INTERNATIONAL DESIGN CONFERENCE – DESIGN 2024
https://doi.org/10.1017/pds.2024.76

DESIGN 2024

Factors that determine design similarity

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Abstract

In recent years, the importance of design has been pointed out as a source of competitive advantage. However, creating a great design also increases the risk of copy products being created. In this study, we used an approach based on visual information and conducted an international comparative judgment survey of elements considered to be similar within products.

Keywords: design analysis, human behaviour, product design

1. Introduction

This research is an interdisciplinary study of the similarity or imitation of product designs concerning consumer image judgment criteria, the relationship between factors, and cultural background. Do factors determine the similarity in color or shape? How similar must they be to be considered resemblance or imitation? There are no clear standards, and judgment relies on arbitrariness. However, since imitations may become the subject of lawsuits and negatively impact product evaluation, it is crucial for product designers and even engineers to develop products with imitations in mind.

In recent years, the importance of design has been emphasized as a source of competitive advantage. For instance, Roy and Riedel (1997) demonstrate that investment in product design positively influences performance. However, creating a great design also elevates the risk of copy products emerging. In fact, disputes over design rights, trademark rights, etc., related to the imitation or similarity of designs are escalating worldwide. Examples include the Tokyo Olympics emblem issue and the intellectual property battle between Apple and Samsung Electronics. Japan's Design Law states that the effect of a design right "extends to the range that it is the same as or similar to the design to which the design right pertains." Although the Japan Patent Office has examination standards regarding this "similarity," in many cases, the outcome is not clear until a verdict is issued. This complicates matters for those who do not own design rights (followers), making it challenging to judge in advance whether they are similar. Consequently, they are compelled to exercise caution in product development.

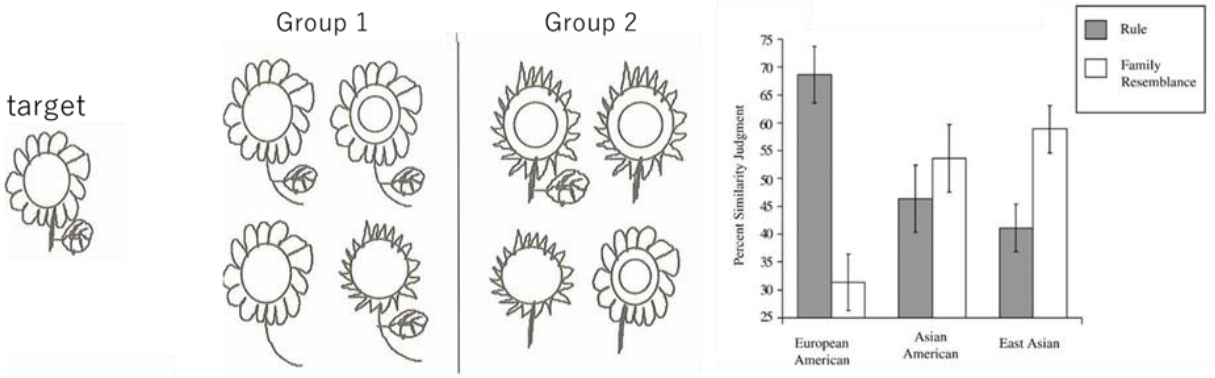
2. Characteristics of previous research and this study

Many studies related to product development focus on development methods, innovation, or design management (Lorenz 1986, Morinaga 2005). However, there are very few studies addressing the processes leading to imitation and similarity of designs and consumer recognition, as discussed in this study, particularly in terms of practical applications. For example, in the case of color trademark registration, a product specified by a color sample or color code is registered, but the question remains, "Can consumers really recognize subtle color differences?" Regarding design, "To what extent do consumers need to be similar enough to judge that they are similar, and mistakenly think that they are the same brand or manufacturer?" This aspect marks the inception of the academic "question" in this

research topic, and the study will develop a hypothesis based on the cultural background. This topic is rooted in the significance and importance of design in product development.
Taking cultural background into consideration shows how similar judgments differ depending on cultural differences of countries and regions. This comparison focuses on Japan and the Netherlands. From Japan's perspective, the Netherlands can be considered a country that has had a distinct influence compared to others, given its historical privilege as "Dejima" during the Edo period. Consequently, it is plausible that a "cognitive habit" has formed due to heightened exposure to design, potentially influencing perceptions of similarity.
How much do judgments of similarity differ between the Netherlands, situated in the West, and Japan, situated in the East?

