Improving visibility and reducing resistance of writers to fusion of handwritten and type characters

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Abstract. Most Japanese people feel happy to receive a handwritten message, but they often have resistance to writing a message by hand. One of the reasons for this is that they are shy about showing their handwriting to others. In this study, we consider a technique that fuses handwriting with typeface in order to reduce the resistance to handwriting and improve the impression of the message. Experimental results demonstrate the visibility and readability of the considered fusion technique and show that the resistance to sending handwritten messages fused with typeface can be decreased.

Keywords: Handwriting, Type Characters, Fusion Character.

1 Introduction

Computers and smartphones can be used to easily input typeface characters by means of a keyboard or flick operation. This has led to an inevitable decrease in handwritten notes and letters. However, according to a survey on handwriting by Zebra Corporation [1], 90% of Japanese people have very positive feelings about handwritten messages. In addition, according to a public opinion poll by Japanese Agency for Cultural Affairs [2], almost half of the people in Japan who participated in the opinion poll tend to feel that they should handwrite greeting cards and letters, presumably because handwritten text contains the unique characteristics of the writer and can emphasize their sincerity from the trouble of writing something by hand.

On the other hand, most Japanese people actually have resistance to handwriting a message themselves. Zebra Corporation [1] found that more than 80% of Japanese people are aware that they are bad at handwriting. In general, they tend to feel it is troublesome to write by hand, and they are often ashamed of showing their handwritten text to others. In fact, according to the Zebra survey, more than half of Japanese people have a negative impression of their own handwriting.

As stated above, everyone can use computer fonts on computers or smartphones, and create a beautiful text message. People can choose a suitable font for the situation because there is a huge number of computer fonts available in the world today. Universal design (UD) font is based on the concept of "a design that as many people as possible can use" [3]. Computer fonts have several advantages, including visibility (i.e., people can recognize the characters at a glance), readability (i.e., people can easily read the

characters), and legibility (i.e., people are less prone to reading error and illusion) [4]. UD font is made in consideration of these three functions.

Handwriting has its own advantages in that people feel a personal touch and appreciate the trouble that was taken while writing, but the main problem is that people are resistant to showing their handwriting to others. Although with computer fonts people can easily create messages beautifully, the disadvantage is that the personal touch and the trouble taken are lost.

The objective of our work is to reduce resistance and embarrassment pertaining to one's own handwriting and help promote feeling of warmth and joy in the reader when they receive a message comprised of a fusion of handwriting and typeface.

To this end, we performed an experiment to evaluate the impression of a sentence on a message card written in characters that are a fusion of handwriting and UD font by means of a method proposed by Saito et al. [5]. Specifically, we examined through experiments how the readers and writers evaluated the visibility and readability, as well as the writer's resistance to sending the message card to the others when the fusion characters are used on a message card.

The contributions of this paper are as follows.

- We demonstrate that the resistance of the writer to fusion characters is less than that to handwriting.
- We demonstrate that the fusion characters retain the characteristics and warmth that handwriting has.

2 Related Work

There have been many studies related to handwriting at this point.

In terms of researches on how to help writers produce beautiful handwriting, Zintnick [6] et al. proposed a technique where the degree of coincidence of strokes written at that point is calculated by utilizing the curvature, and the handwriting of an individual user is beautified by determining where its degree of coincidence is high and averaging it. Xia [7] et al. proposed a technique in which handwriting is approximated to the character of an exemplar by applying a template of the exemplar to the handwriting, and the printed style of written Chinese characters of the sculptural handwriting style is generated using a method that generates the printed style of written Chinese characters. A study by Kurihara [8] et al. is often cited as an important work on how to predict handwriting based on ambient multimodal recognition. Specifically, they developed a "Speech Pen" that supports users when taking of handwritten lecture notes by matching speech recognition with online handwriting recognition.

As for researches on changing the impression of the handwriting by altering and embellishing it, Kambara [9] et al. proposed "Onomatopen", which can draw textured lines or shapes based on onomatopoeia such as "zig-zag" and "tick-tock" provided by the user when writing by hand.

