

Designing Mobile Application Icons with Elderly as Target Consumers

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Abstract— The growth of applications, or apps, created for smartphones and tablets over the past few years has been nothing short of exponential, and competition in the app stores is extremely intense. In the app store interfaces, each app is represented by an icon, and this "first impression" is of paramount importance in attracting the attention of consumers. However, as yet there is little research on how to achieve an outstanding visual effect with these icons so that they would appeal immediately to senior consumers. One of the motivations for this study is to provide some insight into the above and establish a knowledge set that would in turn aid the industry in understanding the perception of graphics among senior mobile device users, which seems especially significant given the lack of relevant research both in Taiwan and abroad. The purpose of this study is to find out whether icon design is a factor in senior consumers' preference for game apps by exploring the effect of mental representation among mobile device users aged between 50 of 65. Statistical verifications indicate the following: (1) Positive correlations exist between older consumers' preference for game apps and the principles of icon design pertaining to primary icon and graphics comprehension. (2) Positive correlations exist between older consumers' preference for game apps and game app design elements such as realistic, fun and cute characters, interesting setting and props, sharp contrast, and graphic comprehensibility. A theoretical framework is constructed through an integrated examination of topics ranging from mobile device industry trends, the physiological changes of aging, needs of the elderly, icon design theory to game app design and consumer preference theory. Hopefully, the principles of app icon design derived by this study for game apps that target senior consumers may serve as a theoretical as well as practical reference for game developers and designers in the future.

Index Terms— aging society, app, icon design, mobile devices.

I. INTRODUCTION

Background of the study

In recent years, there are more and more studies related to the seniors (over 65). Issues about another group, senior learners, have been noticed. The senior learners are populations over 50 years old. Many studies show that the seniors learners of this generation have a positive attitude toward learning, and they believe that "living happily and learning happily" is a habit, which is why they are called "the senior learners". I think that the seniors and the senior learners have different using habits due to their generations when using mobile devices. Also, the senior learners will soon become the seniors. If both groups are issues to study in the

future, this recent research of the senior learners may have great impact on the market and may provide forward-looking and comparative thoughts on senior issues. For reasons above, the targets of this study are males and females from 50 to 65 years old. Afterwards, in the study, seniors about this age are called the senior learners.

For video games industry in Taiwan, the young groups were often viewed as main consumers, and the businessmen spent millions to billions funds on the application development of web games, online games, and single-user games. While there are many competitors in this genre, it has become harder to gain the attention of the consumers and to make profits. Obviously, new consumer targets should be developed. In other words, if business people in the industry face with the increasing market of the senior learners, and attract the group with game applications on mobile devices and tablets, which are capable of arouse their interests and could be part of their daily social life, there will be new opportunities for the industry.

The primary concept of the study is to observe the great production and economic scale ignored in the senior group. Currently, most of the principles on designing application icons are against general consumers (mostly young people) while there are only few studies on the seniors. The study aim to provide evidence on whether there is a positive correlation between the visual characteristics and needs of the seniors. In the future, the related industry market may consider this study of icon design as a reference.

1-1 Statement of the problem

As the increasing of mobile application software, there is a fierce competition among them. An icon brings the first impression to the consumers while they are using application software. Every icon represents an application. A soon as the consumers see the icon, at the first sight, their attitude toward an application is determined. The design of the icons should provide excellent visual effects in order to attract the consumers. Will the principles of icon design affect the seniors' attitude toward the applications? Are their primary choices of applications influenced by their preference degree of the icons of the applications? Are there ways to solve the difficulties to recognize icons caused by visual degeneration for the seniors? Like the preference and understanding of patterns? Currently there are not many studies about these issues worldwide.

Due to the shorter time period of development of application software, there are few related studies and disclosures from the scholars. Nowadays, companies mostly rely on the direct experiences from the industry and designers through marketing observation, while there are not many data-based principles of application icon design. This shows that researchers in the past and nowadays haven't combine issues of the seniors with issues of game application software

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to further related studies. Also, they rarely focus on the study of preference degree and demands of the seniors when it comes to the seniors' visual characteristics of the game application icons.

1-2 Purpose of the study

This study focuses on the seniors' visual recognition of application icons. Based on theories like "icon design and application", the study investigates and focuses on the icon design of game applications, targeting on the 2015 App Store and Google Play top 100 best-selling rank. Cross-referencing from these two main systems, the related data and results in this study can be more relevant and indicative. Through the verification of data, this study hopes to sort out the principles and elements of game application icons which are popular among the seniors. The results may provide the industry with better understanding of how to increase the seniors' demands of game application icons. Further, their reception behavior of game information will be affected.

