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Effects of OCT (open caption telop) color on value perception in the news context

– From the tone perspective –

GONG LI* and YASUHIRO KAWABATA*

* Hokkaido University, School of Humanities and Human Sciences, Department of Psychology (Sapporo, Hokkaido, Japan)

Abstract: Several studies have shown that color plays a vital role in the perception of visual information. This study clarified the cognitive differences generated by OCT (Open Caption Telop) colors in the perception of news value as importance, novelty, and timeliness among the negative, neutral, and positive news contexts. We also explored the news value integration by the color in the news emotional context. In this study, three tones, i.e., the bright, deep, and vivid with eight chromatic hues were selected from the Practical Color Co-ordinate System (PCCS), which are tried to be loyal to the news practice. We conducted a repeated measures ANOVA and correlation tests to clarify the OCT color effects. Our findings suggest that the OCT with deep-tone hues can facilitate the news to perceive more important, particularly in the negative context and vice versa. In some ways, this result partially applies to the news timeliness dimension, although its performance is relatively more complicated. The color performance in the perception of news novelty was observed to be the contrary with the other two dimensions. The 3D spaces created reveal that the news value integration by color highly depends on the news emotional context.

Keywords: *Color, perception, news value, OCT*

1 INTRODUCTION

Color not only has aesthetic significance but also has practical functions, such as being a medium for conveying meaning.[3, 25, 27] In the process of visual news information, one goal of journalism is to subjectively enhance the dissemination of the content through the editing and processing of the original materials. The processing of the visual content itself needs to take into account the reality of the news, so there is little room for processing, but the secondary processing of the content, such as adding open caption telop (OCT, or simply Telop), a kind of subtitles, is of great significance.[14, 24, 30, 31]

In the following, this paper explains OCT in terms of its type, function, and traditional form, respectively. Subtitles traditionally appear at the bottom of the screen area, hence sub, which is a more general term. The term caption which can be used to refer to legend under images and figures, i.e., the explanation for images, and even to subtitles themselves.[30]

In the visual contents, as shown in the left part of Fig. 1, the term Closed Caption (C.C.) which the viewer can choose whether to have them displayed or not has traditionally been used as an aid for individuals with hearing impairments or other situations. By contrast, subtitles seen on screen which viewers cannot choose to view the program with or without them are always in an open state on the screen is named as Open Caption. As shown in the right part of Fig. 1, it is always displayed on the screen along with the content, and the viewer cannot

turn it off. Also, unlike C.C. where nearly all utterances and sounds in the dialogue and narration are displayed, Open Captions display only selective parts of the current scene. In other words, C.C. is reproducing the content itself, while OCT places more emphasis on enhancing the content effects. It is important to note here that C.C. is not in the scope of this study. The C.C. is explained here in contrast for better understanding of the style of Open.

Fig. 1 | The left part of this image is an example of Closed Caption application. By clicking on the cc button circled by black loop, the captions with its transparent background will be displayed on the screen. The right part of this image is two examples of Japanese news scenes in which two OCT designs circled by black frame were selected. The copyright of these original materials belongs to news agencies.

Telop, which came from <u>Te</u>levision <u>Op</u>aque Projector,

was the trademark name of a multifunction, four-channel project-all slide projector developed by the Gray Research & Development Company for television usage, and was introduced in 1949. As shown in Fig. 2, it is a device used to transmit separately prepared text or graphics directly onto the TV screen without the use of an additional camera. It is the most common term used in Japan for the abovementioned open captions. However, the term Telop alone is specific to Japan, and it is also limited to textual inserts on TV. Thus, worldwide people are unfamiliar with this term and its origin, so comprehension and consistency are difficult, both in the literature and in the industry.[29] As we have seen, the term places more emphasis on its origins and physical properties, i.e., the text and graph carrier shaped as bands or straps.

Fig. 2 | Gray Research Telop Machine, Television's First Optical Projection System. This machine was able to televise opaque cards, which was the forerunner of transparent slides. It also had added on features that would allow a news type horizontal ticker scroll across the bottom of the screen (on real ticker tape) and a vertical scroll for credits. The copyright of this image and its descriptions belongs to the person or group with rights.

Therefore, OCT can be considered as a special kind of subtitle that appears on the screen in an open form, and its purpose is to highlight the program or content effect through visual design, rather than only the subtitle text itself (e.g., C.C.). Secondly, it carries the description text, i.e., caption; thus, it has the functional property of subtitles. Furthermore, it is mainly located at the bottom of the screen and has the traditional form of subtitling, i.e., telop, which also can be understood as a solution for visual effects in terms of screen contents.[30, 36]

At this stage, the OCT application is mainly focused on entertainment programs. Experimental studies have shown that in the field of soft content, such as entertainment shows, the color and font of OCT and other elements can influence the effect of the program.[11, 12, 29-31, 36 (cf. 17, 19)] For example, a study pointed out that different colors of OCT have different effects on the cognitive evaluation of the taste of food. [15] In a study on OCT of NHK (Japan Broadcasting Corporation) entertainment programs, the author pointed out that, as in the 1990s, the design of OCT including elements such as fonts and colors were enhanced to bring out the decorative effect of OCT further.[36] In recent years, there has been a gradual focus on the use of OCT in journalism, although there are fewer related studies. As a study indicated that the usage of OCT is not limited to the entertainment genre. More recently, news programs have also incorporated OCT into their everyday content. The OCT may not be as aggressively employed in news programs as it is used in entertainment programming, its use, especially for factual content, may influence viewers in their interpretation and comprehension. For example, according to NHK, they aimed to achieve intuitive and simple messaging by using short expressions, which were used with simple color combinations to ease reading.[28, 29] Due to the paucity of empirical study on OCT in news context, it is difficult to clarify to any conclusions for its effects.

Although this issue has been recognized, research has not yet to systematically investigate the effects of color. [29] Therefore, this research will focus on this and clarify the effects of color on visual news cognition (mainly the value element of news) through the following experiment. Specifically, in the news context, does the OCT color, especially the tone, also including the hue affect the cognition of Importance (impact / newsworthiness), Novelty (unexpectedness), and Timeliness (recency / current) dimensions? [7,8] Are there any differences in the perception of news value between news scenes with different colored OCT? What color manipulations of OCT in news scenes will facilitate the perception of news value? What color manipulations of OCT in news scenes will inhibit the perception of news value? Moreover, can multiple news value dimensions be integrated by a single color within a news scene? If it is, which colors can integrate news value dimensions, or which colors are difficult to achieve news value integration?