The studies above focused primarily on the handwriting itself, along with its embellishment. In the present work, we go one step further by demonstrating that the characteristic warmth and trouble of writing something by hand can also be felt in the fusion characters of the handwriting and UD font.

Researches that focuses on the characteristics of typeface are also slightly different from ours. Lin [10] et al. conducted a research on generating the font of several thousand or more Chinese characters and symbols; specifically, they conflated Chinese characters by means of the components of characters extracted from the users' handwriting. With this technique, it is possible to generate Chinese font by handwriting 400 Chinese characters. Bernard [11] et al. examined the different preference of the older population when reading passages containing two serif and sans serif fonts at 12 and 14-point sizes. They found that 14-point fonts can be read faster than 12-point fonts, were more legible, and were more preferred by the participants. In a similar study, Cai [12] et al. measured the minimum visible font size for the most commonly used Chinese characters in the Ming, Kai, and Li styles and found Ming to be the most legible, followed by Kai and then Li. They also showed that both the character style and the number of strokes have a significant impact on the legibility. Liu [13] et al. investigated the effects of font size, stroke width, and character complexity on the legibility of Chinese characters and found that the font size and character complexity have a significant effect on the legibility, but the stroke width does not have much importance.

The studies above examined the font itself and the changes to reader impression by transformation of the shape of the font. However, it is not clear what happens to the visibility and readability of the fusion character of handwriting and typeface, and what its characteristics are. For this reason, we investigate the fusion character and clarify the visibility characteristics and the resistance of the writer.

3 Building the Data Set

We performed an experiment to clarify how handwriting, typeface, and the fusion character used in simple sentences are evaluated by the writer and the reader. Specifically, we built a data set consisting of message cards with each of the three styles to determine the impressions.

First, we used Saito et al.'s method [5] to generate the fusion character. This method represents type character as a numerical formula that parameterizes "t" by performing Fourier series expansion to change the character's core and thickness. It also uses the weighted average of the typed character's numerical formula and the handwriting's numerical formula. The generation of the character at the fusion ratio between handwriting and type character of 0.0 (handwriting), 0.5 (fusion character), and 1.0 (type character) using this method is given in Fig. 1.

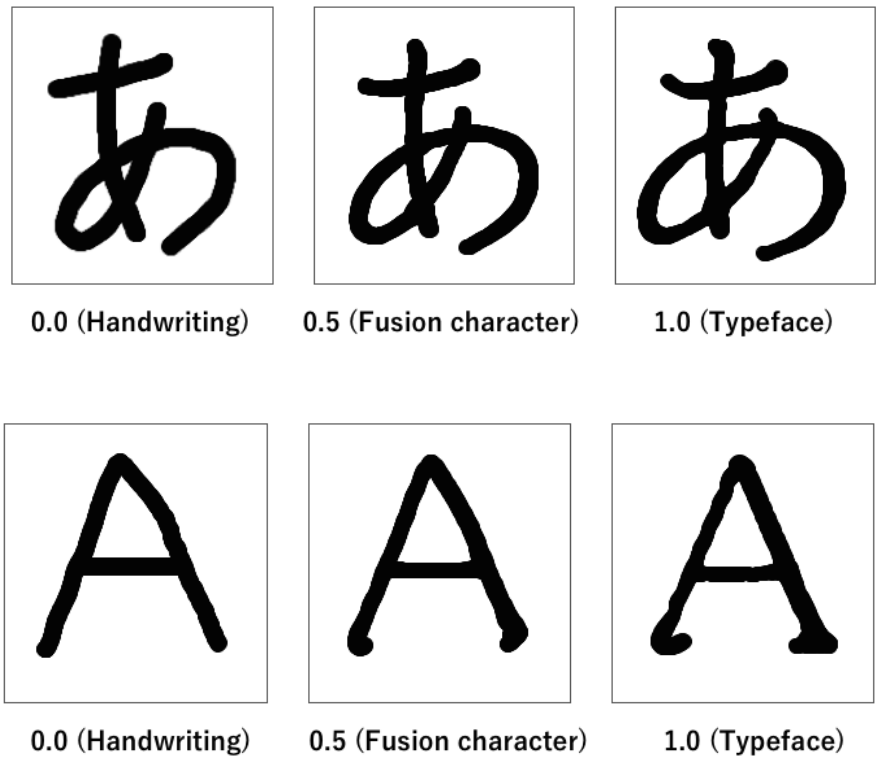

Fig. 1. Japanese character "あ" and English character "a" of the fusion ratio between handwriting and type character at intervals of 0.5 between 0.0 and 1.0.

