Interactive Infographics and Delivery of Information: The Value Assessment of Infographics and Their Relation to User Response

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Abstract

Background Research related to the design of infographics and to their delivery of information, such as comprehension, recollection, and preference, has long been conducted. However, feeling and comprehending do not account for everything in communication. An effective infographic should be able to induce its user to form positive attitudes and assist them in easily accessing information.

Methods Research related to the design of infographics and to their delivery of information, such as comprehension, recollection, and preference, has long been conducted. However, feeling and comprehending do not account for everything in communication. An effective infographic should be able to induce its user to form positive attitudes and assist them in easily accessing information.

Results We were able to find that reliability, entertainment, and informativeness were the elements of the value assessment that cause change in the user response, with entertainment being the most influential element.

Conclusions We were able to find that reliability, entertainment, and informativeness were the elements of the value assessment that cause change in the user response, with entertainment being the most influential element. As a result of our experiment, we were able to find meaningful conclusions. When we looked at the influence of interaction design types on the value assessment of infographics, infographics with interactions generated more positive evaluations than those without interactions in the aspects of entertainment, reliability, and informativeness. Reliability and entertainment showed meaningful influences on the attitude towards and perceived cognitive effects of infographics, while informativeness showed minimal influence on attitude and showed no influence on cognitive effects. In the case of acceptance intentions, entertainment and informativeness showed meaningful influence but reliability itself did not influence acceptance intentions. Overall, entertainment showed the greatest influence. And entertainment especially showed a very high correlation with perceived cognitive effects.Thus, this study will provide information to people in disadvantaged situations previously excluded from the business world and academia, and facilitate their contributions to the development of 3D printing for design.

Keywords Charts, Information Visualization, Interaction, Infographics

Citation: Won, J. (2018). Interactive Infographics and Delivery of Information: The Value Assessment of Infographics and Their Relation to User Response. *Archives of Design Research, 31*(1), 57-69.

http://dx.doi.org/10.15187/adr.2018.02.31.1.57

Received : Jul. 24. 2017 **; Reviewed :** Nov. 17. 2017 ; **Accepted :** Nov. 17. 2017
pISSN 1226-8046 **eISSN** 2288-2987

1. Introduction

An infographic may be defined as the visualization of data or a concept for prompt and effortless understanding by the user (Smiciklas, 2012). In this age of social media, infographics excel in the generation of interest, direct acquisition of information, and their ability to spread quickly (Jung, 2012). According to research conducted by the Korea Press Foundation on Korean consumers' patterns of news consumption, online portal sites and social media have been gaining their share throughout the last four years, while shares of TV, radio, and newspapers have each declined (Nam et al., 2014). Infographics are a form of information delivery optimized for the characteristics of mobile internet and social media. Therefore, researchers are starting to explore the cognitive effects of infographics on outcomes such as recall and comprehension. Specifically, research on how infographics design elements differ from previous forms of information delivery is gaining momentum. However, not enough research focuses on the capacity of infographics to impact users' attitudes and behaviors. Bateman et al. (2010)'s research shows that decorative elements do not exert measurable differences in comprehension, but we expected there to be a difference in perceived cognitive effect, such that people expect to comprehend the information much easier when presented with infographics. In this research, we propose the following hypotheses to identify the influence of interactive infographic designs on the value assessment of information and the relationship between the value assessment and the user response.

First, Hypothesis 1 relates to elements that can influence the value assessment of infographics: entertainment, reliability, and informativeness.

H1-1: Expression types of interactive infographics will exert positive influences on their entertainment.

H1-2: Expression types of interactive infographics will exert positive influences on their reliability.

H1-3: Expression types of interactive infographics will exert positive influences on their informativeness

Then, Hypothesis 2 relates to the relationship between the elements mentioned above and user responses such as attitude, cognitive effects, and acceptance intention.

H2-1: Infographics' entertainment will exert positive influence on users' attitude, acceptance intentions, and cognitive effects.

H2-2: Infographics' reliability will exert positive influence on users' attitude, acceptance intentions, and cognitive effects.

H2-3: Infographics' informativeness will exert positive influence on users' attitude, acceptance intentions, and cognitive effects.

