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Chia-yin Yu
Fu Jen Catholic University, Taiwan

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Visual Representations of Taiwanese Endemic Bird Species on Digital Media

Chia-yin YU

Fu Jen Catholic University, Taiwan

140467@mail.fju.edu.tw

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Abstract: This study investigated the aptness of digital-media visual representations of Taiwanese endemic bird species. First, expert interviews were conducted to obtain crucial graphic design-related bird features. Second, we applied graphic rendering and overall-conformation extraction to three stylizations—2D design and color block, 2D design and gradation, and stereoscopic effect and gradation. Degrees of similarity were tested, involving 239 participants aged 20–45. The results showed that (1) the crucial features in bird-related graphic design are body-part color, overall tone, the conformation of individual body parts, overall contour and style, and wing color. (2) Graphic designs based on the 2D design and color block approach yielded the greatest recognizability. (3) In single-colored birds, color contrasts constitute the most apparent features. (4) The conformation of bird body parts should be retained in bird-related design for better visual representations and recognizability. Further study will adopt interactive information design and explore digital-media applications of visualized bioinformatics.

Keywords: endemic bird species of taiwan; visual graphics; animal graphic design; flat design

1. Introduction

Among endemic species in Taiwan, birds are the most crucial indicator of environmental quality. By observing birds, the importance of environmental protection can be better appreciated, and the relationship between natural–environmental changes and the lives, health, and safety of an area’s residents can be better understood. Thus, this study investigated the aptness of digital-media visual representations of Taiwanese endemic bird species. In addition to size limit, this study aimed to understand how graphical representations of birds on digital media balance between visual fatigue and visual aesthetics as well as between features of appearance and their recognizability. Different levels of graphic design stylization and degrees of similarity were tested to investigate how stylized designs affect recognition accuracy, which could be design references for designers to make

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visual information more efficient on digital media.

2. Literature Review

2.1 Graphics

Graphics are typically reproductions of figurative objects. For easier visual communication, reproduced graphics are simplifications of the original object. Most reproduced graphics are of the form of an explicit simile, or a 'signifier'. According to Riding and Ashmore (1980), human beings are either verbalizers or imagers when absorbing visual information. Verbalizers use words to analyze what they see, and imagers use inner, habitual mental images when seeing. The difference between them lies in their preferred method of absorbing information. In contrast to words, graphics are more salient and memorable (Ashcraft, 1993; Messaris, 1997). In designing the graphical representations of real objects, simplification is the most commonly applied method. In graphical simplification, an original object's main elements are extracted and their inter-relationships are represented. These extracted elements are considered to constitute an adequate representation of the original object. The method of simplification can be divided into two types: extraction of overall conformation and extraction of partial features (Hsu & Wang, 2010). In extraction of overall conformation, the proportion of the whole structure and its features are retained. Viewers can identify the original based on the simplified overall conformation and proportion. Extraction of partial features, by contrast, puts less emphasis on the overall structure, focusing instead on retaining important features of the original. Viewers can recognize what the graphics represent based on their experience (see Table 1).

Table 1 Examples of graphic simplification

Extraction of the overall conformation	Extraction of partial features

2.2 Stylized design

Hiebert (1998) believed that the transformation of graphics from figuration to abstraction is a process of simplifying existing objects. As the level of abstraction increases, designers can add more conceptual ideas to the design, allowing them to convey their desired message through the graphics. In addition to mere abstraction, designers also employ various other techniques to accentuate detail, through stylization, when simplifying objects to convey their desired message. Stylized objects or graphics not only deepen the impressions of viewers but also enable greater self-awareness through the viewer's interpretation of the meaning

behind the graphics, in addition to enabling constant self-examination (Grubb & Grathwohl, 1967; Kleine III, Kleine, & Kernan, 1993; Atakan, Bagozzi, & Yoon, 2014a; 2014b). Meyer and Laveson (1981) classified graphics (from realistic depictions to pure abstractions) into five levels as follows: (1) natural photography, where the visual features of objects are realistically depicted through photography; (2) pictorial illustration, where the visual features of objects' appearance are realistically depicted through refined presentations of textures and the selective presentation or augmentation of detail; (3) graphical renderings, where shape and contour details of objects are preserved through painting techniques, thus representing color and texture in the form of blocks; (4) graphic symbology, where the shape and contour details of objects are transformed into flat graphics and color blocks by removing color, texture, and the stereoscopic effect; and (5) abstract symbology, where conceptual ideas are represented by skewing the original shape and contour details of objects (see Figure 1).