Prior to the experiment, we selected a phrase "Thank you", which is commonly written in a variety of gratitude and farewell situations. The main reason we selected this phrase is that it is so frequently used in messages. Also, since it is a short phrase, the stroke order and stroke count do not vary much from person to person.

Two fonts were selected for fusion with the handwriting: "BIZ UDP Mincho" and "BIZ UDP Gothic", both of which were generated by Morisawa [14]. We selected these fonts because Mincho and Gothic are among the most commonly used fonts. Each font was mathematized in advance using Saito et al.'s method [5].

BIZ UDP Mincho
BIZ UDP Gothic

Fig. 2. UD fonts used in the experiment

When building the data set, we requested 15 participants (four males, 11 females) to imagine a situation that they were writing a message card to a close friend and write the phrase of "*Thank you*" in Japanese on a tablet computer. Their handwriting was mathematized using Nakamura et al.'s method [15]. The input device was Surface Book (Microsoft Corporation) and the participants were permitted to rewrite characters in 1-stroke unit until they were satisfied with their own handwriting. Finally, we generated the fusion characters from the phrase (five characters) that each participant handwrote and from the font (two types). Then, on the message card (see Fig. 3), we conflated the characters at the fusion ratio between handwriting and typed character of 0.0 (handwriting), 0.5 (fusion character), and 1.0 (type character) and saved them as an image. Figure 4 shows the message card written in the fusion character.

Fig. 3. Template of the message card that we used in the experiment.

Fig. 4. Message card written in the fusion character.

4 Experiment for the Writer

In this experiment, we examined whether the writers felt resistance when sending their close friends a message card written with the fusion character that combines their own handwriting and typeface. Two items were examined:

1. Which message card the writers wanted to send to their friends: the one written with their own handwriting, or the one created with the fusion character.
2. What impression the writers had for the message card written with their own handwriting, in typeface, or with the fusion character.

4.1 Experimental Procedure

The same 15 people that helped build the data set in the previous chapter cooperated here as research participants. In the experiment, we randomly presented three types of message cards: written with their own handwriting, in typeface, and with the fusion character, or in the two different fonts and their own handwriting. They examined the cards and decided which one they would want to send to their close friends (see Fig. 5).

The experiment consisted of two trials in total (1 type of the sentence) × (2 types of the fonts). We also had participants look at an image of a Japanese character (see Fig. 6) in a variety of fonts for three seconds in between each trial to ensure that the ranking was not affected by a comparison with the previous or next message card. The system used in this experiment (and the others) was constructed using PHP, JavaScript, and MySQL.

Fig. 5. Experimental system

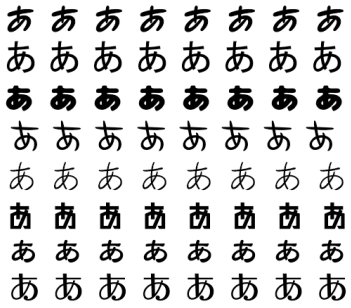

Fig. 6. Image of Japanese characters in various fonts.

Next, we showed the participants their own handwriting, the fusion character, and the typeface one by one in random combinations consisting of one phrase and two types of font, and they performed an impression evaluation using a 7-stage semantic differentials method（−3 − +3）for each phrase. We presented the participants with five pairs of adjectives selected from previous research [17, 18, 19, 20, 21, 22]: “hard-to-read—easy-to-read”, “bad—beautiful”, “indistinct—distinct” for visibility and readability and “hesitant—confident”, “resistant—acceptable” for complexity of handwriting. We also had the participants look at an image of Japanese characters written in a variety of fonts for three seconds between each trial. The number of trials in this experiment was five（2 types of the font）+（2 types of the fusion character）+ (1 type of their own handwriting).