Concerning the association between color and emotion, a study revealed that the principal hues comprised the highest number of positive emotional responses, followed by the intermediate hues and the achromatic colors.[20] The lightness as one of three attributes of color is highlighted to reveal the relevance between color and emotion, as revealed by a study that indicated bright colors elicited mainly positive emotional associations, and dark colors elicited mainly negative emotional associations.[23] Francis et al. considered the color component brightness, as determined by comparing data on white, grey, and black is strongly associated with positive evaluation, but also with negative potency.[1] Furthermore, there is a

comprehensive perspective of brightness and saturation to illustrate the emotional tendency of color; for example, Valdez P. and Mehrabian A. have suggested that saturation and brightness evidenced strong and consistent effects on emotions. Brightness effects were nearly the same for chromatic and achromatic colors. Blue, blue-green, green, red-purple, purple, and purple-blue were the most pleasant hues, whereas yellow and green-yellow were the least pleasant. Green-yellow, blue-green, and green were the most arousing, whereas purple-blue and yellow-red were the least arousing. Green-yellow induced greater dominance than red-purple.[32] Also, there are using electrophysiological methods to clarify that the wave length-selectivity neuronal activity occurs at the first stage of cortical processing in several brain parts, which also proves the nature attributes on the color perception.[2]

Based on the previous research, the experimental idea will be elaborated on in the following. In this paper, an experiment was conducted to explore the cognitive performance and effects of OCT color on the news value of news with different emotions from the perspective of tone. Regarding the results, a repeated analysis of variance was used to explain the influence of color parameters on the value perception of specific news scenes, and the correlation analysis conducted creatively explored the degree of news value integration by color OCT on the perception of different news scenes.

2 METHODS

2.1 Apparatus and Stimuli

The experimental period was during the epidemic stage of the COVID-19. To ensure the safety and health of the participants, the experiment was conducted online. Thus, the experimental equipment was prepared by the participants themselves. During the experiment, all participants provided the appropriate equipment as required. The requirements of the experimental equipment and operating environment were: this experiment requires the use of 9.7-inch iPad (Participants using iPads with screen sizes larger than 9.7 inches were required to inform the experimenter in advance), but the use of smartphones and iPads with screen sizes smaller than 9.7 inches to participate in the experiment will not be recognized. The iPad requested for use in this experiment is based on the 6th generation (officially announced to be manufactured in 2018), which has the following technical specifications: with a 9.7-inch retina level display, 2048 × 1536 resolution, 264ppi. Make sure that the iPad used can be displayed normally and properly. The screen should be adjusted on non-night view mode, and the brightness

manually set to 50% for the experiment duration. If there are any uncertain display problems, please inform the experimenter in advance, and make sure that the iPad system does not see any abnormalities. The experiment needed to be completed independently and quietly, so the iPad needed to be on silent mode.

The above requirements can reduce the differences generated by the parameter settings of different monitor brands, different color rendering methods of monitors, and differences in the usage status of monitors in terms of age to a certain extent. Therefore, the using of a uniform size iPad was adopted. Although there may be other better ways to avoid possible problems due to monitor color differences[35], this is the method used in this experiment so far. We will also continue to explore methods that are more suitable for online experiments.

The visual stimulus (the news scenes) used in this study is composed of color OCT and news images. The prototype of OCT was designed regarding the actual usage in Japanese news, and its original intention is to fit the news form that could be used in the official news scenes since its simple design style. It also fulfills the three aspects of OCT, i.e., it is envisioned to be applied in an open state and to partially illustrate the contents appeared on screen, with a striped appearance.

Fig. 3-1 | The OCT pattern. The image of Chinese character in the center of the graphic part 1 can be translated to NEWS in English. This pattern was designed by using Adobe Illustrator (Ai) version 2019.

As shown in Fig. 3-1, this OCT pattern can be divided into two parts: graph and text. Graphic part 1 is the text carrying parts, and the background color is white-gray. In order to achieve a visual balance between OCT and news background, a 5% transparency was manipulated on the graphic part 1. Graphic part 2 and 3 are color-carrying components, where part 2 is a bar shape, and part 3 is a bubble shape. Text part 1 is a Japanese/Chinese component and the contents carried correspond to the news content as Fig. 4, which are the words *Earthquake*, *Transaction* and *Support*. Text part 2 as an icon indicates

the news channel. The design size of OCT is L × H = 64.8mm × 20.1mm, and the actual display size by 9.7-inch iPad is L × H = 37.0mm × 11.5mm.

Regarding the color research, the color systems used vary according to the purpose and focus of the study. In this study, we aim to be practical and more focused on the tone of color. Accordingly, the Practical Color Co-ordinate System (PCCS) was selected for this study, as shown in Fig. 3-2.
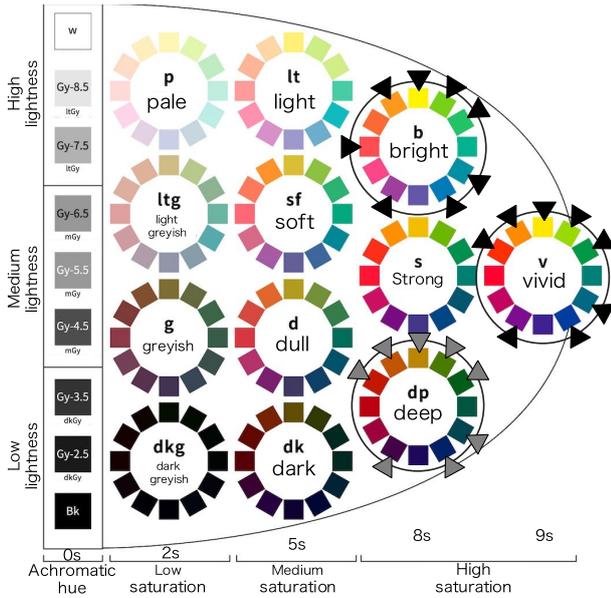

Fig. 3-2 | The PCCS color system. In this experiment, the vivid tone (*v3, v6, v8, v10, v11, v16, v18, v22*) was used as the control condition, and the bright tone (*b2, b6, b8, b10, b12, b16, b18, b22*) and the deep tone (*dp2, dp6, dp8, dp10, dp12, dp16, dp18, dp22*) as experimental conditions. The corresponding eight hues circled by black loops were selected.

Specifically, PCCS is a color system with the main purpose of systematically solving the problem of color harmony. Its hue ring is an arrangement of the highest saturated colors of the 24 hues in such a way that they perceptually shift to equivalent paces. Within it, the lightness levels are based on the Munsell system, and the representative color (the vivid tone) of each hue is set to the same saturation (9s), and the changes from there to achromatic colors are divided so that they are perceptually perceived as equally spaced. Even within the same family of hues, there are differences in tone, such as light and dark, strong and weak. This difference in color is called tone. Setting up a color space for these tones is one of the most important features of PCCS. Each hue is divided into 12 tones, and colors with the same tone from each hue are grouped together. Although there are differences in

brightness, groups with a common sense of vividness are created.