2.1. Comparison between the West and the East in relation to design

In a cognitive psychological experiment by Imai and Gentner (1997), they found that Japanese people, in comparison to Westerners, exhibit a categorization bias toward non-shape features like color, material, texture, and skin texture, as opposed to visual shape features. This tendency is believed to stem from the Japanese mentality of identifying similarities between things that may not appear alike at first glance (Yamada, 2000). Furthermore, Richard E. Nisbet et al. (2002) have derived many findings from their extensive research on the differences between the "East" and the "West." The experiments that form the basis of this research are introduced below. In the experiment, Koreans and European Americans were shown with the flowers depicted in Figure 1 and were asked to identify which group the target illustration is closer to. Interestingly, Koreans were more inclined to choose Group 1 (Shaded bar “Family Resemblance” in Figure 1), whereas European Americans were more inclined to choose Group 2 (white bar “Rule” in Figure 1).
Group 1 is depicted with a "Family Resemblance" that vaguely resembles the target, but there are no common rules for all illustrations.
Group 2 has "stick-like stems", even though some of them do not resemble the target. Nisbett revealed that Westerners tend to find such "Taxonomic Rules" quickly. In contrast, Easterners are less adept at applying rules to classify things into categories and, instead, focus on the relationship between parts and the whole and the commonality of meaning. The experiment revealed that while Westerners' cognitive structure categorizes the world into things (individuals), Easterners understand the world as relationships among various events.



Norenzayan, A., Smith, E. E., Kim, B. J., & Nisbett, R. E. (2002).

Figure 1. Stimulus map used in the experiment

2.2. Global and local perspective

Visual information is considered to comprise a global area as a whole and multiple local areas that make up the area. Navon (1977) created a stimulus (Navon figure) that simplified this property, and the global area is perceived with priority over the local areas. He proposed the "forest before the trees" hypothesis. Subsequent studies aimed to test this hypothesis. Most of them involve visual search tasks, requiring participants to detect whether a specific letter or geometric figure is present in a global or local area of

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a stimulus, followed by measuring response latency and accuracy (Kinchla & Wolfe 1979; Martin 1979; Navon 1977). Furthermore, there are some similarity judgment tasks (Kimchi & Palmer 1982) in which subjects are asked to select the one that is similar to the reference stimulus from two stimuli that have the same global or local features as the reference stimulus. Murakami (2010) measured observers' visual impressions by asking whether the global or local areas appear more impressive, and this task similarly represents the results of a comparison between the global and local areas.
Therefore, in this study, we aimed to clarify the following issues through exploratory investigation based on these previous studies.

1. What factors determine similarity between the Netherlands and Japan (color, shape and size), and what are the distinctions?
2. Will the similarity judgment for products align with the aforementioned factors?
3. How does global and local orientation in the Netherlands and Japan influence on similarity judgments?

3. Research method

The research design conducted to clarify the above issues is as follows.

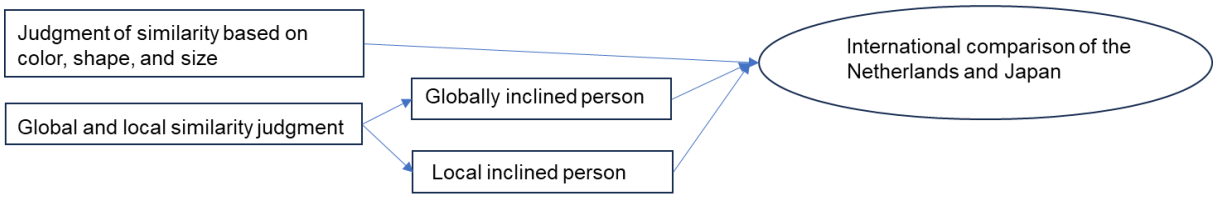

Figure 2. Research flow

In this research, the key factors include identifying where similarities exist in designs and determining how to define these similarities. First, we conducted an international comparison between the Netherlands and Japan using survey items related to "Judgment of similarity based on color, shape, and size" and "Global and local similarity judgment."
Next, the subjects were divided into local and global groups, and a two-way analysis of variance was conducted for these groups and countries (Netherlands and Japan). The similarity rating was conducted on 10 smartphones configured according to characteristics such as color, shape, and size, and the similarity to the target was evaluated on a four-level Likert scale.