Fig. 7. Experimental system

4.2 Results

The results in Table 1 shows the mean of the degree to which participants wanted to send the three types of message card (3 points = first place, 1 point = second place, and 0 points = third place in terms of the ranking) and the rankings of the message card's character by type.

Table 1. Mean of degree to which participants wanted to send a message card and the number of people that ranked a character type as highest.

	Mean			Number of people that ranked a character type as highest		
	Handwriting	Fusion character	Typeface	Handwriting	Fusion character	Typeface
Mincho	0.93	2.73	0.33	2 people	13 people	0 people
Gothic	0.47	2.47	1.13	1 person	11 people	3 people

As shown in the table, the mean of the degree to which participants wanted to send the message is the highest for the fusion character, for both Mincho and Gothic fonts. The second highest value is the handwriting in Mincho, followed by the font in Gothic. In addition, 13 people ranked the fusion character in Mincho as the highest, followed by 11 people for the fusion character in Gothic. These results show that the fusion character is the most supported. Interestingly, none of the writers ranked the message card for typeface in Mincho as the highest.

Figures 8 and 9 show the mean of the impression evaluation experiment for Mincho and Gothic, respectively, by type of character.

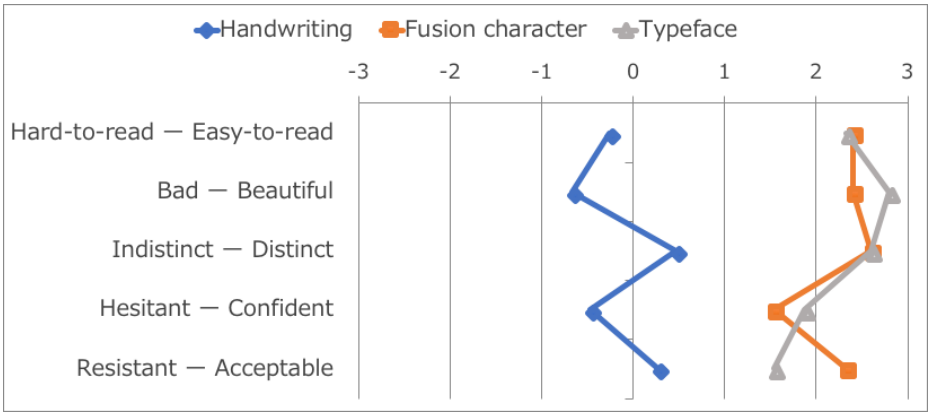

Fig. 8. Mean of the impression evaluation for Mincho

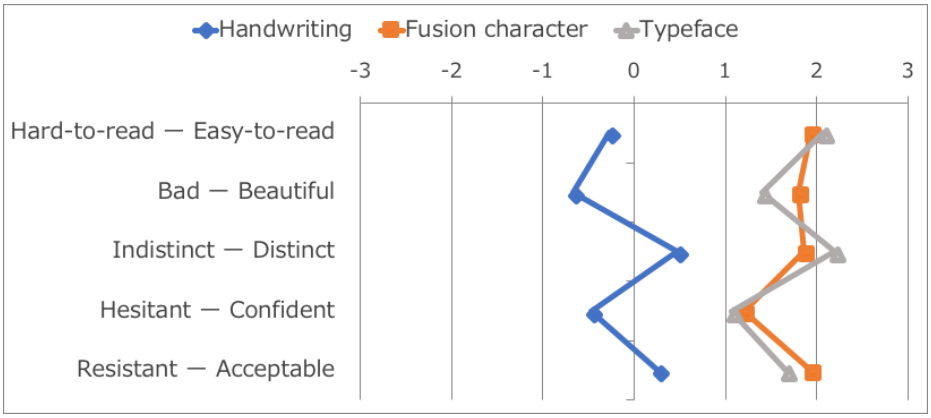

Fig. 9. Mean of the impression evaluation for Gothic

As shown in the figures, in terms of visibility and readability (that is, "hard-to-read ―easy-to-read", "bad―beautiful", "indistinct―distinct"), the mean of the evaluation for the fusion character is higher than that for the handwritten items in both Mincho and Gothic. The mean of the evaluation for the fusion character was also higher than for the handwritten items in terms of visibility and readability (that is, "indistinct―distinct") and complexity ("hesitant―confident", and "resistant―acceptable") in both Mincho and Gothic.