Figure 1 Stylization levels proposed by Meyer and Laveson (1981) (re-illustrated and used in this study)

2.3 Endemic bird species in Taiwan

According to the official website of the Endemic Species Research Institute, Council of Agriculture, Executive Yuan, 15 endemic bird species were spotted in 2017. As depicted in Table 2, 10 species are of an identical color, three species have small differences in appearance (the collared bush robin *Tarsiger johnstoniae*, Taiwan firecrest *Regulus goodfellowi*, and yellow tit *Parus holsti*), and two species have large differences in appearance (Mikado pheasant *Syrnaticus mikado* and female Swinhoe's pheasant *Lophura swinhoi*).

Table 2 Endemic bird species of Taiwan

Taiwan hill partridge (<i>Arborophila crudigularis</i>)	Taiwan blue magpie (<i>Urocissa caerulea</i>)	Taiwan barwing (<i>Actinodura morrisoniana</i>)	Taiwan Liocichla (<i>Liocichla steerii</i>)	Male Mikado pheasant (<i>Symaticus mikado</i>)

Female Mikado pheasant (<i>Symaticus mikado</i>)	Taiwan whistling thrush (<i>Myophonus insularis</i>)	White-eared sibia (<i>Heterophasia auricularis</i>)	Male yellow tit (<i>Parus holsti</i>)	Female yellow tit (<i>Parus holsti</i>)

Male Taiwan firecrest (<i>Regulus goodfellowi</i>)	Female Taiwan firecrest (<i>Regulus goodfellowi</i>)	Male collared bush robin (<i>Tarsiger johnstoniae</i>)	Female collared bush robin (<i>Tarsiger johnstoniae</i>)	Male Swinhoe's pheasant (<i>Lophura swinhoii</i>)

Female Swinhoe's pheasant (<i>Lophura swinhoii</i>)	Taiwan bush warbler (<i>Locustella alishanensis</i>)	Taiwan laughing thrush (<i>Garrulax morrisonianus</i>)	Taiwan yuhina (<i>Yuhina brunneiceps</i>)	Taiwan Bulbul (<i>Pycnonotus taivanus</i>)

Current research on Taiwanese endemic animal and plant species have focused on conservation, habitual behaviors, and their ecological environment. In particular, most books on Taiwanese endemic bird species are illustrated handbooks. These books order their content based on *The Checklist of Birds of Taiwan* (Bird Record Committee, Chinese Wild Bird Federation, 2017) and *Clements Checklist of Birds of the World* (Cornell Lab of Ornithology, 2017). However, those who do not understand the sorting system, especially those who know little about birds, find it difficult to retrieve the desired information from these books. The detailed knowledge contained in those books also cannot be properly absorbed and used by these readers. In biological species-related graphic design, the aim is to deepen the readers' understanding and make their learning more efficient by enabling the visualization of information. Despite size constraints and the need to balance between visual fatigue and visual aesthetics, digital-media graphics are typically semi-figurative and abstract, typically

presented as graphic renderings, graphic symbology, and abstract symbology. This study focused on simplified digital-media graphic designs of Taiwanese endemic bird species, investigating how features can be better retained and recognizability can be better enhanced.

3. Methods

3.1 Visual features of Taiwanese endemic bird species

Expert interviews were conducted to understand the key visual features of Taiwanese endemic bird species. The interviewees were four professionals in the field of visual design with more than five years of experience. Interviewees were interviewed on the key features, the rationale behind visual identification, and the focus of the visual design. Interviewees were also asked to rank the importance of each feature and element in the graphic design of Taiwanese endemic bird species. As for the interview results, the key features identified were divided into three categories of color, contour and style, and personified characters. And the foci of visual design from most to least principal were (1) color of the individual body parts, (2) overall tone, (3) conformation of the individual body parts, (4) overall contour and style, (5) color of wings, (6) style and length of tail feathers, (7) size and length of the body, (8) color of tail feathers, (9) color of beak, and (10) color of feet.

3.2 Graphic design of Taiwanese endemic bird species

The graphical representations of the Taiwanese endemic bird species were designed based on the interview results of expert interviews. The first five of the aforementioned features were used as the focus of design: (1) color of individual body parts, (2) overall tone, (3) conformation of individual body parts, (4) overall contour/style, and (5) color of wings. In total, 20 graphic designs were made for 15 Taiwanese endemic bird species (both male and female). The method of overall-conformation extraction was used for graphical simplification. Graphic rendering, commonly seen in digital media, was adopted to retain the shape and contour details of birds within the hierarchy of stylization. Three sets of graphics of Taiwanese endemic bird species with different stylization levels were produced to examine differences with respect to degrees of matching. Each set comprised 20 graphics of Taiwanese endemic bird species of both genders, for a total of 60 graphics (see Tables 3). The different levels of stylized design are as follows.