3.1. Judgment of similarity based on color, shape, and size

Until now, in the field of design studies, the composition principle of design has been understood as a formative order consisting of formative elements such as color, shape, and texture, as well as harmony, contrast, and variety. This study specifically focuses on the visual domain and investigates whether the criterion for determining similarity lies in color, shape, or size.
As depicted in Figure 3-1, the research stimuli comprised circles, triangles, and squares, considered basic shapes, set in three sizes: large, medium, and small. With the addition of two colors, red and white, a total of 3 x 3 x 2 = 18 pieces were prepared. In the survey, participants were asked to select the three most similar shapes from numbers 1 to 18.

3.2. Global and local perspective

A visual similarity judgment task (Kimchi & Palmer, 1982) was used as a method to distinguish between global and local trends. This is presented by placing three types of stimuli at the vertices of a triangle, as shown in Figure 3-2. Students are tasked with judging which of the two comparison stimuli in the lower row is similar to the reference stimulus positioned in the top. All of these stimuli are a type of Navon figure using triangles, squares, etc., and the global and local areas of the reference stimulus are

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the same as any of the comparison stimuli. In Figure 3-2, the global area (triangle) of the left comparison stimulus is identical to the global area of the reference stimulus, and the local area (triangle) of the right comparison stimulus is the same as the local area of the reference stimulus.
The survey asked them to answer, "Which is more similar, A or B, to the reference stimulus?"

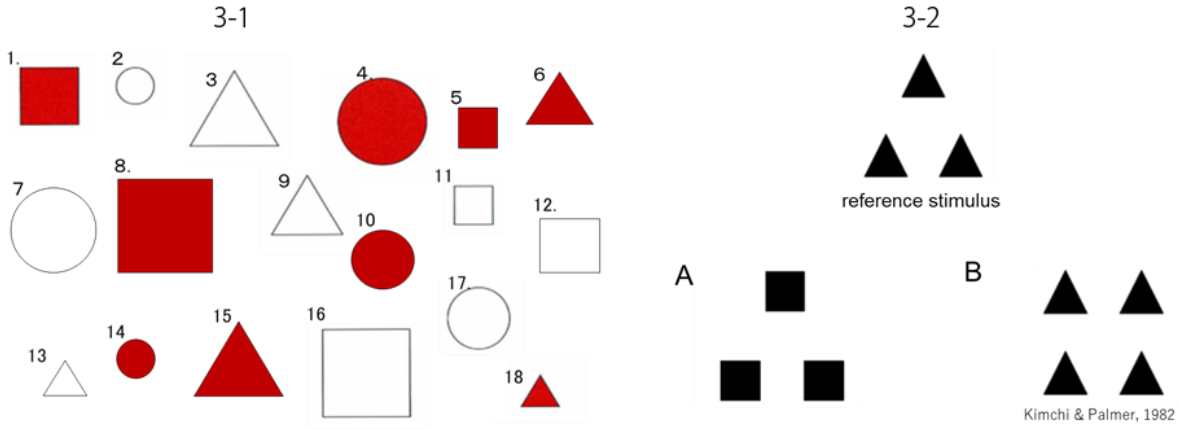

Figure 3. Survey stimulus diagram

3.3. Similar factors for products (smartphones)

The following questionnaire was set up to clarify the factors that determine the similarity of actual products.
The subject of this research is smartphones. Smartphones are items that are frequently used on a daily basis and are visible to many people. However, since it is an information device, it does not have as complex a design as a fashion item, and it is thought that it is easier to classify similarities. As shown in Figure 4, we prepared a total of 10 stimuli that differed in color, shape, size, etc. from the reference target (on the most left).
The survey requests a 4-level evaluation in comparison with a standard target: "Similar to the extent of being a rip-off or copy," "Something similar," "Slightly similar," "Not similar at all."