We performed one-way analysis of variance to determine whether the type of character was a factor in the adjective pairs and found significant statistical differences in all items. The change of the impression is particularly large for "bad―beautiful" in Mincho（$F[2, 42] = 64.14$, $P < 0.01$）, and "bad―beautiful" in Gothic（$F[2, 42] = 19.26$, $P < 0.01$）due to the difference of character type. This demonstrates that there is a significant difference in the beauty of characters when it comes to handwriting, the fusion character, and typeface.

4.3 Discussion

The results of this experiment showed that the writers were more inclined to send message cards to their close friends written in the fusion character than in their own handwriting, presumably because the resistance and shyness of the writers regarding their own handwriting were reduced.

In terms of the adjective pairs, the evaluations relating to visibility and readability in the fusion character for Gothic are lower than in the fusion character for Mincho. This is probably because the Gothic character is thicker than the Mincho character, and the gap between lines is narrower in Gothic than in Mincho. In the method we used to generate the fusion character (Saito et al.'s), the thickness of the character in the fusion character depends on the thickness of the character in the font, so the evaluation of visibility and the readability in the fusion character is lowered for Gothic than for Mincho. On the other hand, for the "resistant―acceptable" item, the mean of the evaluation

for the fusion character for both fonts is higher than that for the handwriting. These results suggested that the shape of the character changed more in the fusion character than in the handwriting, but we assume the writers did not feel more resistance to the fusion character than the typeface because they were still able to find an element of their own handwriting in it.

We clarified in this experiment that the writers were more likely to like a message card to their close friends written with the fusion character than with their own handwriting or in typeface. We also found that the writers' resistance to their own handwriting could be reduced because the fusion character improved the visibility and the readability compared to handwriting.

5 Experiment for the Reader

In this experiment, we investigated whether readers preferred the message card written in handwriting, the fusion character or typeface. Two items were examined:

1. Which message card the readers wanted to receive from a close friend: the handwritten one, the fusion character one, or the typeface one.
2. What impression the readers had for sentences written with the writer's own handwriting, the fusion character, or typeface.

We used the message cards created when we initially built the data set. Fifteen individuals (13 men, 2 women) participated in this experiment. These were different people from the individuals who participated in the first experiment.

5.1 Experimental Procedure

We had the research participants rank which message card they would prefer to receive from a close friend: one written with the friend's own handwriting, the fusion character, or typeface. We also had them look at an image of a Japanese character in a variety of different fonts for three seconds between each trial so that the ranking would not be affected by a comparison with the previous or next message card. The number of trials was 30: (1 kind of sentence) × (2 types of fonts) × (15 writers).

First, we randomly presented the participants with cards written in the writer's own handwriting, the fusion character, and typeface one by one and had them evaluate their impression using a 7-stage semantic differentials method （−3 − ＋3） for each sentence. The pairs of adjectives used for visibility and readability were "hard-to-read—easy-to-read", "bad—beautiful", and "indistinct—distinct" and for characteristics of handwriting were "impersonal—personal", and "simple—elaborate", and "generic—unique". In addition, we had the research participants look at an image of Japanese characters in a variety of fonts for three seconds between each trial so that the ranking would not be affected by a comparison with the previous or next message card. The number of trials in this experiment was 47:（2 types of the font)+(2 types of the fusion character) × (15 writers) + (15 writer's own handwriting).

5.2 Results

Table 2 lists the mean of the degree to which participants wanted to receive the three types of message card（3 points = first place, 1 point = second place, and 0 points = third place in terms of the ranking）.

Table 2. Mean of degree to which participants wanted to receive a message card.

	Handwriting	Fusion character	Typeface
Mincho	0.92	2.18	0.90
Gothic	0.88	2.22	0.91

As shown in the table, the mean of the degree to which participants wanted to receive the message is highest for the fusion character for both Mincho and Gothic. Moreover, there is little difference between the handwriting and typeface for both Mincho and Gothic.