- 2D design and color block, where the color and texture of the bird's appearance is transformed into color blocks in the 2D design style.
- 2D design and gradation, where the texture of the bird's appearance is transformed into color blocks and gradation is used to detail the bird's feathers; the 2D design style is adopted.
- Stereoscopic effect and gradation, where the texture of the bird's appearance is ignored and gradation and shadow are used instead to detail the stereoscopic effects of color and contour.

Table 3 Graphic designs of Taiwanese endemic bird species

Hierarchy of stylization	2D design and color block	2D design and gradation	Stereoscopic effect and gradation
Taiwan hill partridge (<i>Arborophila crudigularis</i>)
Taiwan blue magpie (<i>Urocissa caerulea</i>)
Taiwan barwing (<i>Actinodura morrisoniana</i>)
Taiwan Liocichla (<i>Liocichla steerii</i>)
Male Mikado pheasant (<i>Syrmaticus mikado</i>)
Female Mikado pheasant (<i>Syrmaticus mikado</i>)
Taiwan whistling thrush (<i>Myophonus insularis</i>)
White-eared sibia (<i>Heterophasia auricularis</i>)
Male yellow tit (<i>Parus holsti</i>)
Female yellow tit (<i>Parus holsti</i>)
Male Taiwan firecrest (<i>Regulus goodfellowi</i>)

Female Taiwan firecrest (Regulus goodfellowi)
Male collared bush robin (Tarsiger johnstoniae)
Female collared bush robin (Tarsiger johnstoniae)
Male Swinhoe's pheasant (Lophura swinhoii)
Female Swinhoe's pheasant (Lophura swinhoii)
Taiwan bush warbler (Locustella alishanensis)
Taiwan laughing thrush (Garrulax morrisonianus)
Taiwan yuhina (Yuhina brunneiceps)
Taiwan Bulbul (Pycnonotus taivanus)

3.3 Test of degrees of similarity

The degree of similarity was tested using a between-subjects design. The test was issued in the form of an electronic questionnaire, so the participant had to use a digital media such as computer or smartphone to complete the test. Specifically, participants were asked to match the bird's graphical representation with its photographic image. A five-point Likert scale was used. Participants were asked to judge the similarity between the graphical and photographic images and to state the rationale behind their visual identification. Because some participants may have knowledge on birds, the names of birds were not shown during the whole test. Only the graphical and photographic images were provided. Participants were aged 20–45 and were familiar with the use of mobile applications. Besides, to enable

the conduct of follow-up studies, the anticipatory scenario was not limited to indoor use. The graphics could be quickly retrieved and compared with the birds observed during bird watching activities. The photos of birds in the test were also taken from books on other birds and not limited to those of birds in the Taiwanese endemic bird species. Photographs of the sibling species of Taiwanese endemic bird species were also given to participants to examine whether they could correctly distinguish between the graphically represented birds and their similar-looking counterparts. Table 4 lists those birds that have a similar appearance with their counterparts in the Taiwanese endemic bird species.

Table 4 Sibling species of Taiwanese endemic bird species (Liao, 2017) (provided by this study)

Brown-flanked bush warbler (Horornis fortipes)	Light-vented Bulbul (Pycnonotus sinensis)	White-browed bush robin (Tarsiger indicus)	Streak-throated Fulvetta (Alcippe cinereiceps)	Eurasian magpie (Pica pica)

Goldcrest (Regulus regulus)	Red-billed blue magpie (Urocissa erythroryncha)	Green-backed tit (Parus monticolus)	Blue whistling thrush (Myophonus caeruleus)	Blue rock thrush (Monticola solitarius)

4. Result

In total, 239 valid questionnaires were collected. Among them, 80, 79, and 80 participants were tested for the 2D design and color block, 2D design and gradation, and stereoscopic effect and gradation, respectively. According to the results, the graphics of Taiwanese endemic bird species that were designed using the 2D design and color block approach yielded the highest overall degree of similarity (86.5%), followed by those designed using the stereoscopic effect and gradation (85.81%) and 2D design and gradation (84.49%) approach. The results for the degrees of similarity and visual similarity are detailed in Table 5 and 6. And the result for total number of rationale of visual identification is in Table 7.