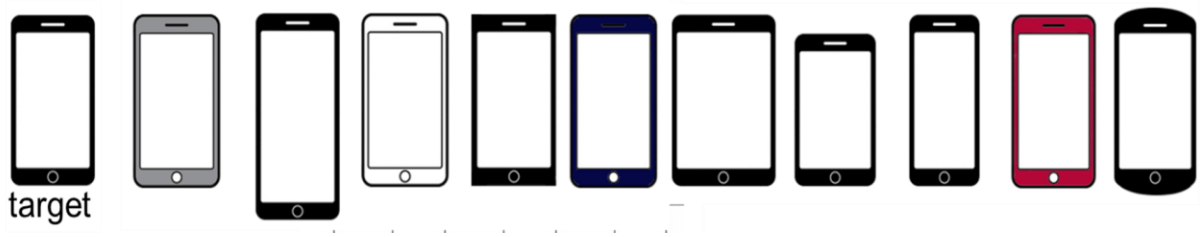

Figure 4. Product similarity survey stimulus

The survey details are as follows.
Survey date: September to October 2023
Survey target: Dutch university students (Delft University of Technology, Leiden University) N=89, Japanese university students (Toyohashi University of Technology) N=90
Survey method: Face-to-face questionnaire survey
Capture investigation items: 4-point evaluation questionnaire on personal characteristics
"Attracted to unique things", "Easily influenced by friends in everything I do", "Has a strong sense of justice", "Has a high interest in design", "Prioritize functionality over design".

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4. Results

The survey results are as follows.

4.1. Factors for determining similarity

Table 1 shows the selected percentage of figures that are judged to be similar. In a preliminary survey, we asked respondents whether they perceive similarities in terms of color or shape, and both the Dutch and Japanese respondents answered that they perceive similarity in terms of shape. Possibly due to narrowing the choices down to two colors in this survey, a significant number of people in both countries opted for the high-impact red. Regarding shapes, Japan exhibited a preference for triangular shapes, while the Netherlands had a more even distribution of choices. In terms of size, in Japan there were fewer small (26.7%) and more medium (39.3%), while in the Netherlands there was a tendency to have large (35.8%).

Table 1. Selection ratio by similar elements

	color		shape			size		
	White	Red	Round	Square	Triangle	Small	Medium	Large
Netherlands	39.6	60.4	31.5	31.5	37	31.5	32.7	35.8
Japan	40.7	59.3	19.3	33.7	47	26.7	39.3	34