In order to investigate our hypotheses, we analyzed existing interactive news and divided them into two general types. Then we created experiment samples (see Figure 1) based on these types, and conducted a survey on 252 students. We investigated entertainment, reliability, and informativeness as the elements for the value assessment of information, and then investigated users' attitude, cognitive effects, and acceptance intentions.

2. Theoretical Background

2. 1. The Concept and the Characteristics of Infographics

Through the innovation of digital technology, a great amount of information is being produced, and the development of mobile media has enabled access to information regardless of time or location. Thus, various attempts are being made to present information, and infographics have come into the spotlight lately.

Infographic is a compound word comprised of information and graphic. It is a visual representation of data, which delivers messages concisely. As stated above, the definition of infographics is "the visualization of data or a concept for prompt and effortless understanding by the user" (Smiciklas, 2012). Jung (2012) separated infographics from images and photographs by stating that infographics deliver information in detail, in a practical manner. She emphasized that infographics excel in the generation of interest, direct acquisition of information, and their ability to spread quickly. Infographics are used to turn vast and complex data into simple information that is easy to comprehend for the general public. They are also used as a means of analysis to identify parameters and causal relationship through information (Adams, 2011).

2. 2. The Meaning of Design in Infographics

Edward R. Tufte is the most commonly mentioned name when searching for detailed definitions of infographics. Tufte created the notion of "chart junk," and insisted that graphic elements unrelated to the information have to be eliminated in order to precisely represent the data.

British graphic designer Nigel Holmes is mentioned with an opinion contrary to that of Tufte. He suggested using ample amounts of graphics and design elements in information design. Visual metaphors and quality designs that have deep connections with their content support the subject and make it more attractive, which helps in recollection of the information. Their contrasting opinions were mentioned in various studies afterward. Bateman et al. (2010) set comprehension and recollection as dependent variables, and conducted a verification experiment in order to study the effects of chart junk. Decorative graphs and minimal graphs did not show a significant difference in terms of comprehension. However, the decorative graph received a higher score in comparison to the minimal graph in recollection after two to three weeks. Moreover, the participants preferred the decorative graph.

Haroz et al. (2015) applied pictograms to isotypes and bar graphs, and found that design elements were effective, aided in their recollection, and let participants look into the information in more detail when used as parts of data mapping. However, unnecessary decorative images distracted and confused the participants, acting as chart junk. Thus, it is essential in infographic design to be able to identify chart junk from valuable elements, and to utilize them appropriately.

2. 3. Measuring Value of Information

The expectancy-value theory suggests that the pursued fulfillment is influenced by beliefs and evaluations of media objects (Hyun, 2008). Therefore, importance is now being given to users' emotional evaluations. In gratification of the expectations, satisfaction refers to

the emotional response to the product, which differs from attitude. Satisfaction influences attitude, and is thereby deeply connected with the behavioral intention that follows. When applied in media usage, the relationship between expectations and acquired gratification is linked to satisfaction, which is related to various results regarding usage in media. In satisfaction, emotional values such as satisfaction or dissatisfaction can be involved. Thus, Palmgreen and Rayburn (1982) and Blood and Galloway (1983) insisted that emotional evaluations should be included in the model.

Moon and Kim (2001) identified variables that affect perceived pleasure; Sim (2009) identified variables that affect participation; and Park and Kim (2010) identified variables that affect attitudes such as entertainment, participation, and reliability. DeLone and McLean (1992) measured online service systems' information quality by informativeness and entertainment. Thus, existing studies support the notion that a user's emotional value judgment affects the belief in, and evaluation of, the information in accepting it. Therefore, in this study, informativeness, entertainment, and reliability were used as variables for judging the value of information on the basis of these previous studies.

2. 4. Measuring Value of Communication

The AIDA model, DAGMAR model, Lavidge Steiner model, and McGuire model are representative models of the cognitive information processing of the audience, but the process from the exposure to the information to the action is shown although there is a slight difference in the process. According to the information processing process at the receiver's end, the cognitive stage, which is exposed to information, and the affective stage, which has appeal or desire, leads to the behavioral stage (see Table 1).