1-3 Limitations of the study

Due to the limitations on human resources and budget, application icons of other genres are not studied/ investigated in this study. This study focuses on the analysis of game genre, which has the highest proportion among all applications. The scope of samples in this study is limited to the application software in the application stores from the iOS system from Apple (Apple's) and Google's Android system. When it comes to the collection and selection of samples, the top 100 application software in middle Asia from the two application stores are taken as samples, and the rank includes free and paid game applications.

II. LITERATURE REVIEW

2-1 The changes of visual aspects

According to statistics, there are 50% of the 65-year-old seniors with varying degrees of vision physiological changes [1], in which the ability to change the visual impact is the largest. Dr. Dale (Edgar Dale, 1900- 1985), the American audiovisual educator, points out that visual experiences conclude 70% of the primary messages that human receive, while hearing stands for 20%, smelling, tasting, and sensing for 10% each. What's more, visual ability is how human identify objects around [2]. However, various organs of human's body are like tools and they can be impaired as the increase of the ages. The gradual degeneration of the senses is a natural change of the seniors. For example, the visual degeneration of the seniors causes them unable to distinguish objects as when they were younger. Moreover, when the speed of visual message processing has become slower, the eyes may become more likely to be afraid of lightings and they may be less sensitive and less adaptive to lightings. The seniors would not differentiate colors as clear as the young people do. To sum up, several changes of the body can directly affect the seniors' quality of life.

There are many domestic and foreign literatures [3] — [6] about the visual characteristics of the seniors. This study is going to explore and summarize these literatures, indicating that the visual changes of the seniors are as follow, such as physiology, pathology, visual ability, the

change of visual works...and so on. The following table (Table 1) describes that due to the physiological changes of aging, the visual adaptability of eyes colors, lightings, and shades can lead to the tiredness and intolerance to light.

Table 1 physiological change of the seniors

Changes on visual aspects	
Changes on visual physiology	<ul style="list-style-type: none"> • The crystal produces a yellow change, cutting down the ability of color identification. • The increase of ages reduces the number of stem cells and cone cells of the retina. • The increase of ages reduces the moving ability of the eyeballs and increases their time to follow up with the objects.
Changes on visual pathology	<ul style="list-style-type: none"> • The age-related macular degeneration has a serious impact on the seniors' vision. • Floaters cause shadows on the retina. • Seniors with diabetes for years can easily have diabetic retinopathy.
Changes of visual ability	<ul style="list-style-type: none"> • Between 40 to 50 years old depth perception began to degenerate. • After 55, human's ability of discerning red and green started to fall. • After 60, human's adaptation to light and dark of the eyes is three times strong as the desired illuminance at 20. • The oculomotor ability to regulate the eye is reduced, which makes it difficult to track fast-moving objects.
Changes of visual works	<ul style="list-style-type: none"> • The reading performance is reduced because of the increase amount of time for visual searching. <p>The eyes can get tired more easily because of the need to take longer time to process the messages.</p> <ul style="list-style-type: none"> • General texts are more difficult to identify, and the visual area can be shortened.

(Reorganized by this study)

Through the theory of visual perception to explore the seniors' cognitive behavioral patterns, we can understand the changes from 1972 Nobel Prize winner Hubel's (Hugh Parker) and Wiesel's (Weiser) studies, and that human's visual system detect and distinguish patterns in a point-to-line series mode [7]. For the sensitive spot, the first stop to detect stimulations is retina. When it comes to visual cells side knee nucleus, the Receptive Field is sensitive to the halo which is dark from the outside and bright from the inside. When it comes to front area of the visual cortex, the aura is arranged in straight line to convey the messages, which makes the Receptive Field into linear or elongated, and it is sensitive to different angles of lines. Due to the overlapping area of the back side of the visual cortex, the Receptive Field is more sensitive to the border and the angles of the graphics. This kind of accumulated layers of messaging is known as the operation mode of "order sequence" or "series" (Hierarchical or Serial Processing) [8].

The generated visual perception means that after the eyes receive the visual information from the optic nerve to the

brain, and that after the analysis processing from the brain, the hands and feet produce reaction after the motor area of the brain conveys commands. Due to the recession of living ability, the reduced sensitivity to the environment, and the worse memory, reaction and ability to learn, the seniors may have slower process of the brain.

