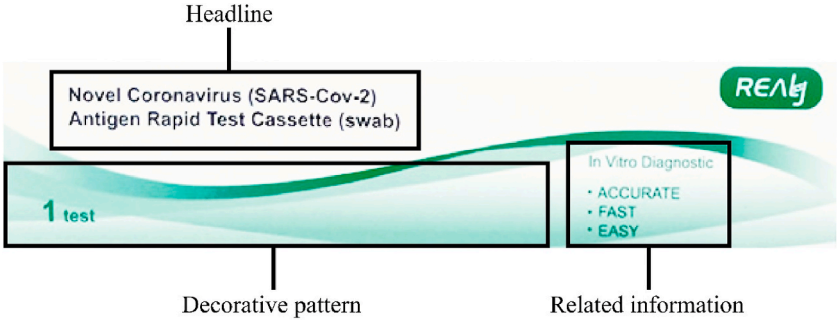

Fig. 1. Four visual elements constitute a typical RDT kit packaging, including the headline, decorative pattern, and related information, and the primary color is green.

gender [49], and the language of the text used [47].

In marketing, the typeface used in marketing materials can also impact consumers' perceived credibility of the brand and product [12]. Typefaces have personalities and convey different moods; specifically, sans serif typefaces appear friendly and personal, whereas serif typefaces appear professional and formal [50]. The association between different emotions and typefaces influences consumer perceptions. However, the effectiveness of typefaces is influenced by whether the connotations they produce are consistent with the product's extrinsic cues [51]. When the typeface does not match the product's extrinsic cues, consumer perception of consistency suffers, and the product loses consumer trust [11]. In contrast, while a stimulus with congruent meanings across cues can facilitate a feeling of trust [52]. Previous research has suggested that when a product is considered utilitarian, serif typefaces can enhance consumers' evaluations [53]. Therefore, this study posits that the typeface used in the packaging of RDT kit similarly affects consumers' perceived credibility. It was hypothesized that a more professional and formal serif typeface, which is more congruent with RDTs, is associated with higher perceived credibility than a sans-serif typeface.

2.2.2. Color

The material world contains waves of light of different wavelengths rather than colors. Colors are perceived by observers and represent secondary qualities of matter that do not reflect the true properties of objects [54]. The psychological impact of colors and their relationship with emotions has long been debated in research. The first school posits that the impact of color is innate or instinctual [55], whereas the second argues that it is learned or associated [56]. The third school of thought suggests that instinct and association jointly influence people's reactions to stimuli [57]. Although specific studies on color and emotion differ in focus, conclusions regarding the impact of color remain consistent. People's choices of color-emotion pairings are the same and remain consistent across different cultures [58].

There are many ways to classify colors. One classification method divides colors into chromatic and achromatic colors based on whether they possess a hue [59]. Black, white, and grey are the most common achromatic colors that vary only in brightness [59]. In addition to these achromatic colors, colors such as blue, red, and yellow are combinations of hues and brightness [59]. In research on chromatic and achromatic colors, some studies investigated participants' physiological responses during visual tasks involving chromatic and achromatic targets [60]. In contrast, others examined participants' preferences and evaluations of chromatic and achromatic color schemes [61].

Color is an indispensable element in company and marketing communication, and its impact on consumer preferences is a key area of marketing research [62]. It induces consumers' emotions, affects their perception [14] and behavior [63], and helps companies position themselves and stand out from the competition [62,64]. Generally, blue, a low-wavelength color, is associated with calmness, relaxation, and positive emotions [65] and is linked to trust, intelligence, communication, efficiency, responsibility, and logic [66]. Blue evokes associations with the sky and sea that may be positively evaluated [67]. Achromatic colors, on the other hand, such as black, white, and grey, are considered neutral and unemotional [68]. It has been suggested that black-and-white images increase the psychological distance between people and objects [69], whereas consumers may perceive products without colorful packaging as less realistic. For example, black was used to convey warnings that could lead to participants' perceptions of risk [70]. However, although colorful packaging draws more visual attention, it has an emotional impact comparable to colorless packaging [13].