In this study, the parameter of tone was used, so that the PCCS may be a more appropriate choice. Its representative color (the vivid tone) is considered as the basic tone as the reference condition for this study. Accordingly, at the present stage, the bright and deep tone were selected as experimental conditions within the same category of saturation that is high saturation, respectively. The effect of other tones from other categories on the perception of news value in news contexts are needed to conduct further experiments. Regarding the hue used in this experiment, the four primary hues (*red, yellow, green, and blue*) and four intermediate hues (*orange, yG/YG, Lb/BG, and purple*) were selected, which correspond to the three kinds of tones (*bright, vivid, and deep*).

The news scenes in the experiment were arranged for the following considerations. The format of the news materials used was the original images from three actual Japanese news reports. The news content of selected images can be understood through the images themselves, without any other assistance. These three news images tend to have negative, neutral, and positive emotion respectively, which was based on the results of a former cognitive evaluation in which 24 news terms including the 3 terms used in this experiment were judged their possible emotional tendencies, i.e., negative, neutral or positive.[16]
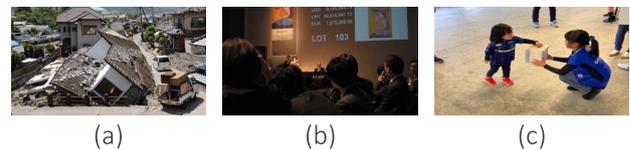

Fig. 4 | The news images used in the experiment (emotional context). (a) The disaster scene (negative emotional tendency). *Japan Meteorological Agency, Kumamoto earthquake received without using aftershocks for earthquake prediction.* (b) The transaction scene (neutral emotional tendency). *Picasso's "crying woman" wins one billion yen "the highest price" in a domestic auction.* (c) The support scene (positive emotional tendency). *Reconstruction assistance for typhoon No.19 disaster area X team donation.* The copyright of the original images belongs to the owner of the images.

As shown in Fig. 4, from left to right, the news images tend to show negative, neutral, and positive emotions. The design size of news scenes is 106.7mm × 60.0mm, the actual display size by 9.7-inch iPad is: L × H = 61.0mm × 34.0mm. As presented, the experiment conducted at this stage involved only static news image and not with video formats; thus, elements such as more complicated

animation, text fonts, etc., were not included. Compared to other media effects studies that involve multiple modes, this study focuses on the factor of color. Thus, the present study does have some limitations on this issue.

An actual example of the stimulus image is shown in Fig. 5, where the image was divided into three parts, the upper part was the stimulus body (A), the middle part was the corresponding image number and *control* text (B), and the lower part was the scale (C). Within the part A, the OCT pattern was colored by bright tone (left) and deep tone (right), compared with the vivid tone (center) as the control tone condition. The area ratio of OCT in the present news scenes is about 20.52%, which is the result of the calculation based on the above design size. As a reference, this ratio is about 24.55% in the upper right of Fig. 1 and about 15.16% in the lower right of Fig. 1, which depends on the specific application scenario, and there is not yet a uniform specification about this ratio. Part B is the numbering of the randomly arranged stimulus images. Part C is the evaluation scale, where 50 was circled by a white-background box for emphasis.
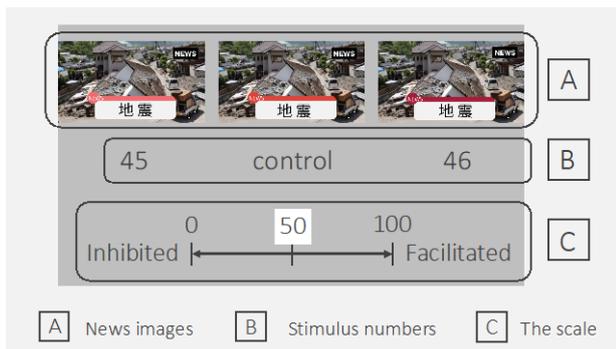

Fig. 5 | An actual stimulus example of tone manipulation by red hue on the earthquake scene. Within the figure, from the left to the right of this stimulus (A), the colored OCT is observed as bright tone (the number of 45), vivid tone (the text of control), and deep tone (the number of 46).

2.2 Participants

Thirty-two students and staff, including but not limited to Hokkaido University, were recruited, including twenty-two Chinese and ten Japanese. There were 20 males and 12 females (20–55 years, $M = 28.69, SD = 8.39$). Of all participants, 20 indicated that they had never participated in similar experiments before, including one affiliated with Hokkaido University; 12 indicated that they had participated in psychological experiments before, including four that they had participated in experiments similar to the current experiment more than twice, and the remaining eight indicated that they had hardly participated in experiments similar to the current experiment before, all affiliated with Hokkaido University.

Of all participants, 20 indicated that they participated in this experiment by wearing colorless and clear myopic glasses, and 17 of them indicated that they wore myopic glasses on a daily basis. The remaining 3 participants had clear, colorless myopic glasses but did not wear them on a daily basis, and they only wore them when reading or watching video. All participants who wore glasses were asked to make sure that the lenses were clear and non-tinted during the experiment. Wearing other eyewear other than for vision correction, including but not limited to sunglasses, etc. was not acceptable in this experiment. Regarding color vision, all participants indicated that they had previously been given and passed the Ishihara test. Thus, all had normal or corrected-to-normal visual acuity and color vision. The participants were provided with informed consent at the beginning of the experiment.

2.3 Procedure

The experiment was divided into a preparation stage and a conduction stage. Regarding the preparation stage, participants confirmed and complied with the following requirements. It included that stay in a relatively quiet indoor environment, and the room equipped with a 60W white fluorescent lamp illuminated from the ceiling. Prepare a piece of A4-sized paper and a pen in advance. Prepare a fully charged 9.7-inch iPad (see more detail in Apparatus), and download the experiment PDF file (the Japanese and Chinese versions available) via the Internet to run on the iPad (adjust to the single page display mode). Set the iPad to landscape mode, and place the iPad on a horizontal table. Sit upright in front of the iPad, and maintain the eyesight perpendicularly to the iPad screen, and keep eyes at a distance of 40 cm (measured by a straightedge) from the iPad front. During the experiment, little breaks was permitted.

When the above operation is ready, the conduction stage begins. This experiment itself was conducted via PDF file. Within the PDF file, based on the Japanese and Chinese translations, as shown in Fig. 6, two major parts were included, i.e., the instructional pages and the stimulus images pages. The instruction pages consisted of a description page, a caution page, a news images page, an evaluation scale page, a control images page, an answer sheet, an answer format page, and a consent form page. Then, the actual trials pages followed.
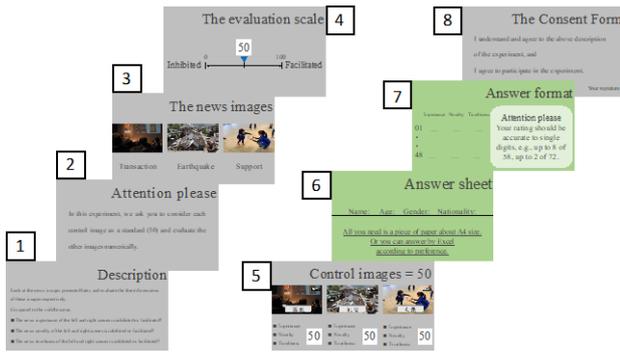
Fig. 6 | The procedures of instruction consisted of the description page, the caution page, the news images page, the evaluation scale page, the control images page, the answer sheet, the answer format page, and the consent form page.