Table 1 1Information processing process

	McGuire	Lavidge Steiner	DAGMAR	AIDA
1. Cognitive stage	Exposure	Awareness	Awareness	Attention
	Attention	Knowledge	Comprehension	Interest
	Comprehension			
2. Affective stage	Yielding	Liking	Conviction	Desire
		Preference		
	Retention	Conviction		
3. Behavioral stage	Action	Action	Action	Action

According to this, a user can form an emotion after seeing the infographic, form a secondary attitude based on the emotion, and share and store the information. Therefore, the degree to which users can easily understand information, attitudes toward information, and intention to store or recommend information are all set as communication effect evaluation items.

3. Case Analysis

3. 1. Categorizing the Types of Interactive Infographics

As a part of the exploratory analysis, to understand the expression types of interactive infographics, and to formulate the experiment plan, we planned a case analysis.
The procedure of the case analysis is divided into four steps (see Table 2).

Table 2Procedure of the case analysis

Case Collection	Collection of interactive infographics examples dated before November 11, 2014 USA Today (18 examples) The New York Times (20 examples) Yonhap News Agency (22 examples)
	↓
Curation of Analysis Cards	Printed 60 sets of analysis cards with images and their properties
	↓
Classification of Design Types	Extraction of main design properties through classification, and charting employing the KJ method
	↓
Result	Preparation of the supporting data for the experiment standards

1) Case Collection: First, we searched for examples of interactive infographics dating before November 11, 2014. We collected 10 to 20 examples from each of the following three interactive news media websites by screen-capture or recording: Yonhap News Agency: Graphic Visual News, The New York Times: The Upshot, and USA Today: Interactive Graphics.

2) Curation of Cards for Analysis: We printed 60 sets of A6-size cards that enabled clear analysis of their contents and expressions. Since it was difficult to show all expression methods on one card, we created a set of cards, which consisted many copies of captured images in order to analyze every characteristic of the interaction (see Figure 1).

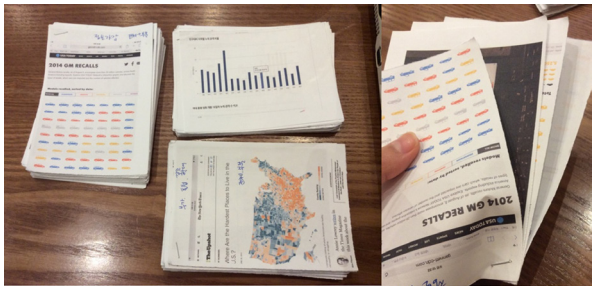

Figure 1 Cards for analysis

3) Classification of Design Types: We categorized and reorganized prepared cards, and recorded our notes of viewing them in different angles and criteria. Various methods of storytelling, colorful videos, and interaction techniques were used (see Table 2). Based on 60

interactive infographic cards, the affinity diagram was used to structure the characteristics of the interaction. We created 60 sentences by describing the interaction characteristics of each card in the post-it. We classified and grouped the statements about each interaction (see Figure 2).

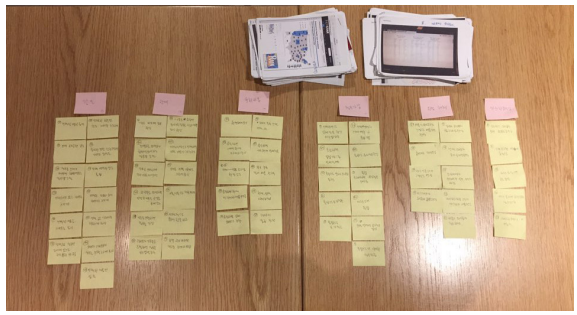

Figure 2 Classification of design types using the affinity diagram

Through our assessment, we were able to divide them into two types: (i) functional expressions that improve the functionality by accentuating and adding information, and (ii) emotional expressions that entertain users and invite their participation. Functional expressions of interactive infographics included functional elements such as adding or subtracting information, accentuating necessary information through interaction, presenting relationships between multiple graphs, and providing selected information in detail through movements or changes in chart types. Emotional expressions included elements such as showing colorful animations—for example, tables put together—and presenting interesting movements without changing the provided information as users interact with them (see Table 3).