Blue is the most common chromatic color used in packaging for IVD reagents, and the preference for blue is referred to as the "blue phenomenon", wherein people are more likely to choose blue when asked to name a color [71]. This study hypothesizes that the blue phenomenon also exists in consumers' perceptions of RDT kits and that people perceive blue RDT kits as more credible than achromatic RDT kits.

2.2.3. Pattern

The purpose of images is to convey information, provide instructions, and prepare for human memory retention [72]. Patterns serve as graphic/iconic elements in packaging and establish extrinsic cues for consumer perception [73]. The impact of patterns on consumers is influenced by visual complexity and activation of emotions and preferences.

Visual complexity is the degree of difficulty in providing a language description of a pattern [74]. It is a crucial source of information processing for consumers in the retail environment [75]. Generally, as the pattern style becomes more concrete, an increase in the number of visible objects [76], details, asymmetry of object arrangement [77], and irregularity increases visual complexity. Low-complexity stimuli lead to higher fluency, and fluency processing triggers positive emotions [78]. Consumers prefer patterns with positive emotional values over neutral or negative ones [79]. That is, compared with high-complexity and negative emotional value patterns (i.e., realistic patterns), consumers prefer low-complexity and positive emotional value patterns (i.e., abstract patterns).

During the selection process, consumers use these cues to infer product attributes both consciously and unconsciously [16]. Packaging patterns can potentially influence consumer attitudes and behaviors toward a product [15]. Patterns that enhance positive emotions in consumers can increase their desire to purchase a product and affect their cognitive and affective responses [72].

Based on previous studies of the effects of visual complexity and emotional activation of patterns on consumer cognition and perception, this study hypothesizes that consumers perceive patterns with low visual complexity and low emotional value (i.e., abstract patterns) to be more credible than those with high visual complexity and high emotional value (i.e., realistic patterns).

2.2.4. Information

One of the most important packaging elements is information [80], and presenting more information in packaging may have a greater impact on a product than other elements [65]. Information on packaging and its sources is positively related to consumer trust [18]. Consumers receive and perceive benefits more effectively if the package information is summarized and carefully designed. The

more consumers know about an objective description, the more comprehensive their perceptions of the product, which influences their perceptions [17]. Research shows consumers are more satisfied when more information is displayed on the packaging [81]. For instance, providing information about a new food product on the packaging can boost consumer acceptance of the new food product [82]. By contrast, a lack of information or poor information design gives rise to obstacles in understanding, which can lead to information silence (i.e., necessary information about the product is not available to consumers) [83]. Therefore, this study assumes that the amount of information presented on a package can influence consumers' perceived credibility and that more information will increase consumers' perceived credibility.

2.3. Research hypothesis

Based on the literature on consumers' perceptions of IVD, it is believed that packaging may systematically impact the consumers' perceived credibility of IVD products. Therefore, we investigated this issue further and compared products with different visual elements in their packaging. Specifically, we examine the effects of typefaces (serif and sans-serif), pattern styles (realistic and abstract), colors (chromatic and achromatic), and information quantity on consumer perception. RDT kits were selected to determine the effects