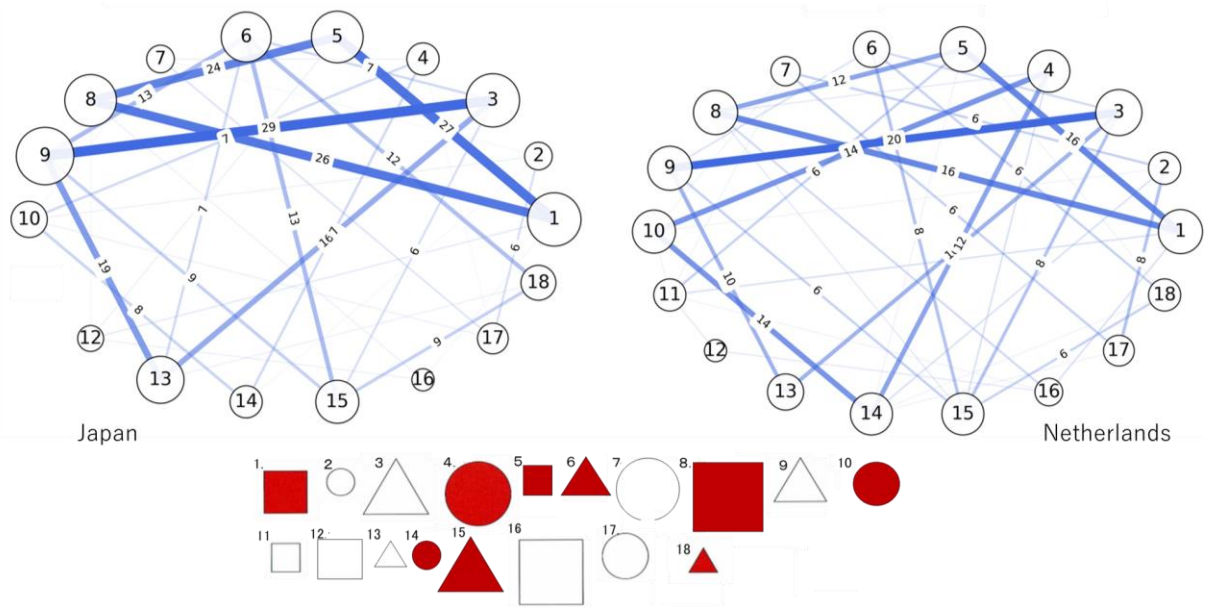

Figure 5. Diagrammatic representation of three points selected as similar

Figure 5 visualizes the combination of the three selected shapes as a network diagram. The size of the node (circle) represents the number of selections, and the thickness and density of the edges represent the number of combinations selected. For example, combination (1,5,8) represents all responses that chose item 1, 5 and 8 and visualized as 3 edges (1,5), (1,8), and (5,8) in the figure. First, if you look at the whole picture, you can see that the number of edges in the Netherlands is larger than that in Japan, creating a complex network diagram. This shows that there are various judgments regarding similarity. In Japan, there are many (1, 5, 8), and the similar components are "red" and "square". The next most common number is (3, 9, 13), which can be interpreted as "white" and "triangle". These points are similar in the Netherlands, but (4, 10, 14) are also seen frequently. This is because "red" and "circle" are similar elements.

4.2. Global and local comparison between two countries

In the visual search task with Navon shapes, in both Japan and the Netherlands, there was no extreme bias between local and global, and a well-balanced selection was made. In comparison, there is a slightly

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higher proportion of global respondents in the Netherlands, while in Japan, there are more local respondents. However, Pearson's chi-square test did not reach statistical significance.

Table 1. Global/local ratio

Actual value

	A	B	total
Japan	43	47	90
Netherlands	50	39	89
total	93	86	179

Expected value

	A	B	total
Japan	46.760	43.240	90
Netherlands	46.240	42.760	89
total	93	86	179

p	0.261

4.3. Similarity in products

Whether the factors used to determine similarity thus far also apply to products. Figure 6 is a graph of similarity judgments regarding 10 smartphones. A quick look at the trends shows that in both countries, odd numbers (1, 3, 5, 7, 9) and even numbers (2, 4, 6, 8, 10) show different trends. Odd number groups are determined to be similar. While they differ in color, they share similarities in shape and size. Conversely, even-numbered groups have the same color but varying shapes and sizes. In essence, when it comes to products, shape and size take precedence over color.

When comparing the Netherlands and Japan, it is apparent that all smartphones in the Netherlands exhibit a higher degree of similarity. However, they are more attuned to differences in width, as exemplified by smartphone No. 6.