The description page described what needs to be done for the experiment. Specifically, look at the news images presented later, and evaluate the three dimensions of these images respectively. Compared to the middle scene, the news importance of the left and right scenes is inhibited or facilitated? The news novelty of the left and right scenes is inhibited or facilitated? The news timeliness of the left and right scenes is inhibited or facilitated?

The caution page highlighted the significance of the reference value, i.e., 50. The news images page, from left to right, presented the news scenes used in this experiment, i.e., transaction, earthquake, and support.

The evaluation scale page, the evaluation scale used in this experiment was a 101-point scale (0–50–100) [34], which appeared in the center of the screen. A blue inverted triangle on the scale pointed to the middle of the scale, which is 50, indicating the value of the news scene with the OCT colored by the vivid tone corresponding with a chromatic hue. The interval of 0–50 indicated that the corresponding news value of the news scene was lower than the control condition, i.e., 50, while the range of 50–100 indicated that the corresponding news value of the news scene was facilitated. Thereafter, the control images page presented, in which three news scenes with the image of OCT by gray color appeared. Below each news scene, the three news value dimensions were presented, and to the right side of the dimension texts was the reference value, i.e., 50 written in black on a white background.

The answer sheet and answer format page (an Excel format file was also attached), with a light green background, required participants to fill in personal information (answer with pen and paper) and record their answers (note: your answer should be accurate to single digits), respectively. Finally, there was the consent form page, where participants were required to sign a consent form for the entry. Above, all the steps in the experimental instruction are introduced.

Regarding the order of the trials, each of the three news value dimensions was evaluated independently, i.e., first all trials of the news importance dimension were conducted, then all trials of the news novelty dimension were conducted, and finally all trials of the news timeliness dimension were conducted. As shown in Fig. 7, the trials order within each news value dimension was a random arrangement, i.e., one of the three news images appeared randomly each time, as well as the OCT pattern was randomly colored by one of the eight chromatic hues at a time. The onset of each trial was with a fixation i.e., +. Then, the recommended duration between the fixation and stimulus (see Fig. 5) was 10s, since the PDF file does not seem to account for the duration parameter, after which the responses began.

Fig. 7 | The order of the trials within each news value dimension was a random arrangement.

Except for the control image (center), each target image (left and right) to be evaluated was set with a unique number, i.e., the image number. In this way, the number of targets to be evaluated for each news value dimension was: 2 tones × 8 hues × 3 news = 48 trials. The total number of targets to be evaluated for the three news value dimensions was: 48 trials × 3 dimensions = 144 trials. Counting the time for reading the experimental instructions, the whole experiment took roughly 30 minutes.

3 RESULTS

3.1 The effects of color in the perception of news value

Based on the design (2 tones × 8 hues × 3 contexts), a repeated measures ANOVA was conducted. According to the results, concerning the parameter of tone, the perception of the importance of news scenes changed, and

there was a significant difference between the bright (Br) and deep (Dp) tones (F [1, 434] =16.31, p <.001). Significant differences were observed in the interaction between tone and emotional context (the news images) (F [2, 434] = 7.39, p <.001), which suggests that regardless of the kind of OCT hue, both factors act on the cognition of news importance simultaneously. Furthermore, the interaction between tone and hue showed significant differences (F [7, 434] = 5.76, p <.001), which indicates the effect of certain colors and the relatively weaker context dependence. However, there was no interaction between tone, hue, and context, which reflects that the processing effect between the conditions composed of these parameters was similar and implies that other factors may affect the visual perception of news value, i.e., the multimode of the visual contents such as sound or other non-visual factors.

Regarding the main effect of the tone (Fig. 8), there was a significant difference between the bright condition and the deep condition, and the importance of the news scene in the deep condition was stronger than that of the bright condition (t = -4.04, p <.001), which suggests that news with deep tone OCT was perceived as more important than news with bright tone OCT.
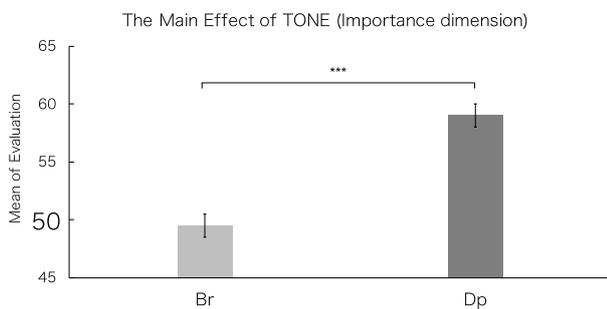

The Main Effect of TONE (Importance dimension)

Fig. 8 | The main effect of tone on the perception of the importance dimension (∗∗∗ : p <.001; ∗∗ : p <.01; ∗ : p <.05, and the error bar represents SE in this paper).

Concerning the interaction between tone and context, as mentioned in the main effect of tone, the performance of the bright tone is lower than that of the deep tone in all contexts. As shown in Fig. 9, the significant difference can be observed in the neutral context and the negative context, i.e., the OCT with deep tone makes the news look more important than that of the OCT by bright tone in the neutral context (t = -3.79, p = .004). Similarly, the OCT with deep tone makes news look more important in the negative context than that of the OCT with bright tone (t = -4.98, p <.001). In condition of positive context, the cognition of news importance was not significantly

different in the processing of the two tones. Thus, the deep tone was more inclined toward the cognition of the importance of negative news, which reveals that the effects of tone are context-specific.

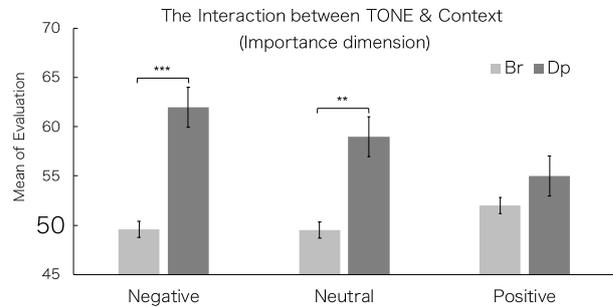The Interaction between TONE & Context (Importance dimension)

Fig. 9 | The interaction between tone and emotional context on the perception of the importance dimension.