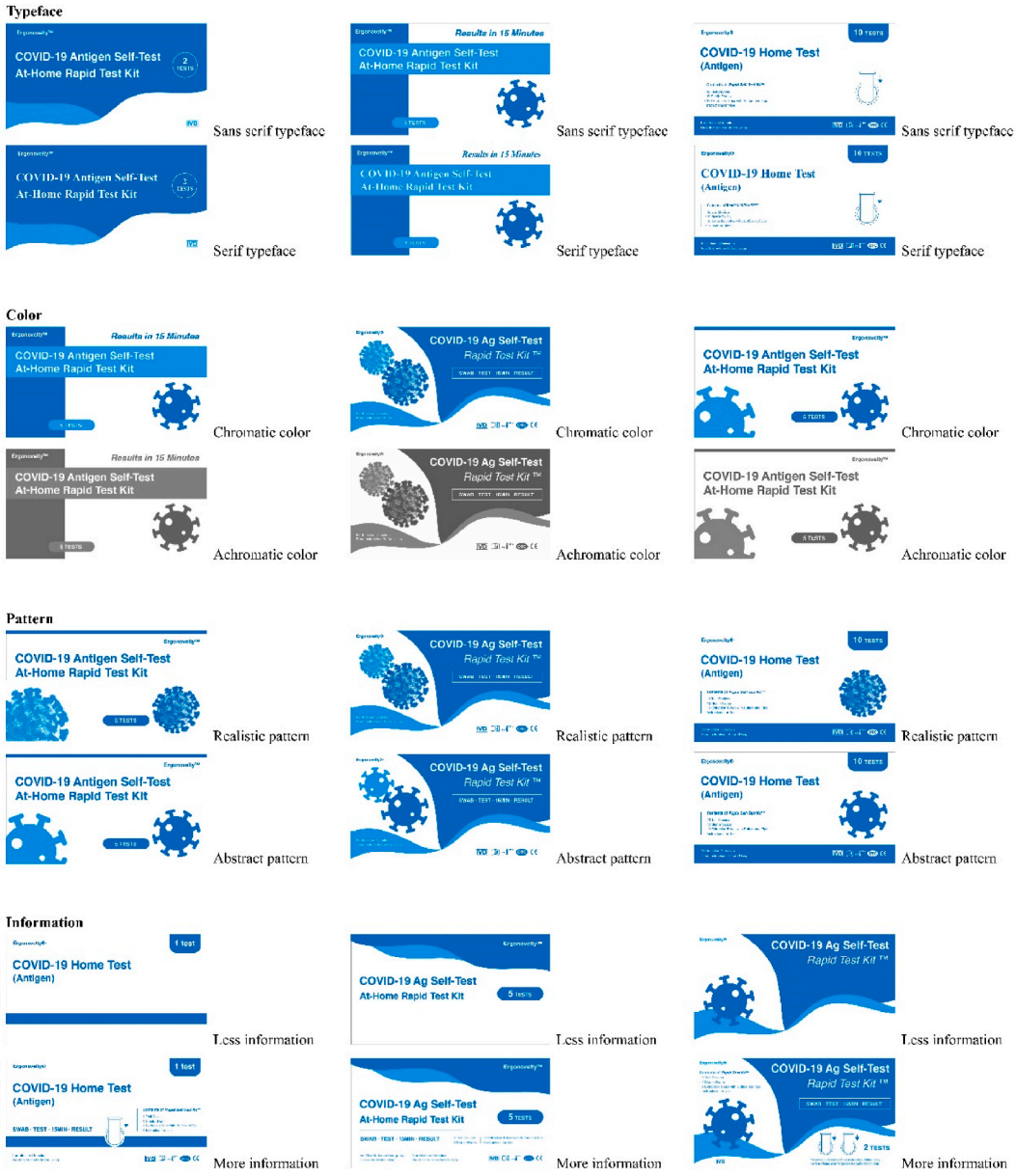

Fig. 2. 12 sets of stimuli.

of the different packaging design options. This study investigated the following four hypotheses.

H1. *Products with serif typefaces on their packaging will be perceived as more credible than products with sans-serif typefaces.*

H2. *Products with abstract patterns on their packaging will be perceived as more credible than products with realistic patterns.*

H3. *Products will be perceived as more credible when the packaging color is chromatic than when the packaging color is achromatic.*

H4. *Products with more information on their packaging will be perceived as more credible than products with less information.*

3. Material and methods

3.1. Participants

The participants were young and middle-aged Chinese individuals who reported normal or corrected vision. The data for this study were gathered through a questionnaire. A total of 249 participants were recruited for this study. Invalid questionnaires (n = 9) were excluded, and n = 24 questionnaires were excluded based on instructed items, resulting in a final sample size of N = 216 (110 males and 106 females). The age range of the participants was 18–60 years, with larger proportions aged 18–25 years (n = 90, 41.7%) and 25–35 years (n = 87, 40.3%). Most participants had used RDTs (regardless of the outcome, including self-testing and helping others with testing) (n = 141, 65.3%), and more than half had used them less than three times (n = 126, 58.4%). The study was explained to the participants before their participation. They were informed that they would participate in the survey anonymously and that all data would be used only for research and teaching purposes. All the participants consented to the survey and received rewards from the questionnaire website.