Figures 10 and 11 show the mean of the impression evaluation for Mincho and Gothic for all writers by type of character.

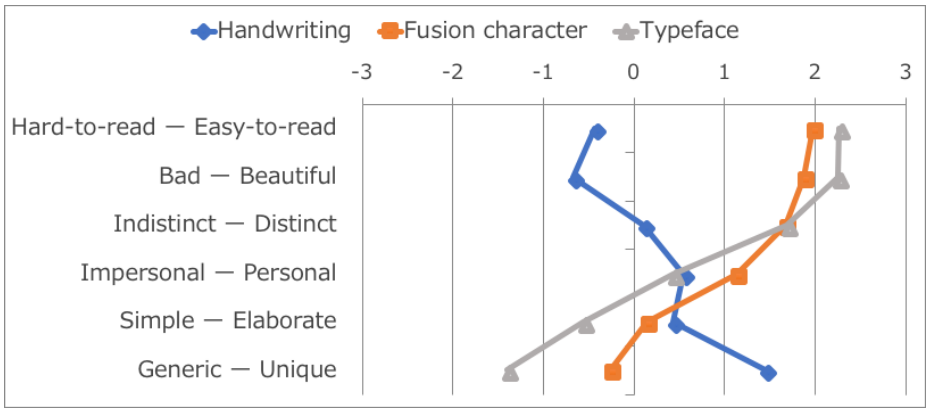

Fig. 10. Mean of the impression evaluation for Mincho

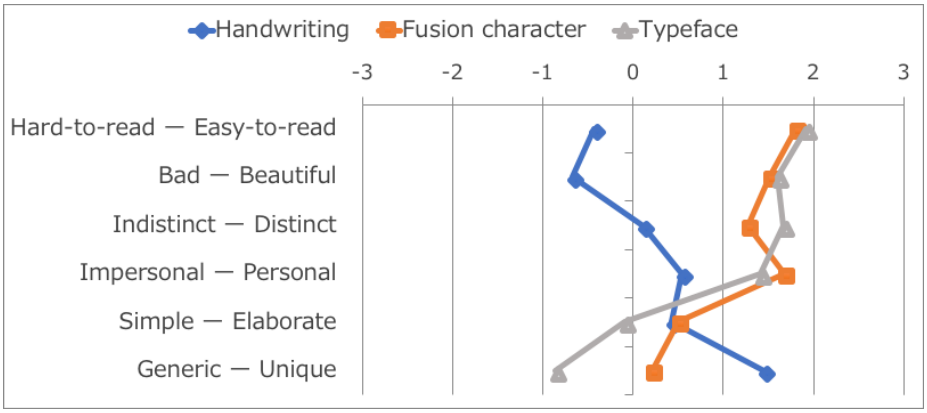

Fig. 11. Mean of the impression evaluation for Gothic

As shown in the figures, the mean of the evaluation for the fusion character is higher than for the handwriting on items that are "hard-to-read—easy-to-read", "bad—beautiful", and "indistinct—distinct" in terms of visibility and readability for both Mincho and Gothic. In addition, for "impersonal—personal", the mean of the evaluation for Mincho is the highest for the fusion character followed by the handwriting and then finally typeface, and the mean of the evaluation for Gothic is the highest for the fusion character followed by typeface and then the handwriting. For "simple—elaborate", the mean of the evaluation for Mincho is the highest for the handwriting followed by the fusion character and then typeface, and the mean of the evaluation for Gothic is the highest for the fusion character followed by the handwriting and then typeface. For "generic—unique", the mean of the evaluation for both fonts is the highest for the handwriting followed by the fusion character and then typeface.

We also performed two-way analysis of variance for the handwriting, the fusion character, and typeface and 15 writers. Results showed a significant statistical difference for the items that are "hard-to-read—easy-to-read" in Mincho ($F[2, 630] = 748.33$, $P < 0.01$), "indistinct—distinct" in Gothic ($F[2, 630] = 106.86$, $P < 0.01$), "simple—elaborate" in Mincho ($F[2, 630] = 92.07$, $P < 0.01$), "simple—elaborate" in Gothic ($F[2, 630] = 68.47$, $P < 0.01$), "generic—unique" in Mincho ($F[2, 630] = 870.09$, $P < 0.01$), and "generic—unique" in Gothic ($F[2, 630] = 627.02$, $P < 0.01$).