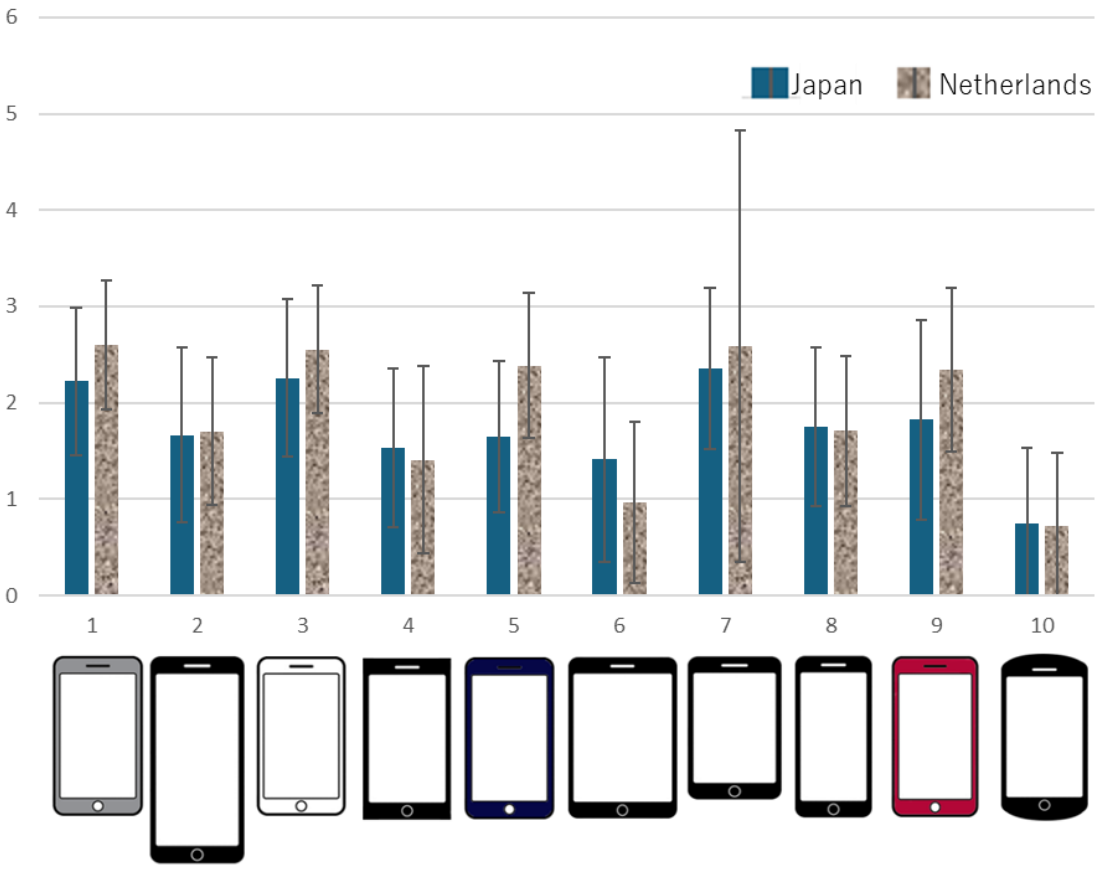

Figure 6. Comparison of two countries in determining product similarity

4.4. Two-factor analysis of variance

Next, we examined whether there were differences in similarity judgments between the Netherlands and Japan, global trends, and local trends. We each conducted a two-way (the nationality and the local/global

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behaviour) analysis of variance on the product-similarity ratings derived from the study explained in section 3.3, for all smartphones (No.1 to No.10).

The results are summarized in the graph in Figure 7 and Table 3. There was a significant interaction ($F(1,175) = 4.105$ $p < .05$) only for No. 2 smartphone. Also, we found a significant main effect in No. 1 ($F(1,175) = 12.202$, $p < .001$) ($F(1, 175) = 4.272$, $p < .04$) and No. 6 ($F(1,175) = 10.121$, $p < .002$) ($F(1,175) = 5.132$, $p < .025$) smartphones for both nationality and local/global behaviours.

In addition, No. 3 ($F(1,175)=6.669$, $p<.01$), No.5 ($F(1,175)=37.975$, $p<.001$), No.9 ($F(1,175)=15.202$, $p<. 001$) is the main effect of country only, No. 2 ($F(1,175) = 9.377$, $p < .003$), No. 8 ($F(1,175) = 10.32$, $p < .002$), N0.10 ($F(1,175)$) $= 8.653$, $p < .004$) smartphones had a significant main effect solely on local/global behaviours.

Due to the interaction on No. 2, in the case of vertical smarts, Japanese people tend to have a higher similarity judgment when it comes to global trends, and Dutch people tend to have higher similarity judgments when it comes to local trends.