3.2. Measures

The participants were asked to participate in a market study of RDT kits, which would compare two images of different product packages. They had to rate which of the two products was more credible in protecting their own and public health ("Please rate how credible each product group is in protecting your own and public health"). The ratings were performed using a slider on a continuum ranging from 0 to 100, with scores closer to 0 indicating that the product on the left was more credible and scores closer to 100 indicating that the product on the right was more credible. To avoid an effect of the initial position of the slider, half of the participants saw each group of images in the opposite order as the other half saw them. The participants were asked to rate 12 sets of products, each rating comparing two images of the products. 12 sets of products were randomized across the participants.

The stimuli for each manipulation group were designed after examining the products' typefaces, colors, patterns, and packaging information. Times New Roman and Helvetica were chosen to study typefaces, and participants compared the image of packaging with Times New Roman to the image of packaging with Helvetica. In a study on color, a colorful package with blue and white color matching was designed. Participants compared the image of colorful packaging with the image of colorless packaging after the image of colorful packaging was reduced to grayscale. A realistic pattern provided by the Centers for Disease Control and Prevention Public Health Image Library and an abstract pattern provided by the United Nations was used to study patterns. Participants compared images of packaging with realistic patterns to images with abstract patterns. In the information study, two types of packaging with varying information content were designed. The participants compared the image of basic packaging with less information to that of packaging with more information and instructions for using the RDT kits. To reduce the interference of textual content on perception, all texts in the packaging were chosen in English, considering that the participants were native Chinese speakers. The stimuli are shown in Fig. 2.

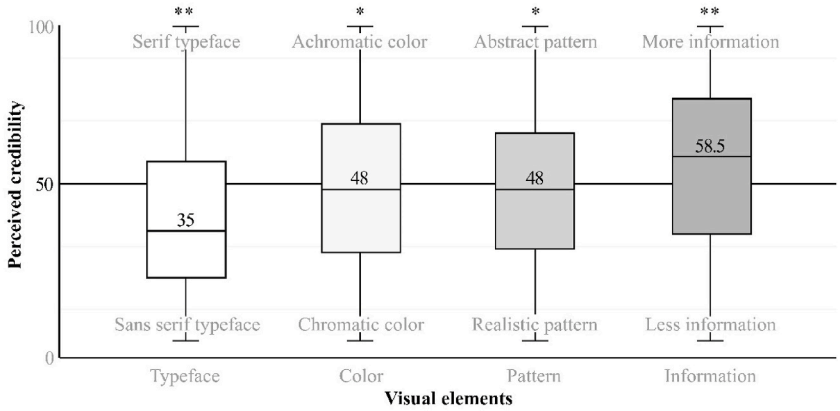

Fig. 3. Box-and-whiskers plot of perceived credibility of each visual element (*p < 0.05, and **p < 0.01).

3.3. Data analysis

To assess the effect of visual elements on perceived credibility, possible differences in the participants' perceived credibility were studied separately for each of the four elements (typeface, color, pattern, and information). In this study, 50 was used as the reference point (i.e., equal perceived credibility of the products), and the sample size was 150. To test whether the difference between the sample mean and 50 was significant, a one-sample *t*-test was conducted using the SPSS software, considering that our sample size of 150 was in line with a normal distribution. The significance level was $\alpha = 0.05$ for all analyses.

To control for individual characteristics that might influence perceived credibility, all specifications (age, gender, and experience with RDT kits; that is, whether the participant has used RDTs and the number of times RDTs have been used) were included as covariates.

4. Results

This section presents the main findings regarding the effect of visual elements on the participants' perceived credibility. Summary statistics are illustrated using a box-and-whisker plot in Fig. 3. Subsequently, the data were analyzed separately for the four visual elements (typeface, color, pattern, and information).