2-2 Definitions of Icon

The definitions of icon are differentiated by the symbolic meaning or visual representation levels. Generally, "icon" means "image", "icon", "picture"... and so on. The original meaning of "Picture" is: drawings, photos, realistic movie image [9]. In the process of human interaction and message convey, the icon represents a rich diversity of meanings. Through the differences of cultural backgrounds and lifestyles of the recipients, they have their own interpretations of the symbolic meanings of icons.

Only certain subjects are defined by the definition of icon, while the scope of icon includes several aspects. The differences between them are Signifies, Formal Techniques, Meaning, and Achieve. From these four aspects, we can examine the different categories of the icon [10]. The goal of icons and pictograms is to explain the purposes in a visual measure, in which the product range is broader. Also, the obstacles for the users can be reduced due to the signs and instructions on the screen. The logos mostly represent the related brand images of the companies, business, and individuals. Familant & Detweiler (1993) explain that in modern society, "Icon" should have major images and implications [11].

Through the observation of computer interactive design, an "icon" usually represents a pattern of a file folder, program or procedure. A small "icon" can usually save space, and integrate the objects [12]. An "icon" can also be interpreted as a symbol or metaphor image, and it can provide users with the control of the computer and the order [13]. Mooris (1994) also state that "icons" usually have characteristics such as small and practical [14]. They often represent other meanings, using metaphors, and they are also on behalf of images on computer screens or symbols that contain hidden meanings [15].

Based on the above, we realize that there are several ways to represent the icons, but the main purpose is to allow users to understand their certain meanings and concepts, and to interpret the symbolic meaning of the icons. We should accept the different cultural backgrounds and ages of recipients can have different interpretations about the icons, which is what icon designers must pay attention to.

2-3 Principles of application icon design

For young people, it is fine to use applications on smart phones and the tablets which have smaller screens. For the seniors, their visual ability has decreased. They need to use the advantages of icon interface design, which can clearly show the application icons in a limited space. When the seniors are searching, they can immediately find the applications they want. Through the icons, the seniors can realize the meaning of the icons without words.

According to Horton (1994), the application software should be able to be downloaded by users around the world [16]. When considering the icon design, besides the significance of the icons, culture differences should also be considered, such as gestures, religion, color..... and other

cultural differences. Theoretically, icon design involves psychological, visual, and perceptual aspects. Domestic scholar Yu (2010) presents icon design in several ways, namely:

- 1 Figurative type of icons: users can get string association between information and familiar things.
- 2 Abstract type of icons: users have the same concept of information and things that they are familiar with. This kind of icon was suitable to express through abstract patterns.
- 3 Forced-shaped icons: the images are frequently used, and they are more suitable for forced-shaped icons.
- 4 Integrated icons: more complex messages or abstract concepts are expressed through integrated icons. Three or above categories can be conveyed in a more detailed way.

In this study, these four types of icon theories are extended for the discussion of application icon design. Nowadays, application icon design is mostly figurative. Limited by the screen space, the icons make the users needless to think but they can recognize the applications immediately, which is suitable for the seniors [17]. In general, there are few abstract types of icons, since the users have to take a look at the introductions of the application, the icons are less suitable for the seniors. The forced-shaped icons are mostly set by enterprise logos, and usually these icons are well-unknown so that the users can identify them by the brand image. Integrated icons are mostly used for game applications. These genres of applications use game characters as the main part of icons. Since the characters are strongly identified, the icon design of these applications can vary by different types of games.

Currently, most of the principles of application icon design aimed at general consumers (mostly young people), and they have a certain reference value for the market. However, there are not many suggestions for the seniors. The application icon design for the seniors should be particularly considered due to the seniors' gradual degeneration of natural physiological changes, their declining vision, the disability to view things clearly and their difficulty to identify icons.

This study concludes the icon design principles that scholars above stated and the visual characteristics for the seniors. Several main points of application icon design are generalized: (1) clear icons, (2) obvious meanings (3) consistency of the icons, (4) highlighted themes... and so on. Table 2 shows the seniors' preference factors and principles of the application icon design:





Table 2 the principles of the application icon design for seniors

Factors	Principles (descriptions)
clear icons	To make users recognize the contents and characteristics of the applications.
obvious meanings	The obvious meaning makes the messages to be understood immediately or to be remembered through association.
consistency of the icons	When the characteristics of the main icons are highlighted, the visual messages can be distinguished easily.
highlighted themes	International icons can express the figurative icons directly.