Table 5 Degree of similarity results

	Degree of similarity		
	2D design and color block	2D design and gradation	Stereoscopic effect and gradation
Taiwan Bulbul (<i>Pycnonotus taivanus</i>)	96.25%	100%	97.5%
White-eared sibia (<i>Heterophasia auricularis</i>)	58.75%	54.43%	73.75%
Taiwan whistling thrush (<i>Myophonus insularis</i>)	96.25%	96.2%	95%
Taiwan hill partridge (<i>Arborophila crudigularis</i>)	95%	92.41%	92.5%
Taiwan Liocichla (<i>Liocichla steerii</i>)	96.25%	91.14%	88.75%
Taiwan laughing thrush (<i>Garrulax morrisonianus</i>)	47.5%	27.85%	50%
Taiwan yuhina (<i>Yuhina brunneiceps</i>)	97.5%	100%	97.5%
Taiwan barwing (<i>Actinodura morrisoniana</i>)	88.75%	88.61%	87.5%
Taiwan blue magpie (<i>Urocissa caerulea</i>)	92.5%	88.61%	91.25%
Taiwan bush warbler (<i>Locustella alishanensis</i>)	63.75%	41.77%	47.5%
Male Taiwan firecrest (<i>Regulus goodfellowi</i>)	83.75%	96.2%	91.25%
Female Taiwan firecrest (<i>Regulus goodfellowi</i>)	80%	70.89%	75%
Male Mikado pheasant (<i>Syrmaticus mikado</i>)	80%	79.75%	72.5%
Female Mikado pheasant (<i>Syrmaticus mikado</i>)	91.25%	93.67%	91.25%
Male collared bush robin (<i>Tarsiger johnstoniae</i>)	92.5%	93.67%	92.5%
Female collared bush robin (<i>Tarsiger johnstoniae</i>)	96.25%	98.73%	96.25%
Male Swinhoe's pheasant (<i>Lophura swinhoii</i>)	90%	89.87%	88.75%
Female Swinhoe's pheasant (<i>Lophura swinhoii</i>)	86.25%	93.67%	92.5%
Male yellow tit (<i>Parus holsti</i>)	98.75%	98.73%	98.75%
Female yellow tit (<i>Parus holsti</i>)	98.75%	93.67%	96.25%
Total/average	86.5%	84.49%	85.81%

Table 6 Visual similarity results

	Visual similarity		
	2D design and color block	2D design and gradation	Stereoscopic effect and gradation
Taiwan Bulbul (<i>Pycnonotus taivanus</i>)	89%	92.41%	89.75%
White-eared sibia (<i>Heterophasia auricularis</i>)	72%	74.94%	77.25%
Taiwan whistling thrush (<i>Myophonus insularis</i>)	73.5%	78.73%	78.25%
Taiwan hill partridge (<i>Arborophila crudigularis</i>)	79%	84.56%	84.5%
Taiwan Liocichla (<i>Liocichla steerii</i>)	71.5%	73.42%	73.5%
Taiwan laughing thrush (<i>Garrulax morrisonianus</i>)	57.75%	62.03%	58.5%
Taiwan yuhina (<i>Yuhina brunneiceps</i>)	89%	89.87%	87.75%
Taiwan barwing (<i>Actinodura morrisoniana</i>)	77.75%	80%	79.25%
Taiwan blue magpie (<i>Urocissa caerulea</i>)	82%	82.28%	80%

Taiwan bush warbler (<i>Locustella alishanensis</i>)	54.5%	54.43%	55.25%
Male Taiwan firecrest (<i>Regulus goodfellowi</i>)	79%	87.09%	82.75%
Female Taiwan firecrest (<i>Regulus goodfellowi</i>)	70%	70.63%	70.25%
Male Mikado pheasant (<i>Syrnaticus mikado</i>)	76%	72.91%	72%
Female Mikado pheasant (<i>Syrnaticus mikado</i>)	73%	76.96%	78%
Male collared bush robin (<i>Tarsiger johnstoniae</i>)	83.25%	81.01%	78%
Female collared bush robin (<i>Tarsiger johnstoniae</i>)	83.75%	86.58%	83.25%
Male Swinhoe's pheasant (<i>Lophura swinhoii</i>)	79.75%	82.78%	78.25%
Female Swinhoe's pheasant (<i>Lophura swinhoii</i>)	79.25%	81.01%	79%
Male yellow tit (<i>Parus holsti</i>)	88.75%	91.9%	88.75%
Female yellow tit (<i>Parus holsti</i>)	81.5%	80.51%	80.5%
Total/average	77%	79.2%	77.74%

Table 7 Total number of rationale of visual identification (number of people)

	2D design and color block	2D design and gradation	Stereoscopic effect and gradation
Color of individual parts	1026	1055	1025
Overall tone	680	726	737
Conformation of individual parts	809	906	844
Overall contour/style	661	663	817
Color of the wings	329	373	313
Others/no similarity	14	9	11