4.1. Typeface

The results of the one-sample *t*-test showed that, participants' perceived credibility between products in packaging using the sans-serif typeface and products in packaging using the serif typeface showed significant difference at the significance level of 1% ($p < 0.01$), $t(216) = -2.557$, Cohen's $d = 0.2009$. Surprisingly, as seen in Table 1, participants judged the product packaging using the sans-serif typeface to be much more credible (38.11 ± 24.43), contrary to H1.

4.2. Color

The main effect of packaging color on perceived credibility was also significant at the 5% significance level ($p < 0.05$) (Table 2), $t(216) = -12.449$, Cohen's $d = 0.97809$. The participants considered products in colorful packaging more credible than those in colorless packaging (47.90 ± 25.96), supporting H2.

4.3. Pattern

The same was true for products packaged with realistic patterns compared to those packaged with abstract patterns, showing significant difference at the 5% significance level ($p < 0.05$) (Table 3), $t(216) = -2.127$, Cohen's $d = 0.16711$. When using realistic packaging patterns, the participants judged the products to be more credible than abstract packaging patterns (47.90 ± 23.56), contrary to H3.

4.4. Information

Finally, a significant difference was found between products packaged with less information and those packaged with more information at the 1% significance level ($p < 0.01$) (Table 4), $t(216) = 5.819$, Cohen's $d = 0.45718$. The participants considered products in packaging with more information to be more credible than the products in packaging with less information (56.06 ± 26.10), supporting H4.

5. Discussion

Owing to increased awareness of health and the influence of the overall environment, IVD has become an important public health intervention [3]. During the COVID-19 pandemic, for personal and public health protection, individuals have shown a greater preference for using RDTs for daily at-home testing as opposed to regular PCR testing [4]. However, most consumers' trust in test results

Table 1
Descriptive statistics for Set 1.

		M (SD)
Set 1	Sans-serif is more credible (0)-Serif is more credible (100)	38.11 (24.43) **
1	Sans-serif is more credible (0)-Serif is more credible (100)	37.19 (23.84) **
2	Sans-serif is more credible (0)-Serif is more credible (100)	38.96 (25.12) **
3	Sans-serif is more credible (0)-Serif is more credible (100)	38.17 (24.39) **

Note: Set 1 represents the total results of the experiment with three typeface manipulations (serif and sans-serif) of the packaging text of the RDT kits, with the next three lines comparing each manipulation. Mean (M) and standard deviation (SD), N = 216. P-values are denoted by *$p < 0.05$, **$p < 0.01$.

Table 2
Descriptive statistics for Set 2.

		M (SD)
Set 2	Colorful packaging is more credible (0)-Colorless packaging is more credible (100)	47.90 (25.96) *
4	Colorful packaging is more credible (0)-Colorless packaging is more credible (100)	46.22 (24.64) *
5	Colorful packaging is more credible (0)-Colorless packaging is more credible (100)	38.96 (25.12) -
6	Colorful packaging is more credible (0)-Colorless packaging is more credible (100)	44.74 (25.73) **

Note: Set 2 represents the total results of the experiment with three manipulations of the color (blue and greyscale) of the RDT kit packaging, with the next three lines comparing each manipulation. Mean (M) and standard deviation (SD), N = 216. P-values are denoted by *p < 0.05, **p < 0.01.

Table 3
Descriptive statistics for Set 3.

		M (SD)
Set 3	Realistic pattern is more credible (0)-Abstract pattern is more credible (100)	47.90 (23.56) *
7	Realistic pattern is more credible (0)-Abstract pattern is more credible (100)	48.41 (24.06) *
8	Realistic pattern is more credible (0)-Abstract pattern is more credible (100)	47.31 (22.91) -
9	Realistic pattern is more credible (0)-Abstract pattern is more credible (100)	47.39 (23.79) -

Note: Set 3 represents the total results of the experiment with three pattern manipulations (realistic and abstract) on the RDT kit packaging, with the next three lines comparing each manipulation. Mean (M) and standard deviation (SD), N = 216. P-values are denoted by *p < 0.05, **p < 0.01.