Table 3 Analysis of Dynamic Expressions

Types	Expression Characteristics	Examples of Expression Methods
Functional Expressions	Adding /Subtracting Information	– Chart types change when selected (bubble to bar) – Additional information is provided through tooltips – Unselected elements are dimmed or turned off – The shape of graphs changes when the item is selected or changed
	Accentuation	– Selected layered item comes forward – Zoom in – Selected items are colored, underlined, bolded, or bordered
	Relationships	– Values from surrounding charts change depending on the input – Information changes as x–axis slides – Items in the same area (map) can be selected for comparison
	Changes	– Rotations, zoom–ins, and movements – Types of charts change
Emotional Expressions	Completion /Disintegrations	– Lines tangle and scatter – Lines descend and turn into a line graph – Bubbles scatter to complete a graph – Bubbles bounce up to complete a chart – Random rotations/spins before completion of information – Bars rise up to form a graph (when clicked/from the beginning)
	Simple Movements	– Graph bounces when dragged – Fluid movements, simulating underwater movements – Change of graph shapes

4. The Survey: Comparison of Plain Interaction to Functional and Emotional Interactions

4. 1. Participants and Apparatus

The survey was conducted on college students in Seoul and Chungcheong area, from March 24 to April 7, 2014. Of the 260 responses received, we excluded 8 incomplete responses and utilized the remaining 252 in our statistical analysis.

4. 2. Preparation of the Experiment Stimuli

As noted above in our case analysis, we have found two main types of expressions: functional and emotional. We focused on expressions consisting movements or interactions, and did not focus on storytelling, topic, or forms of graphs as they have been extensively studied in preceding case analyses.

We created three variables: functional expressions, emotional expressions, and no movement (see Table 4).

Table 4 Criteria deducted from expression analysis of interactive infographics

Criteria	Expression Methods
Functional Expressions	Selected bar graph's color changes for accentuation and additional information is provided with a tooltip
Emotional Expressions	Playful shape changes are shown on selected bar graph
No Movement	No changes are made upon mouseover

Interactions were triggered when the user hovers the mouse over the human-shaped bar graph (see Figure 3). For functional expressions, new information was presented through a tooltip and the area was accentuated with color. For emotional expressions, the shape of the graph changed playfully, matching the topic of obsessive-compulsive disorder. The control group with no interactions showed no change upon mouseover.

Initial Image Upon Mouseover

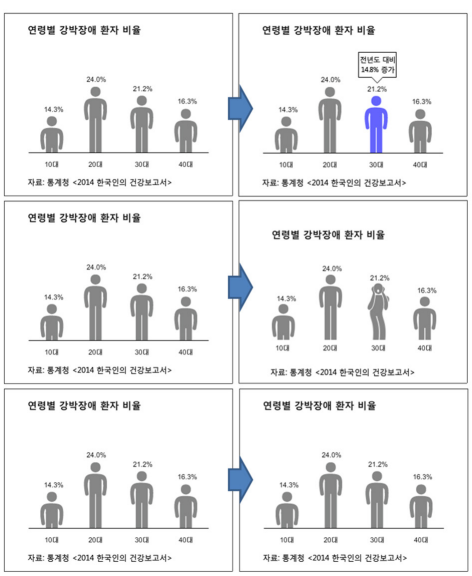

Figure 3 Samples of interactive infographics for the experiment

Top: Functional Interaction / Middle: Emotional Interaction / Bottom: No Interaction

4. 3. Composition of the Survey Items

Referring to prior research on uses and gratifications theory, we picked "entertainment," "informativeness," and "reliability" of infographics as measures that can affect the value assessment of information; and as measures to see the effect of the aforementioned elements to user response, we added "attitude," "cognitive effects," and "acceptance intention" to the infographic (see Figure 4).