As shown in Fig. 10, the overall interaction between tone and hue was consistent with the above; the performance of deep tone was stronger than bright tone, and significant differences were observed in the hue of red (t = -5.14, p <.001), green (t = -4.10, p = .009), and purple (t = -5.26, p <.001). Although there were differences in other hues, they were not significant, and the differences in warm colors were smaller than those in cool colors. It is worth noting that the difference between the two orange tones was the smallest, and the mean value of bright orange was higher than other hues within the same tone. The hue of purple by deep tone was stronger than other intermediate colors in terms of the indication of news importance.

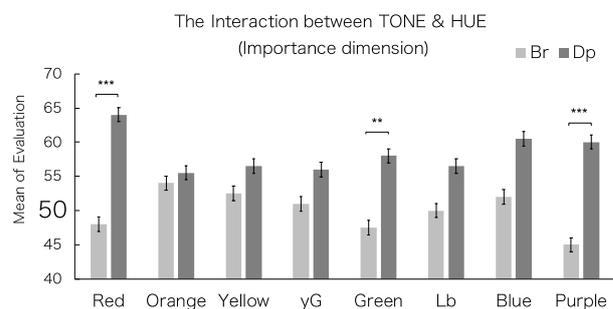The Interaction between TONE & HUE (Importance dimension)

Fig. 10 | The interaction between tone and hue on the perception of the importance dimension.

Concerning the cognition of news novelty, the main effect of tone factor showed significant differences (F [1, 434] = 45.20, p <.001), and the interaction was also

significantly different between the factors of tone and hue (F [7, 434] = 8.08, p <.001), which suggests that the color of OCT does have certain influences on the visual freshness of news content, but needs to correspond with specific news context.

However, there was no significant difference between the factors of tone and context on the interaction, which was unexpected and suggests that regardless of the kind of news, the effect of the tone of OCT may be the same. However, the tone by itself had a strong novelty indicating effect. There was no significant difference in the interaction between tone, hue and, context. In addition to the above-mentioned third-party parameters that may exist other than color vision, there were hints at the limitations of color in visual news. As believed by other researchers, color plays an auxiliary rather than a fundamental role in the process of this kind of news dissemination[9, 31], i.e., the importance and novelty of news and the timeliness of transmission themselves may affect news perception with the color factors simultaneously.

As shown in Fig. 11, the significant difference between the main effects of tone factor was mainly reflected in the novel feeling of the bright tone, which presented visual freshness generally better than the deep tone (t = 6.73, p <.001). It is worth noting that the tone performance was totally different from the importance dimension.
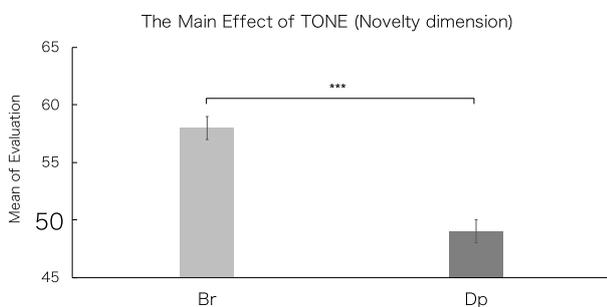

Fig. 11 | The main effect of tone on the perception of the novelty dimension.

In the interaction of news novelty perception between tone and hue, as shown in Fig. 12, the mean values of the two tones in red, green, and purple were very close. By contrast, the two tones combined with other hues showed huge and significant differences in the OCT news scenes. Specifically, the orange in the bright tone far exceeded the deep tone (t = 6.43, p <.001). The yellow in the bright tone also performed better than that of the deep tone (t = 6.77, p <.001). The yG color by the bright tone was better than that of the deep tone (t = 4.43, p = .002), bright Lb color was better than the deep tone condition (t = 5.17, p <.001),

and bright blue was significantly different from the deep blue (t = 4.47, p = .001). According to the feedback from participants, there was visual closeness between the test conditions, i.e., bright tone or deep tone and the control condition, i.e., vivid tone in the red, green, and purple, which reflects the stability of these three chromatic hues.
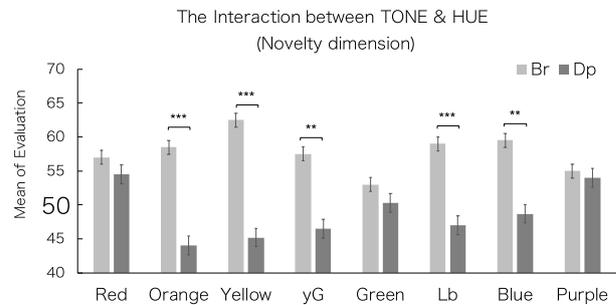

Fig. 12 | The interaction between tone and hue on the perception of the novelty dimension.

The visual cognition of news timeliness is that what kinds of colors could enhance the temporal newness of news, or what kinds of colors would inhibit the recency expression of news. Based on this analysis, there was a large cognitive difference between the timeliness dimension and the other two news value dimensions. The fact that there was no significant difference in the main effect of the tone reflected. By calculating the mean value of the bright tone and deep tone, we found that both conditions were approximately equal to 54, and they both were higher than the control condition of 50. Therefore, both tones had the effect of facilitating news timeliness, and their effects were at the same level.

The interaction between the factors of tone and context was significant (F [2, 434] = 10.87, p <.001). When the OCT manipulated by bright tone, the news scene with a positive context seemed more time-sensitive than the negative context (t = -2.96, p = .049) (Fig. 13), whereas in the deep tone condition, the news scene with a negative context were perceived as temporal fresh than in the positive context (t = 4.81, p <.001). This contradicted the above bright tone and indicates that the combination of tone factor and specific context can make news timeliness more targeted. The news timeliness of the neutral context also seemed stronger than that of the positive context within the deep tone condition (t = 3.05, p = .04). Thus, when the bright tone OCT adopted, news scenes with a positive context may be perceived as timely and fresher, whereas news scene with a negative context could present more time recency against the deep tone OCT.
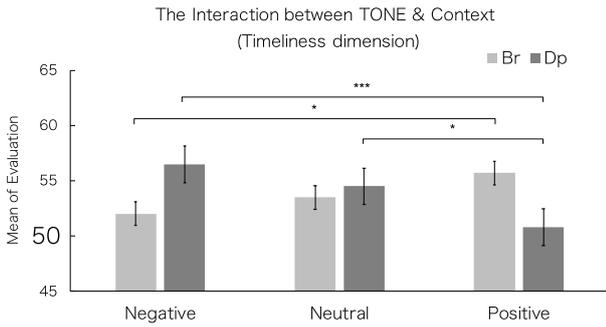
Fig. 13 | The interaction between tone and emotional context on the perception of the timeliness dimension