	Nationality main effect	Global/local main effect	interaction
Smartphone 1	○	○	
Smartphone 2		○	○
Smartphone 3	○		
Smartphone 4			
Smartphone 5	○		
Smartphone 6	○	○	
Smartphone 7			
Smartphone8		○	
Smartphone 9	○		
Smartphone 10		○	

Figure 7. Global/local country-specific similarity judgment evaluation

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Table 2. Global/local country-specific similarity judgment evaluation

PhoneNo.	Cases	Sum of Squares	df	F	p
1	Ntionality	6.077	1	12.202**	<.001
	Global/Local	2.127	1	4.272*	0.04
	Ntionality × Global/Local	0.392	1	0.786	0.377
	Residuals	84.667	170		
2	Ntionality	4.554 × 0.00001	1	6.887 × 0.00001	0.993
	Global/Local	6.201	1	9.377**	0.003
	Ntionality × Global/Local	2.715	1	4.105*	0.044
	Residuals	112.42	170		
3	Ntionality	3.723	1	6.669*	0.011
	Global/Local	0.556	1	0.996	0.32
	Ntionality × Global/Local	0.116	1	0.208	0.649
	Residuals	94.916	170		
4	Ntionality	1.399	1	1.79	0.183
	Global/Local	1.484	1	1.899	0.17
	Ntionality × Global/Local	1.539	1	1.969	0.162
	Residuals		170		
5	Ntionality	22.79	1	37.975**	<.001
	Global/Local	0.145	1	0.241	0.624
	Ntionality × Global/Local	0.291	1	0.485	0.487
	Residuals		170		
6	Ntionality	9.086	1	10.121**	0.002
	Global/Local	4.607	1	5.132*	0.025
	Ntionality × Global/Local	0.972	1	1.083	0.3
	Residuals		170		
7	Ntionality	1.62	1	0.566	0.453
	Global/Local	6.261	1	2.188	0.141
	Ntionality × Global/Local	0.183	1	0.064	0.8
	Residuals		170		
8	Ntionality	0.196	1	0.323	0.571
	Global/Local	6.246	1	10.32**	0.002
	Ntionality × Global/Local	1.913	1	3.161	0.077
	Residuals		170		
9	Ntionality	13.279	1	15.202**	<.001
	Global/Local	1.171	1	1.341	0.248
	Ntionality × Global/Local	0.026	1	0.03	0.863
	Residuals	148.496	170		
10	Ntionality	0.131	1	0.224	0.637
	Global/Local	5.044	1	8.653**	0.004
	Ntionality × Global/Local	0.194	1	0.333	0.564
	Residuals		170		

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Looking at the significant main effect of nationality for smartphones 1, 3, 5, 6 and 9, results suggest the Dutch people's similarity judgments are largely influenced by the color. Additionally, smartphone 1, 2, 6, 8 and 10, which all tend to have deviant shape from the target was statistically significant for the global/local main effect. According to these results, size and bold appearance tend to have a strong influence on similarity judgments made by people with global tendencies.

5. Discussion

This research conducted an approach based on visual information and an international comparative study of elements that are judged to be similar within products. Judgments of similarity were more variable among the Dutch than among the Japanese, and various standards existed. When investigating only simple shapes, in addition to the influence of color, Japanese people used shapes such as squares and triangles, and Dutch people used shapes such as circles as criteria for determining similarity. When applied to actual products, we found that color has little effect, and shape and size have a large effect. In addition, people in the Netherlands tended to perceive product similarities more strongly and were particularly sensitive to differences in product width.

Furthermore, looking at the differences between people with global tendencies and those with local tendencies, we found that size and bold appearance tend to have a strong influence on similarity judgments among people with global tendencies.

Previous research had predicted that Asians would have a strong global tendency due to their family resemblance, while Westerners would have a strong local tendency because they find taxonomic rules quickly, but this study found that no trend was observed. Although, some findings differing from previous research have emerged, we believe that further investigation into the differing conditions will enable us to explore the influence of nationality and global tendencies on similarity judgments more comprehensively.

However, we would like to note some limitations to this study. While this study endeavours to shed light on the similarity judgment evaluation in a global context, one notable constraint is the reliance on simplified 2D representations for data evaluation. This approach may overlook crucial nuances inherent in the three-dimensional aspects of product design, such as form and textures. Therefore, future studies should expand upon our findings by considering a broader range of factors.

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