(Sources: Reorganized by this study)

Furthermore, based on the literature reviews above, which include the application icon design and icon design, this study sums up the four elements of the design. These become the categories of the seniors' application icon design, and the model can be used for the questionnaire questions, namely: (1) characters with realistic figures, (2) cute fun game characters, (3) game props or scenes and (4) characters easy comprehend. Related categories and integration is shown in Table 3.

Table 3 suitable icon design factors for senior

category	operation identification	sample
realistic game characters	The style of the main pictures is realistic game characters.	
cute and fun game characters	The style of the main pictures is cute and fun game characters.	
props or scenes in the games	The main pictures are props or scenes in the games.	
quick understanding the icons	Game contents are easy to be understood through the main picture.	

(Sources: Reorganized by this study)

According to the analysis of literature reviews above, this study constructs the principles of application icon design and the model of design elements, which can be categorized into: realistic game characters, cute and fun game characters, props or scenes in the games and quick understanding the icons. These categories are used as the construction of the questionnaire in this study. Then, after the data being collected and analyzed, in this study, the suggestions and trend of visual design elements for the game applications that are suitable for the seniors can also be used for future designers and industry.

III. RESEARCH METHODOLOGY

3-1 Research design

This study adopted content analysis and questionnaire methods. Application icon samples aww collected and chosen to construct the categories of application icon design, in order to understand the current trend of application icon design and the seniors' preference and cognitive difference of application icons. After being collected and analyzed, the results of design principles and design elements can be references for future related designers. The following is a brief description of the research steps taken in this study.

The first step: The samples are collected and chosen.

The top rank 100 game applications of central Asia in App store and Google Play are collected individually as primary samples (200 icons in total). Repeated icons are deleted, and the remaining 148 icons recoded by the researcher and the research assistant. According to literature reviews above, this study analyzes and inducts the elements of

icon design according to design elements, samples collected, and principles of icon design that mentioned above. Further, this study examines what kind of application design elements are preferred by the seniors.

The second step: the research hypothesis

The purpose of this study is to organize the principles of the application icon design, and to construct the framework and the questionnaire. Thus, we can understand the cognitive preference relationship between the application icons and costumers. According to the study purpose, questionnaire structure, and questionnaire questions, the research hypothesis of this study is:

H: The principles of application icon design have a positive relationship with the visual cognition of the seniors.

The third step: questionnaire design

The questionnaire aimed to measure the 50-65 year-old seniors' visual cognitive preference of application icons, and examines the statistic results with design principles that the literature reviews mention. Through content analysis, independent variables are the four main elements of application icon design: (1) realistic figurative game characters, (2) cute and fun characters, (3) props and scenes in the games and (4) the understanding of the icons. Dependent variable is the seniors' visual cognitive level. This study adopts the Likert Scale, which is a scale used to design several items for a concept and to measure each participant's reaction and preference of the concept. The scope of the object is limited as the seniors that have smart phones and who have experiences for using Internet and playing games.

The four step: Questionnaire

First, interviews and the pre-test of questionnaire are done at the Senior University and the questionnaire design is done. The questionnaire design is going to measure in "group distribution" and "computer online survey" these two ways. The online questionnaire would be put online on "My survey". Through emails and phone calls, YS Foundation is appointed to help drum up this questionnaire information. The seniors are asked to answer the questionnaire whether through online or paper assistant. The test time is three weeks and 335 valid questionnaires are reserved.

The five step: Data analysis and statistical methods

In this study, SPSS statistical software is used as analysis tool. The method is outlined as follow.

1. Reliability Analysis: To make sure the reliability of the research tool in this study, Cronbach's α is used for reliability testing, and the coefficient of the questionnaire would be achieved.
2. Correlation Analysis: This study uses correlation analysis to make statistical association between the principles of application icon design and the seniors' visual cognition.
3. Multiple Regression Analysis: Multiple regression analysis is used in order to understand if there is an obvious difference of the design elements that can affect the seniors' preference.

The research steps mentioned above are the reasons and measurements taken in this study, and the purpose is to explore how the design elements of game application icons can affect the seniors' visual cognition. In the future, the

principles of application icon design which are summed up in this study can be references and practice for related game developers and designers when they serve the seniors with icon design on mobile phones.