5.3 Discussion

The results above demonstrate that readers want to receive message cards from close friends written with the fusion character more than with handwriting or typeface. This would be because these cards led to greater feelings of joy in terms of visibility and readability.

Moreover, as shown in the evaluation by adjective pairs in Figs. 10 and 11, the mean of the evaluation of the fusion character for both Mincho and Gothic is higher for the

handwriting for “impersonal—personal". This would be because the readers felt closer to the fusion character since it had a beautiful shape while retaining the elements of personal handwriting.

In addition, the evaluation of two items of “simple-elaborate” and “generic-unique” resulted in better handwriting than fusion character in both of Mincho and Gothic. From this result, it was found out that the fusion character is evaluated lower than handwriting regarding unique of one’s handwriting. Nevertheless, we assume that it is important that characters on the letter do not only have unique but also they are beautiful and easy for readers to read. Therefore, we think that a fusion character that is excellent in these points is better than a handwriting.

Further, from the results of two-way analysis of variance, we know there is a significant statistical difference for the type of character in terms of “simple—elaborate” and “generic—unique” for both Mincho and Gothic. Therefore, it seems that characteristics of handwriting are still clearly perceivable in the fusion characters with any combination of handwriting and type of fonts, regardless of the writer of the handwriting.

In addition, we compared the result of the first experiment with the result of the second experiment. It was found that the readers always evaluated the message card written with the fusion character the most highly, regardless of the type of letter (the fusion character, handwriting, typeface) the writer wanted to use for the message card. Therefore, regardless of the selection by the writers, it is clear that the readers wanted to receive the card written with the fusion character the most.

6 Conclusion and Future Work

In this paper, we focused on the use of fusion character that combines handwriting with a UD font. We separated writers from readers and conducted experiments to determine how visibility and readability might differ between handwriting and typeface and to evaluate the resistance of people in terms of sending a message card using the fusion character.

First, we examined which message card—the one with their own handwriting, with the fusion character, or with typeface—the writers wanted to send to their close friends and what kind of impression the writers had for each type of card. The results showed that the writers were most likely to select the card with the fusion character as the one they wanted to send the most. Also, the results of the impression evaluation experiment showed that resistance and shyness related to one’s own handwriting could be reduced because the visibility and readability of the fusion character was improved compared to that of handwriting alone.

Next, we examined which message card a reader wanted to receive—handwritten, with the fusion character, or with typeface—and what kind of impression the readers had for each of the characters. The results showed that the readers were most likely to select the fusion character as the character of the message card they wanted to receive the most. Also, the results of the impression evaluation experiment showed that the

evaluation for the fusion character is high in terms of visibility and readability (characteristics it shares with UD fonts), and is also high in terms of the characteristics of handwriting (warmth, care taken).

Only two fonts were used in these experiments, but of course the number of fonts available in the world today is beyond number. Therefore, in the future, we will investigate things such as whether or not the fusion character loses its shape, and if it reflects the characteristic of the handwriting regardless of the font with which it is fused. Moreover, we used 0.5 as the fusion ratio in this study, but we intend to carry out surveys for other ratios as well.

Also, this experiment was limited to a fusion character in Japanese. However, in the future, we will consider the generation of fusion character in other languages. For example, Chinese characters and Japanese Kanji have the same form, so we think fusion characters for Chinese also show characteristics of the fusion characters we revealed in this study. However, it is still unknown that fusion characters of the alphabet, etc. show these characteristics. Thus, in the future, we need to do the verification.

As future work, we will develop a method that generates the fusion character of handwriting and typeface that corresponds to various fonts, and use it to create an app for writing a message card using the fusion character with smart phones, a system that can use the fusion character to display the lyrics in musical videos, and a system that can use its own fusion characters for cartoon captions, text illustrations, and movie subtitles. The next step will be to develop a method that promotes understanding using fusion characters when reading a difficult text such as a technical book.

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