The interaction between tone and hue mainly reflected the following tendency. The timeliness of news scenes in which the OCT was colored by deep tone red was higher evaluated than that of the bright tone, but there was no significant difference between the two tones (Fig. 14). The news timeliness of deep-tone red was significantly stronger than that of yellow (t = 3.63, p = .038), yG (t = 3.59, p = .044) and Lb (t = 5.17, p <0.001) colors within the same tone, while the bright-tone red was generally lower than these three hues within the same tone condition. The news timeliness performance of orange color in the bright tone was significantly better than that of purple within the same tone (t = 3.54, p = .022). This difference indicates that in addition to the primary hues, there is also a clear difference in the strength of the temporal indications between the intermediate hues in a specific tone.
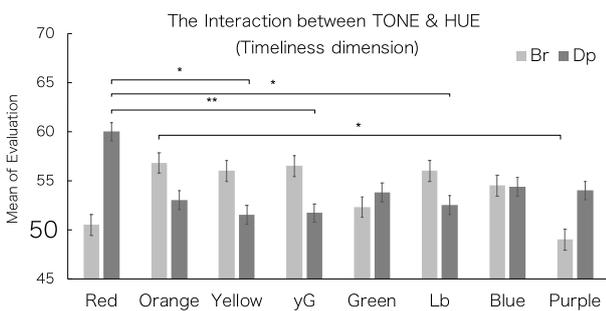

Fig. 14 | The interaction between tone and hue on the perception of the timeliness dimension.

3.2 The news value integration by color in the emotional contexts

In journalism practice, whether one color can integrate the three news values simultaneously, as well as the integrated

extent and trend, needs to be considered. According to the emotional contexts, 3D spaces that can present the three news values simultaneously were created. As shown in Fig. 15, the value perception of the different news scenes after tonal processing deviated from that of the control condition, i.e., the star-shaped origin. This suggests that a close relationship between tone and emotional context affects the perception of news value to a certain extent.

Fig. 15-1 shows that in the negative context, the overall performance of bright tone and deep tone had a distribution from the upper right to lower left. Regardless of tone, the hues were mostly distributed independently in space. We also observed that the deep tone was spatially located on the right side of the bright tone, which revealed that the deep tone had a greater impact on importance indication.
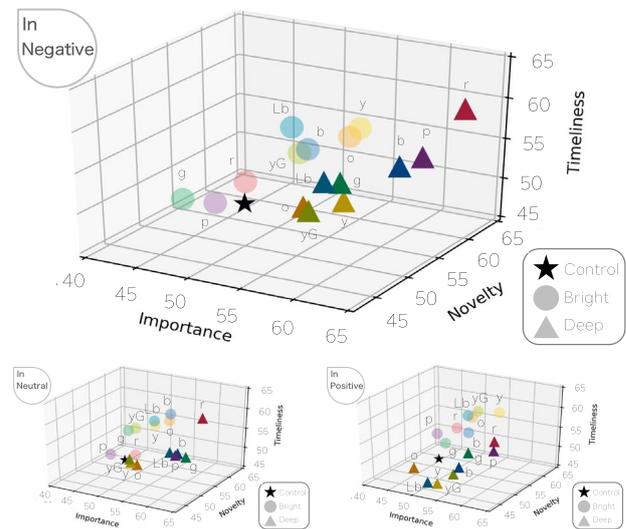

Fig. 15-1 | The integration of three news values in the negative emotional news context presented by the space. The spaces of neutral (left) and positive (right) were shown in the lower position as conferring information.

The red in deep tone was always in a more eye-catching position.[21] In the negative context, the overall performance of red was the most prominent, and the integration of these three news value categories as importance (I), timeliness (T), and novelty (N) were significant respectively (r $_{[I, T]}$= .713, p <.001; r $_{[I, N]}$= .513, p = .003; r $_{[N, T]}$= .444, p = .011), although the correlation of the latter two was not as stronger as that of the former.

The location of deep-tone yellow was at the bottom of the space as a whole; thus, it was difficult to integrate the dimension of timeliness. By contrast, the bright-tone yellow achieved a better combination of importance and timeliness (r $_{[I, T]}$ = .711, p <.001), as well as novelty and

timeliness ($r_{[N, T]} = .607$, $p < .001$).

Green was weak enough to perform in the domain of timeliness, and the deep tone was no exception. It is worth noting that, in the negative context, there was a negative correlation between importance and timeliness ($r_{[I, T]} = -.069$, $p = .706$), although it was not significant. This suggests that green with the deep tone cannot integrate the two dimensions. Green with the bright tone was on the far left of the lower left side, and the integration of news values was very limited.

Regarding blue, the deep tone tended to be suitable in the negative context, while the bright tone blue tended to fit the neutral context. In the negative context, the deep tone blue was in the upper right direction, and its importance was second only to red condition, while novelty performance showed the negative effect, although the negative correlation between the two was not significant ($r_{[I, N]} = -0.55$, $p = .763$), which suggests that the news value was less integrated with the deep tone condition. The bright tone blue was the opposite, effectively integrating the two dimensions of novelty and timeliness ($r_{[N, T]} = .650$, $p < .001$).

In the negative context, the deep-tone orange was on the right side of the control, pointing in the important direction same as other deep-toned hues. The correlation between importance and timeliness showed significance ($r_{[I, T]} = .588$, $p < .001$), hinting at a time-sensitive tendency compared to other hues. In the bright tone condition, novelty, and timeliness were significantly higher integrated ($r_{[N, T]} = .786$, $p < .001$).

The yG color by deep tone, integrated the importance and timeliness dimensions ($r_{[I, T]} = .480$, $p = .005$), but it was inferior to the other hues based on its effectiveness. Its novelty performance had a negative effect and was biased toward the vertex, which highlights importance and time sensitivity but lacks novelty. The bright tone slightly improved the visual importance of news, and novelty and timeliness also tended to the backside, but there was no significant correlation ($r_{[N, T]} = .085$, $p = .644$); thus, the integration was not sufficiently clear.

The Lb color, the deep tone visually showed the same level of news timeliness as active as purple in the negative context, and the indication of news importance showed the same level effect as active as the yG color, with a tendency to the vertex that represents important and time-sensitive while lacking novelty, but no significant correlation was observed; thus, the degree of integration is not satisfactory. The bright-tone Lb color shows as higher as the yellow on the timeliness, and the novelty was close to orange, but the importance dimension shows a passive expression; thus, the integration of news value stays in the dimensions of news novelty and news timeliness ($r_{[N, T]} = .419$, $p = .017$).