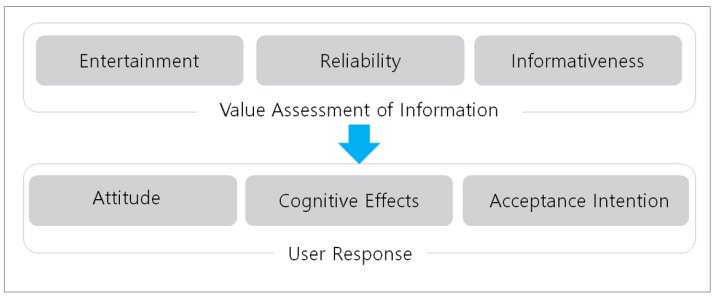

Figure 4 Measures

Part 1: Measures that affect the value assessment of the information

Participants check the interactive infographic samples on the monitor and evaluate their assessment in terms of entertainment, informativeness, and reliability on a 7-point scale. Each measure is defined as follows:

-Entertainment: The amount of enjoyment gained through the infographics

-Reliability: The reliability the user feels about the information portrayed in the infographics

-Informativeness: The amount of social and personal benefits gained through the infographics

Q1–Entertainment: These infographics are interesting.
It was enjoyable to see these infographics.
These infographics are entertaining.

Upon reliability analysis, Cronbach's alpha was at .903, which led us to judge it was suitable for measuring the entertainment element of the infographics.

Q2–Reliability: I can trust these infographics.
These infographics were not exaggerated.
These infographics seem to be true.

Upon reliability analysis, Cronbach's alpha was at .881, which led us to judge it was suitable for measuring the reliability of the infographics.

Q3–Informativeness: These infographics are in-depth.
I find these infographics useful.
These infographics provide information that I need.

Upon reliability analysis, Cronbach's alpha was at .793, which led us to judge it was suitable for measuring the informativeness of the infographics.

Part 2: Value assessment of the information and user response

In order to identify elements that affect value assessment of the information and their relationship to user response, we have defined "attitude," "perceived cognitive effects," and "acceptance intention" as follows:

-Attitude: The extent of positivity or negativity that a user feels to perceived

information

-Cognitive effects: The perceived extent of how well the contents of the infographics are delivered to the user

-Acceptance intention: Intention to accept the information and save, recommend, or share it

Cognitive effects have always been deemed important in research related to infographics, and numerous tests have been conducted to measure them. However, in this experiment, we aimed to measure users' perceived cognitive effects. Also, we have based the survey on advantages of infographics, which include their ease of understanding and eye-catching characteristics.

Q4–Attitude: I like these infographics.
I'm satisfied with the contents of these infographics.
I'm satisfied with the designs of these infographics.

Upon reliability analysis, Cronbach's alpha was at .863, which led us to judge it was suitable for measuring the attitude towards the infographics.

Q5–Cognitive effects: These infographics are easy to remember.
These infographics have clear messages.
These infographics are eye-catching.

Upon reliability analysis, Cronbach's alpha was at .851, which led us to judge it was suitable for measuring the perceived cognitive effects of the infographics.

Q6–Acceptance intention: I'd like to show these infographics to others.
I'd like to share these infographics on social media.
I'd like to download or save these infographics.

Upon reliability analysis, Cronbach's alpha was at .907, which led us to judge it was suitable for measuring the acceptance intention for the infographics.

5. Results

Before verifying our hypotheses, we conducted descriptive analyses for each variable against all infographics stimuli. The user response to the infographics was generally positive, with entertainment having a mean score of 4.480, reliability of 4.206, informativeness of 3.765, attitude of 4.455, cognitive effects of 4.621, and acceptance intention of 3.650 (see Table 5).

Table 5 Descriptive analyses for each variable

Variables	N	Mean	Std. Deviation
Entertainment	252	4.480	1.374
Reliability	252	4.206	1.052
Informativeness	252	3.765	1.041
Attitude	252	4.455	1.257
Cognitive Effects	252	4.621	1.259
Acceptance Intention	252	3.650	1.467

We have also calculated simple correlation coefficients among the main variables measured in this research. As shown in Table 6, correlations among the variables ranged from .332 to .797, showing similar correlations across all variables. Notably dependent variables of this

research—attitude, cognitive effects, and acceptance attention—showed a high correlation to most of the independent variables, partially supporting the legitimacy of the research plan that assumed entertainment, reliability, and informativeness as main independent variables (see Table 6)