Table 4
Descriptive statistics for Set 4.

		M (SD)
Set 4	Less information is more credible (0)-More information is more credible (100)	56.06 (26.10) **
10	Less information is more credible (0)-More information is more credible (100)	58.08 (25.54) **
11	Less information is more credible (0)-More information is more credible (100)	55.00 (25.38) **
12	Less information is more credible (0)-More information is more credible (100)	55.08 (27.34) **

Note: Set 4 represents the total results of the experiment with three manipulations of information (more and less) in the RDT kit packaging, with the next three lines comparing each manipulation. Mean (M) and standard deviation (SD), N = 216. P-values are denoted by *p < 0.05, **p < 0.01.

stems from the institutions providing the tests rather than trust in the products themselves [4]. Asymmetric information reduces consumers' perceived credibility, decreasing their trust in IVD. This is one reason that hinders consumers from purchasing or using IVD.

Based on the literature in the field of EOI, which explains the search, experience, and credence attributes of products [5,7], and previous research on vaccine credence attributes [29], this study conceptualizes the credence attributes of IVD as benefits to oneself and society in terms of health through the use of IVD.

Expectancy theory explains the influence of extrinsic cues, such as packaging, on the perception of intermediate expectations [19]. However, in the domain of OTC pharmaceutical products, consumers are more likely to make purchase decisions based on the limited information displayed on the PDP, such as product name, decorative patterns, and packaging color, rather than detailed descriptions of the packaging, such as positive judgment values, reference ranges, and product stability [9,10]. However, previous research and policy work has focused on optimizing the presentation of detailed pharmaceutical product information on the back of packaging [84]. Marketing did not contribute to the role of visual packaging elements in enhancing perceived credibility. Therefore, this study investigates whether the visual elements in packaging systematically impact consumers' perceived credibility.

Given the rapid development of DTC marketing models in the pharmaceutical industry, particularly in the case of medical testing and OTC drugs, this study aims to contribute to the discourse surrounding DTC marketing and communication in the pharmaceutical industry by analyzing the impact of visual packaging elements on consumers' perceived credibility. Specifically, this study focuses on IVD products.

5.1. Theoretical contribution

Given this overarching context, this study aimed to investigate the influence of visual packaging elements on consumer-perceived credibility. Specifically, this study examined consumers' perceptions of the credibility of packaging in protecting personal and public health through a series of RDT kit packaging designs. Packaging is performed using different typefaces, colors, patterns, and levels of information. Therefore, this study contributes to the visual design literature on packaging design and extends DTC marketing literature to the field of visual packaging design.

Our findings indicate that the visual packaging elements' typeface, color, pattern, and information level can impact consumers' perceived credibility. The results of these experiments for color and information are the same as expected and can be confirmed by previous studies on the visual elements of packaging. However, the experimental results for the typeface and pattern were the opposite

of what was expected.

Surprisingly, the participants perceived the sans-serif typeface as more credible than the serif typeface. Considering that the participants looked at the stimuli on the screen, this might have been related to readability. Previous studies on printed materials have shown that serif typefaces are more readable than sans-serif typefaces [85]. In contrast, the readability of the same typeface on the screen differs from that of the printed material. People prefer sans-serif typefaces when looking at them on the screen because the serif typefaces show worse readability [45]. Previous research on rapid malaria diagnostic kits showed general problems with the readability of information in the evaluated rapid malaria diagnostic kit packages [86]. It is evident that the readability of IVD kit packaging has a greater impact on consumer perceptions.