Regarding purple, in the negative context, the deep tone tends to upper right vertex visually, and the importance is the same as other hues; thus, the news importance in deep tone has an effect, and the news timeliness is active, but no significant correlation was observed between them ($r_{[I, T]} = .253$, $p = .162$). At the same time, it is very different from the other deep-toned hues because of its positive effect on novelty perception, and it is worth noting that the mean value of novelty is close to red. The correlation between novelty and timeliness was significant ($r_{[N, T]} = .567$, $p < .001$). The purple by deep tone can effectively integrate the news value of the two dimensions. The purple by bright tone is around the control origin, which reveals that the effect is determined by tone manipulation.

As shown in Fig. 15-2, in the neutral context, the distribution of both tones showed a stacked situation, which suggests that the effect of manipulation within this kind of tone or hue was relatively closer. The overall distribution visually tended to be more up and down. In particular, except for red, the other deep-toned hues were below the bright tone accordingly, which indicates that the timeliness of news scenes colored by bright-toned OCT was better than those colored by deep-toned OCT in the neutral situation.
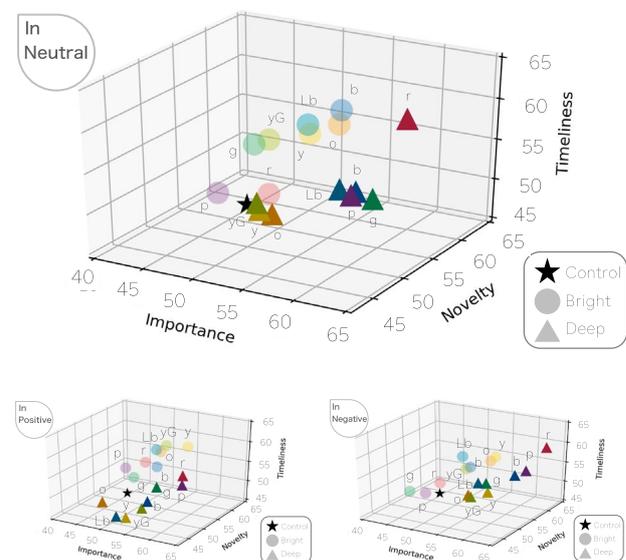

Fig. 15-2 | The integration of three news values in the neutral emotional news context is presented by the space. The spaces of positive (left) and negative (right) are shown in the lower position as conferring information.

Within the neutral context, the news value perception of deep-tone red is slightly lower than that of the negative context, and the overall position moves to the lower left, and the correlation between importance and novelty

dimension is lower, i.e., the directional trend of a single news value (r $_{[I, N]}$ = .189, p = .300), but the news novelty and news timeliness were integrated to a certain extent (r $_{[N, T]}$ = .543, p = .001).

The deep-tone yellow was very close to the control condition, indicating there is a harmony integration within the neutral context, but limited by the size of effect considering the mean values of the evaluation (r $_{[I, N]}$ = .537, p = .002; r $_{[N, T]}$ = .559, p <.001; r $_{[I, T]}$ = .448, p = .010). Besides, the bright-tone yellow is significantly correlated in terms of the integration of the news novelty and news importance (r $_{[I, N]}$ = .721, p <.001).

The green by the deep tone was clear in importance dimension, while the green by the bright tone moved diagonally to the upper right, indicating news novelty. Other negative effects, such as news importance, are reduced, and timeliness was moderate. The value integration within green is relatively general in the neutral context.[18]

The blue is similar to green within the deep tone, i.e., the news importance is clear. Also, under the bright tone condition, a remarkable integration of novelty and timeliness was presented (r $_{[N, T]}$ = .761, p <.001).

The deep-tone orange was closer to the control condition, and the integration of news values is weak. While, the orange color by bright tone expresses the significant correlation between novelty and timeliness by a limited effect in the neutral situation (r $_{[N, T]}$ = .424, p = .016). The deep-tone yG color is the same as above, and it also integrates the news importance and timeliness as the passive impression feedbacked from part of the participants (r $_{[I, T]}$ = .499, p = .004). As the bright-tone yG color, the integration of novelty and timeliness is significantly correlated (r $_{[N, T]}$ = .599, p <.001), which suggests that different tones may have an influence on the expression of news timeliness in emotionless scenes. The deep-tone Lb color almost overlaps with blue. The Lb color by bright tone is the same as above, and it also integrates the news novelty and timeliness, showing a relatively higher correlation (r $_{[N, T]}$ = .650, p <.001) than that of the negative context.

The purple by deep tone is similar to the blue; hence, it will not be repeated. The purple by bright tone can refer to the performance in the negative context mentioned above, given its stable performance.

As shown in Fig. 15-3, from the perspective of positive context, within the coordinate，the distribution of all targets visually comes into an S-shaped trend as a slope, toward the lateral oblique direction, given that the perception of the importance dimension tends to be stable. We observed that the integration of novelty and timeliness in the bright tone was better than in the deep tone.
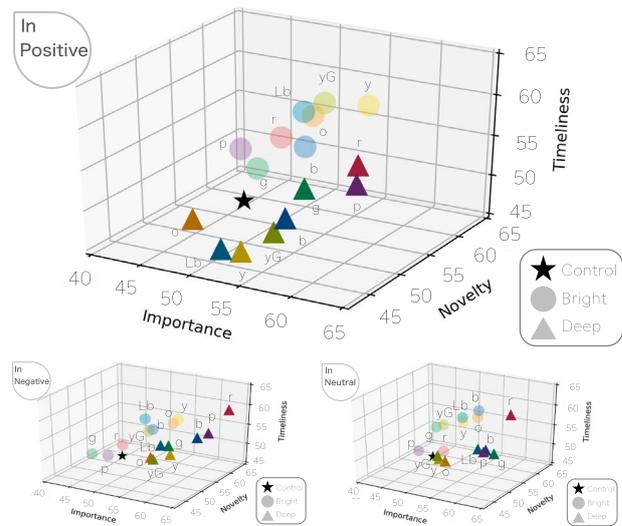

Fig. 15-3 | The integration of three news values in the positive emotional news context is presented by the space. The spaces of negative (left) and neutral (right) were shown in the lower position as conferring information.

The deep tone of red once again showed a tendency to move toward the lower left, and both the news importance and timeliness decreased simultaneously, and the correlation coefficient between the two dimensions is significant (r $_{[I, T]}$ = .647, p <.001). While the novelty changes little, the integrations with the timeliness and importance after that reduction are significant respectively (r $_{[N, T]}$ = .550, p = .001; r $_{[I, N]}$ = .651, p <.001). This indicates that the importance of deep tone is limited to a specific context.

The deep-tone yellow reached the lowest evaluation among all hues in the novelty dimension, and timeliness also appeared a passive effect. The correlation between the two was significant considering the simultaneous reduction (r $_{[N, T]}$ = .550, p = .001); thus, yellow may not be suitable for integrating these news values. However, bright yellow exhibited the opposite features, and its expressiveness was similar to that of the negative context.