Table 6 Correlation among variables

	Entertainment	Reliability	Informativeness	Attitude	Cognitive Effects	Acceptance Intention
Entertainment	1					
Reliability	.332**	1				
Informativeness	.530**	.450**	1			
Attitude	.764**	.594**	.571**	1		
Cognitive Effects	.714**	.489**	.489**	.797**	1	
Acceptance Intention	.612**	.382**	.599**	.585**	.565**	1

**Correlation is significant at the 0.01 level (2-tailed).

5. 1. Types of Interactive Infographics and Value Assessment of the Information

In order to find out how different types of expression in interactive infographics affect the value assessment of information, we conducted an analysis of variance (ANOVA) from the survey results of three groups—functional interactions, emotional interactions, and no interaction.

For the no interaction group, there is no change when you hover over a human-shaped bar chart. Functional interactions provide additional information to the tooltip when the mouse is over, and the selection information is highlighted in blue. In emotional interactions, we see change in the appearance and behavior of a human-shaped bar graph when the mouse is over (see Figure 3). As shown in Table 7, the entertainment element and the type of infographic interaction showed statistical significance ($F = 40.764$, $df = 2.\ 249$, $p < 0.05$). The entertainment element in each group was in the order of L3 > L2 > L1, but through post analysis, we established that all levels show distinct meaningful differences. Thus, "H1-1: Expression type of interactive infographics will exert positive influence on their entertainment" has been supported (see Table 7).

Results of the analysis indicate that the relationship between interaction types and reliability had no positive effect ($F = 3.536$, $df = 2.\ 249$, $p < 0.05$). The P value was 0.031, but the f value did not reach 4, and there was no statistically significant relationship between the groups in the post analysis interactions. Thus, "H1-2: Expression type of interactive infographics will exert positive influence on their reliability" has been rejected (see Table 8).

The types of interaction and informativeness showed statistical significance ($F = 4.942$, $df = 2, 249$, $p < 0.05$). Informativeness for each group were in the order of L2 > L3 > L1, but post analysis showed a distinct significant difference between L1 and L2. Thus, "H1-3: Expression type of interactive infographics will exert positive influence on their informativeness" has been supported (see Table 9).

Table 7 Relationships between Interaction Types and "Entertainment"

Groups	N	Mean	Std. Deviation	F	df	Sig.	Eta-Squared	Comparison Groups
L1: No Interaction	84	3.62	1.25	40.764	2, 249	0.000	0.247	*L1/L2 *L1/L3 *L2/L3
L2: Functional Interactions	84	4.52	1.18					
L3: Emotional Interactions	**84**	**5.29**	**1.16**					

*The mean difference is significant at the .05 level.

Table 8 Relationships between Interaction Types and "Reliability"

Groups	N	Mean	Std. Deviation	F	df	Sig.	Eta-Squared	Comparison Groups
L1: No Interaction	84	4.07	1.05	3.536	2, 249	0.031	0.028	
L2: Functional Interactions	84	4.45	1.15					
L3: Emotional Interactions	84	0.91	0.91					

*The mean difference is significant at the .05 level.

Table 9 Relationships between Interaction Types and "Informativeness"

Groups	N	Mean	Std. Deviation	F	df	Sig.	Eta-Squared	Comparison Groups
L1: No Interaction	84	3.55	1.10	4.942	2, 249	0.008	0.038	*L1/L2
L2: Functional Interactions	**84**	**4.04**	**1.03**					
L3: Emotional Interactions	84	3.71	0.94					

*The mean difference is significant at the .05 level.

5. 2. Value Assessment of Interactive Infographics and User Response

As shown in Table 10, overall, "Reliability," "Entertainment," and "Informativeness" each influence "Attitude" ($F= 212.165$, $df = 3, 248$, $p < 0.05$). After verifying significance levels of individual variables, we have found "Entertainment" to have the most influence on "Attitude," which leads us to accurately predict positive attitude when the entertainment value is high ($\beta = 0.596$). "Reliability" exerts considerable influence on "Attitude" ($\beta = 0.353$). In other words, reliable infographics tend to draw a more positive attitude. "Informativeness" also influenced "Attitude," but its influence was weaker than that of the other two variables ($\beta = 0.096$).