Regarding the effect of packaging color on perceived credibility, a colorless package was rated as less credible than a colorful package. This conclusion may be based on preferences, attractiveness, and readability. Blue is the most commonly used color in the pharmaceutical industry [87]. According to studies on Chinese preferences for seven chromatic colors versus three achromatic colors, Chinese participants prefer blue over any other color [88]. Blue-white is widely adopted in the pharmaceutical industry and in other industries and may form a familiarity preference among consumers, leading to color preference [89]. It is preferable to use the blue color in the packaging design of IVD kits to increase consumer trust. Research on interface design has also shown that reducing color to grayscale impacts user perception and behavior, owing to its reduced attraction [90]. This study demonstrated that this law of attraction also applies to the packaging of IVD kits, where colorful packaging draws participants' attention more than colorless packaging and causes them to choose blue packaging. Another factor influencing the participants' preference for blue is improved readability, which is affected by color combinations [91]. White text on a blue background, such as on screens and billboards, is more readable, for example, on screens [92] and billboards [93]. Although blue can be used as the first option when designing IVD reagents, further research is required to determine whether consumers experience habituation effects when all IVD kit packages are blue.

Regarding the role of patterns in packaging, the results imply that realistic patterns are more credible than abstract patterns. Although this result contradicts our expectations, such a difference can be explained by the fact that the previous study focused on FMCG and HPC. In contrast, while our study focused on OTC medical devices. Differences in the perceptual impact of realistic versus cartoon-style images on users have been demonstrated in human-computer interaction. Salminen et al. [94] investigated participants' perceptions of characters with various styles and discovered that more realistic images increased their trust in the characters while improving their perceived integrity, consistency, and empathy. Cartoon-style characters are also perceived as more attractive, pleasant, and friendly than realistic ones [95]. These results align with research on cigarette package graphics, which found that more realistic and highly emotional graphics increased participants' risk perceptions and evoked negative emotions [96]. In this study, some participants stated that their perceived credibility increased despite their fear of realistic patterns on the package. Therefore, this study speculates that the high perceived credibility of realistic patterns stems from participants' more negative emotions and risk perceptions. Further research should be conducted on the roles of emotion and risk perception in mediating the relationship between patterns and perceived credibility.

As expected, participants perceived products with more package information as more credible. This is consistent with previous studies showing that the more information on a package, the more satisfied consumers are with the product [81]. Displaying summarized product information in packaging will assist consumers in receiving information and increase their sense of benefit [83], resulting in increased trust in the product.

5.2. Practical contribution

The results of this study should be of interest to pharmaceutical companies, particularly those considering DTC marketing through packaging and companies that have not yet prioritized DTC marketing for pharmaceutical products. Packaging has helped companies seek advantages in a competitive market environment and is an important tool in modern consumer product marketing activities [97]. This study offers a novel design strategy to enhance consumer perceptions of the credibility of pharmaceutical companies and strengthen public acceptance of pandemic intervention policies. Enhancing consumer perceptions of credibility has effectively promoted consumer decision-making and usage [98,99]. During the COVID-19 pandemic, the credibility of RDTs is of significant importance to consumers [4]. In addition to common third-party certification labels, our research results demonstrate that the visual elements of packaging can enhance consumers' perceptions of credibility. Adjusting the visual elements is an easily implemented and cost-effective measure. Therefore, this innovative design strategy enables companies to enhance consumer perceptions of credibility simply and economically.

This study provides important insights into consumer perceptions of pharmaceutical companies. Consumers value the credibility of products, but they also require a level of trust before paying a premium for them [21], making credibility a critical indicator for pharmaceutical companies to gain a competitive advantage. For the IVD market, where vertical differentiation is insignificant, leveraging credibility to enhance product differentiation is crucial for companies [21].

Considering the increasing number of IVD products in the market, it is highly beneficial for pharmaceutical companies to understand the design strategies that enhance consumer perceptions of credibility. Specifically, pharmaceutical companies can consider using sans-serif typefaces, blue packaging, realistic-style patterns, and including more information, which have been shown to enhance consumer perception of credibility compared to serif typefaces, achromatic packaging, abstract-style patterns, and less information. Moreover, it is worth noting that enhancing consumer perception of credibility is a common measure in marketing for other products. Therefore, companies in other industries may also benefit from our results.