The deep-tone green is better than other hues, except for the same tone red in the news timeliness expression. Also, the correlation between the news novelty and timeliness is significant (r $_{[N, T]}$ = .559, p <.001). The distribution of bright green locates in the middle of the space, which better balances the integration relatively (r $_{[N, T]}$ = .758, p <.001; r $_{[I, T]}$ = .684, p <.001; r $_{[N, I]}$ = .580, p <.001), although the effect is limited as its moderate mean value.[4]

The blue by deep tone still pointed to importance, whereas the correlation between novelty and timeliness

was significant, as the simultaneous reduction (r $_{[N, T]}$ = .668, p <.001), and the overall degree of integration was slightly lacking. Based on the bright tone, blue points to the integration of importance and timeliness (r $_{[I, T]}$ = .687, p <.001), with a rare novelty focus; thus, the integration was not sufficient in the positive context.

The deep tone of orange inhibited the simultaneous expression of importance and novelty, and timeliness was closer to the control origin. Here, the deep-tone orange made it difficult to integrate news value into the positive context. Regarding the bright tone of orange, novelty, and timeliness had a significant correlation (r $_{[N, T]}$ = .594, p <.001) as we expected.

The deep-tone yG color tended to visually lean toward the base side, which indicates that novelty and timeliness were reduced, although the correlation between them was significant (r $_{[N, T]}$ = .537, p = .002). Nevertheless, it did not have a reasonable integrity of news value. The position of the bright-tone yG color was higher overall, and its performance was even close to that of yellow. Its novelty performance was not inferior to that of the other hues within the same tone. Its expression of importance was in the upper grade within the intermediate color, and the correlation between news values was significant generally (r $_{[N, T]}$ = .727, p <.001; r $_{[I, T]}$ = .555, p <.001; r $_{[I, N]}$ = .549, p <.001), which suggests that this color condition can achieve the news value integration.

Lb color by the deep tone visually tended closer to the lower part of the front side, which revealed that novelty and timeliness lost their effectiveness, although we observed a significant correlation between them (r $_{[N, T]}$ = .602, p <.001). The importance of the bright Lb color was the same as that of the deep tone of those mentioned above. Therefore, its performance in the integration of news values was poor.

The deep-tone purple was visually close to the right side of the space, and it showed positive effects on the three dimensions. The correlations between them are significant respectively (r $_{[I, T]}$ = .702, p <.001; r $_{[I, N]}$ = .565, p <.001; r $_{[N, T]}$ = .535, p <.001), indicating that the integration of purple under this situation was relatively feasible. Although purple by the bright tone was a little different from that of the above, it was located above the control and closes toward the inner vertex of the space, which indicates that timeliness and novelty have been enhanced. According to the correlation coefficient, there was a significant correlation between the two dimensions (r $_{[N, T]}$ = .721, p <.001). Therefore, it can be said that purple can partially integrate news values.

4 DISCUSSION

The effects of OCT color on news value perception were investigated by using the three tones corresponding with eight chromatic hues in the news emotional contexts. The results revealed certain effects of color in the single news value dimension and the integrated situation. We found that the tone of OCT color has a completely different impact on different value dimensions in the specific context, which suggests that not only the hue but also the tone may affect the news value perception in specific journalistic work and practice. Under the specific conditions of color and context, the extent of news value integration indicates that using the advantages of certain colors may effectively facilitate the news value perception, which can promote news transmission and vice versa.

The deep tone may make news scenes look more important compared to bright tone. This effect was mainly reflected by the negative context and the neutral context, whereas the positive context did not show any significant difference[1], which suggests that the OCT color, especially the tone, may influence the viewer's perception associated with the emotion originating from the contents itself. Further, the integration figures show that the news importance was closer to the negative context than to the positive and neutral context by the deep tone OCT, which is in line with the insight, i.e., bad is stronger than good.[6]

Contrary to the importance dimension, the bright tone may make the news perceive more novel than the deep tone. The results show that the mean value of bright tone was higher than that of deep tone. Interestingly, between the two tones, significant differences were observed for red, green, and purple in the importance dimension, while there was no significant difference in the novelty dimension, and the opposite is true for the other hues. Moreover, the distributions of deep-toned red, green, and purple were on the relative right side in the neutral, positive, and even the negative context (see Fig.15), which indicates that even the OCT with the deep tone, these three hues can still hold the news novelty to certain extent[10], which is distinctly different from the other deep-toned hues. The performance of bright colors, e.g., the orange and yellow as the main force leading should be considered, and the blue that suddenly rose is noteworthy. This reveals that warm color such as orange and yellow with bright tone, have better novelty directionality in the news context. As for the cool color, the blue series in bright tone was relatively more suitable for news novelty than deep tone, especially the Lb color.

Unlike the above dimensions that present an obvious unilateral tendency, the timeliness dimension falls into a more complicated blending state, i.e., the mean value of deep-tone red, green, and purple was higher than that of

bright tone, while the orange, yellow, yG color, and Lb color by bright tone was higher than the corresponding deep tone. The blue by these two tones almost appeared to overlap. The deep tone performance was extremely consistent with the other two dimensions. The integration analysis also revealed the diversity in which red integrated timeliness and importance in the negative context; green achieved an integration of timeliness and novelty in the positive context; as for purple, the integration of novelty and timeliness was shown in the negative context; and the integration of the three dimensions in the positive context was significant. By contrast, several participants reported that the part of the intermediate hues colored by deep tone made them feel psychologically oppressive; thus, their sensitivity to time perception after the experiment became lost, while the primary hues did not feel that way.

In summary, color can carry meaning[3], and OCT as a medium may contribute to the achievement of color meaning in the news context. The OCT tone and hue can influence the cognitive differentiation on a single news value dimension and achieve varying degrees integration on multiple news value dimensions simultaneously. This study practically provides an applicable color scheme while discussing the cognitive effects of color in the scope of news. As to whether the more complex situations involved in OCT itself, such as design forms, fonts, and animations, affect the perception of news value, and how the audio-visual coordination involved in OCT in dynamic visual content affects the perception of news value, it is necessary to clarify them in a series of studies and discussions in the future.

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AUTHOR BIOGRAPHIES

GONG LI received B.A. degree in Journalism from Business College of Shanxi University in 2013, and M.A. degree in Publishing from Nanjing University in 2016. He is currently engaged in the PhD program in the Department of Psychology at Hokkaido University. Through his major background in journalism, publishing, and psychology, he is interested in the cognitive effects between vision and media.

YASUHIRO KAWABATA, PhD, received B.A. and M.A. degrees in psychology from Hokkaido University. After receiving his Ph.D. from Hokkaido University (Sapporo, Japan) in 1993, he held research posts at Ritsumeikan University (Kyoto). In 1999, he returned at Hokkaido University, where he now serves as a Professor in the Department of Psychology. His research interests have included color vision modeling in a changing visual environment, color pattern recognition, and memory.