As shown in Table 11, overall, "Reliability" and "Entertainment" influences "Perceived Cognitive Effects" ($F= 114.652$, $df = 3, 248$, $p < 0.05$). After verifying significance level of individual variables, we have found "Perceived Cognitive Effects" to change according to "Reliability" and "Entertainment." However, "Informativeness" does not influence "Perceived Cognitive Effects" ($\beta = 0.003$, $p > 0.05$).

Table 12 shows that "Entertainment" and "Informativeness" influence "Acceptance Intention" ($F = 78.196$, $df = 3, 248$, $p < 0.05$). After verifying the significance level of individual variables, "Entertainment" and "Informativeness" have considerable influence (Entertainment: $\beta = 0.398$; Informativeness: $\beta = 0.345$). "Reliability" showed a low correlation with "Acceptance Intention" ($\beta = 0.095$, $p < 0.05$).

Table 10 Influence of value assessment of infographics on the attitude towards the infographics

	β	t	Sig.	df	F	R^2
Reliability	.353	9.296	.000	3, 248	212.165	.720
Entertainment	.596	14.913	.000			
Informativeness	.096	2.271	.024			

Table 11 Influence of value assessment of infographics on perceived cognitive effects of the infographics

	β	t	Sig.	df	F	R^2
Reliability	.282	6.074	.000	3, 248	114.652	.581
Entertainment	.619	12.670	.000			
Informativeness	.003	0.056	.955			

Table 12Influence of value assessment of infographics on the acceptance intention towards the infographics

	β	t	Sig.	df	F	R^2
Reliability	.095	1.841	.067	3, 248	78.196	.486
Entertainment	.398	7.349	.000			
Informativeness	.345	6.039	.000			

6. Discussion

The purpose of this research was to confirm the communication effect of infographics, which have been gaining popularity through increased usage of social media and mobile devices, and to verify the influence of design elements on information acceptance, which has long been debated since Edward Tufte's conception of the idea of chart junk. Through our experiment, we were able to establish five meaningful conclusions.

- First, when we looked at the influence of interaction design types on the value assessment of infographics, infographics with interactions generated more positive evaluations than those without interactions in the aspects of entertainment, reliability, and informativeness. Emotional interactions recorded the highest scores for entertainment, while functional interactions received high scores in informativeness and reliability.
- Second, reliability and entertainment are shown to have a significant influence on the attitude towards the infographics and perceived cognitive effects of infographics, while informativeness has minimal influence on attitude and no influence on cognitive effects.
- Third, in the case of acceptance intentions, entertainment and informativeness have a significant influence. While reliability is one of the most basic elements in information delivery, reliability itself did not influence acceptance intentions.
- Fourth, overall, entertainment showed the greatest influence, which led us to explore the possibility of greatly changing the effectiveness of infographics information delivery depending on the emotional functions of the design.
- Fifth, while most of the preceding studies have shown minimal influence of design on recognition, in perceived cognitive effects, the design of the interactive infographics was positively correlated to the "reliability" and "entertainment" aspects of the infographic. A very high correlation was especially noted for "entertainment."

This research differs from previous studies on cognitive effects by introducing the form of self-diagnosis through surveys, thereby measuring perceived cognitive effects. This was based on the fact that users of this age actively select, accept, and share information, and we saw that personal judgment played an important role in this process. Preceding studies have shown design to have minimal influence other than in recollection, but in perceived cognitive effects, it influenced reliability and entertainment, especially showing high correlation to entertainment.

Despite the above significance, our study has limitations that need to be addressed in future research. This research was conducted in an environment of desktop monitors, which may differ from the environment of other devices such as smartphones. Furthermore, the respondents were college students in their 20s, so it is not appropriate to generalize these results to the entire population. Thus, in future studies, experiments on various devices targeting a group of respondents comprised of wide demographics would be necessary. While this research focused on simple infographic news for the experiment, we look forward to future studies applying variables that represent various purposes of information delivery such as commercial advertisements or public service announcements.

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