Because the 2D design and color block approach had the highest overall degree of similarity (86.5%), this study further investigated it concerning visual identification. The degrees of similarity for 17 out of 20 birds were higher than 80%. Among them, the degrees of similarity for eight birds were over 95%. The degrees of similarity for both male and female yellow tits (*Parus holsti*) were 98.75%. The degree of similarity for the Taiwan yuhina *Yuhina brunneiceps* was 97.5%. The degrees of similarity for the following birds were 96.25%: Taiwan Bulbul *Pycnonotus taivanus*, Taiwan whistling thrush *Myophonus insularis*, Taiwan Liocichla *Liocichla steerii*, and female collared bush robin *Tarsiger johnstoniae*. And the degree of similarity for the Taiwan hill partridge *Arborophila crudigularis* was 95%.

Thus, the results demonstrated that based on most of the graphics of birds designed by this study, participants could clearly distinguish between birds of similar appearance. The degrees of similarity of the following three birds were lower than 80%: Taiwan bush warbler *Locustella alishanensis* (63.75%), white-eared sibia *Heterophasia auricularis* (58.75%), and Taiwan laughing thrush *Garrulax morrisonianus* (47.5%). The results indicated unclarity in the participant rationales underlying visual identification, thus indicating their limited usefulness. According to participants, the gradation of feathers of some birds was crucial for identification. Thus, the sole use of color blocks potentially

impedes identification. Moreover, when viewing many birds that are similar in appearance and overall tone, the participant rationales underlying visual identification as follows: (1) color of individual body parts, (2) conformation of individual body parts, (3) overall tone, (4) overall contour/style, and (5) color of wings, similar to the expert interview results. Notably, the conformation of individual body parts were, however, more critical for participants than for experts, indicating that more considerable attention should be paid to this element in the design of bird graphics.

5. Conclusion

Taiwanese endemic bird species are essential in Taiwanese culture. The comprehensive understanding of their visual features and the use of such features in the design of teaching materials on ecology can deepen not only the impressions of users regarding these birds but also aid the in-depth investigation of the ecology and culture of Taiwan. This study explored the aptness of the digital-media visual representations of Taiwan's endemic bird species. The methods of graphic rendering and overall-conformation extraction were adopted. Three levels of stylization were adopted in the graphic design: the 2D design and color block, 2D design and gradation, and stereoscopic effect and gradation approach. Degrees of similarity were tested to understand how accurately the graphical representations depicted the actual birds. According to the results, when participants used digital media, such as computer or smartphone, to viewed birds with similar appearances, the graphic designs using the 2D design and color block approach yielded the highest degree of similarity (86.5%), followed by stereoscopic effect and gradation (85.81%) and 2D design and gradation (84.49%) approaches. The study's findings are as follows.

1. The expert interviews and test of degree of similarity demonstrated that when designing the graphical representation of birds, the visual foci are as follows, from least to most important: (1) color of individual body parts; (2) overall tone; (3) conformation of individual body parts; (4) overall contour/style; and (5) color of wings.
2. The 2D design and color block approach yielded the highest degree of similarity. The gradation of the feathers of some birds, however, was crucial for identification and must be retained in the graphic design.
3. The color contrast of single-colored birds constitutes their most noticeable feature and thus aids identification.
4. The conformation of individual body parts aids the distinguish of birds from their similar-looking counterparts. Therefore, such conformation must be retained in bird-related graphic design for better visual representations and recognizability.

Taiwanese endemic bird species are not only a natural wonder but also crucial for the development of culture and aesthetic education in Taiwan. Through investigating the aptness of digital-media visual representations of Taiwanese endemic bird species, we understand how graphical representations of birds on digital media balance between visual fatigue

and visual aesthetics as well as between features of appearance and their recognizability. In general, this study can contribute to graphic design, information design, design process, visual communication, and education. However, the screen sizes of current digital media are different. By issuing the electronic questionnaires, we are not able to know precisely which kind of digital media participants used to fill in the answers. Furthermore, when the different levels of stylized design showed on a small-screen digital device, the graphics might look very similar, which could result in the similarity score were closed. Bird graphics that had a low degree of similarity should be further discussed and improved. Moreover, through interactive information design, more variety in the test material, such as an animated version or film recording, could be conducted and lead to clearer differentiation. The representation and interaction on digital media applications, such as smartphones and tablet computers, to visualized bioinformatics should be further investigated.

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About the Author:

Chia-yin Yu got her ph.D. in Design from the National Taiwan University of Science and Technology (NTUST). Now she is an assistant professor at the Department of Applied Arts, Fu Jen Catholic University. She is skilled in visual communication, user-centered design, and consumer emotion.