To enhance consumer perceptions of credibility, typeface, color, pattern, and information quantity can be easily manipulated in offline and online marketing contexts. Visual elements are integral to packaging design and digital tools such as websites, apps, and

social media, which are commonly used for marketing. During the COVID-19 pandemic, digital marketing campaigns have been commonly used to promote public health messages [100]. Consistency in the design elements used in digital tools such as typefaces can increase the public perception of credibility [101]. Therefore, companies and governments should consider the use of visual elements when designing digital communication channels.

Furthermore, public skepticism of online promotional messages is particularly high because of the reliance on online cues to evaluate credibility [102]. Perceptions of credibility heavily influence public trust in online information. Thus, enhancing consumer perceptions of credibility is crucial for gaining public acceptance of promotional information. As consumers rely heavily on marketing cues to assess credibility [103], we encourage companies and governments to use visual elements to enhance the public's perceived credibility and improve the acceptability of their promotional messages.

However, for disease transmission, people prefer packaging with a simple design and low visual complexity in the context of disease transmission [104]. When people face a pandemic threat, their behavioral immune system is activated. Products designed with visual minimalism imply the purity, cleanliness, and sense of niche associated with fewer people, which satisfies their' motivation to defend themselves against disease [105]. Contextual cues associated with a product (e.g., packaging) raise contamination concerns, such as damage to the package's surface (e.g., a folded label) [106]. Therefore, when designing packaging for IVD kits, it is critical to balance the visual elements and the amount of information. More emphasis should be placed on the market potential of a product's minimalist design, particularly in the post-epidemic era [105].

In the present study, we conceptualized perceived credibility as consumers' perceptions of the credence attributes of IVDs in the protection of personal and public health. It is not only consumers' perceived credibility that affects their acceptability and compliance with IVDs, but also their fear of IVDs, distrust of information leakage that may result from uploading test result reports to health authorities, the perception that the testing and handling process is too cumbersome, and lack of understanding of the testing process. Therefore, in addition to improving the perceived credibility of consumers in the design of visual elements, the government should also conduct educational activities to jointly build the trust of lay users in IVDs.

5.3. Limitations and future research

This research is subject to study and has some limitations. One limitation of this study is the use of online panel surveys. Participants were asked to look at the stimuli on screens and complete the questionnaire online rather than in a real shop, so their perceptions were subject to bias; for example, looking at screens may affect their perception of the typefaces. In a real-world store, customers would not only perceive package materials, weight, and so on, but they would also compare multiple products simultaneously rather than pairwise, limiting the generalizability of study findings.

Another limitation is the cultural background. The participants were Chinese people from diverse cultural backgrounds from around the world. The glyphs of each script differ significantly across cultural backgrounds, as do consumer' perceptions of the typefaces. English and Chinese letters, for example, belong to different language families and differ in terms of combination, font style, and literal meaning comprehension [12]. Color perception also differs in this manner. Although some studies have explained the "*blue phenomenon*" [71], a growing body of research suggests that color preferences vary by culture and age. When the existing RDT kit packaging colors were compiled, it was discovered that while products manufactured in China prefer blue packages, those manufactured elsewhere have many red and yellow packages. The effects of culture, age, and daily experiences must be further investigated to enhance the validity of the findings.

It should be noted that there was a correlation between participants' perceptions and preferences, and some participants stated that they did not see a difference between the two images. This suggests that demand effects influenced the participants' perceptions. Although this study attempted to avoid influencing the participants' choices, personal preferences and demand effects may still have influenced their perceptions. Therefore, one such investigation could be the application of additional physiological measures in addition to self-reported data.

Finally, future research could extend the current research by focusing on consumer perception in specific scenarios (e.g., online shopping platforms and stores), examining certain types of visual elements (e.g., packaging colors, images of real people or cartoons, and labels), and researching other elements of packaging design (e.g., materials, shapes, sizes, and textures).

Author contribution statement

Wen Yuan: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Zhanxun Dong: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Jiao Xue: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Lingying Luo: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Yifan Xue: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data included in article/referenced in article.

Declaration of competing interest

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

Acknowledgements

This research was supported by the MOST (Ministry of Science and Technology) of the People's Republic of China (2022YFB3303303).

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.heliyon.2023.e17239.

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