IV. RESULTS AND ANALYSIS

4-1 Questionnaire results and statistics

This section describes the sample structure of the questionnaire, and the hypothesis is set through statistics. A total 335 valid questionnaires were obtained. In terms of gender, there are 177 males, accounting for 52.8%, and 158 females, accounting for 47.2% of the sample. In terms of age, seniors who age from 50 to 55 are 147 people in total, accounting for 43.9% of the sample; seniors who age from 61-65 are 82 people in total, accounting for 24.5%. (Table 4) represents the gender and age structure of the sample.

Table 4 the gender and age structure of the sample

Gender					
		number	percentage	valid percentage	cumulative percentage
valid	Male	177	52.8	52.8	52.8
	Female	158	47.2	47.2	100.0
	Total	335	100.0	100.0	

Age					
		number	percentage	valid percentage	cumulative percentage
valid	50~55 years old	147	43.9	43.9	43.9
	55~60 years old	106	31.6	31.6	75.5
	61~65 years old	82	24.5	24.5	100.0
	Total	335	100.0	100.0	

Through Cornbach's α reliability analysis, the Cornbach's α in each facet is bigger than 0.7, which shows a high degree of consistency of the asked items, as shown in Table 5:

Table 5 Reliability analysis of the questionnaire

facet	variables	num of questions	Cornbach's α
The seniors' preference level of application icons	realistic game characters	5	0.749
	cute and fun game characters	5	
	props or scenes in the games	5	
	quick understanding the icons	5	

4-2 Research hypothesis

A research hypothesis of this study is: There is a positive relationship between principles of application icon design and the seniors' preference level of application icons. The average statistics results of application icon design elements are listed

in a high-to-low order: "cute and fun game characters" 4.12 (SD= 0.52), "realistic game characters" 3.95 (SD= 0.46), "quick understanding the icons" 3.73 (SD=0.43) and "props or scenes in the games" 3.32 (SD=0.41). The average of dependent variable is 4.32 (SD=0.52). Table 6 shows the descriptive statistics of total.

Table 6 Descriptive statistical summary table

variables	average	standard error	median	mass	standard deviation
realistic game characters	3.9546	0.0363	3.76	3.76	0.4591
cute and fun game characters	4.1248	0.0304	3.21	3.21	0.5173
props or scenes in the games	3.3225	0.0358	3.58	3.58	0.4161
quick understanding the icons	3.7355	0.0347	3.34	3.53	0.4351
the seniors' visual perception	4.3275	0.0334	3.95	4.37	0.5235
N=335					

This study uses Pearson's correlation coefficient to verify whether the presentation of the realistic figurative game characters, cute and fun characters, props and scenes in the games and he understanding of the icons are independent from each other, and whether there is a significant level of high and low between the independent variables and dependent variables of the consumers' visual perception. Table 7 shows the correlation coefficient results of the four variables. In accordance with statically results, Pearson's correlation coefficient among the four variables is less than 0.5, indicating that the four variables are self-independent variables which have no correlation. This study set it as an independent variable in correctness.

Table 7 Pearson's correlation coefficient analysis

variables	realistic game characters	cute and fun game characters	props or scenes in the games	easy understanding the icons
realistic game characters	1	.385**	.327	.453**
cute and fun game characters	.385**	1	.402**	.388**
props or scenes in the games	.327	.402**	1	.373
easy understanding the icons	.453**	.388**	.373	1

** In the significant level of 0.01, * the relevant is significant. (N = 335) (Source: organized by this study)

Through correlation analysis, we can observe the relation level between the two variables. The constant

correlation coefficient value is between -1.0 to +1.0, +1 (0 $r > 1$) on behalf of a fully positive correlation between the two variables, -1 (0 <math>r < 1</math>) represents between two variables is perfect negative correlation. Table 8 shows the results of dependent variable (the seniors' visual perception) and Pearson's correlation coefficient among the four variables, which presents a positive correlation by 0 to 1.

Table 8 Pearson's correlation analysis

variables	realistic game characters	cute and fun game characters	props or scenes in the games	easy understanding the icons
the seniors' visual perception	.374**	.417**	.315**	.322**

** In the significant level of 0.01, * the relevant is significant. (N = 335) (Source: organized by this study)

Statistics show that independent variables and dependent variables, both are arranged in descending relevance: cute and fun game characters, realistic game characters, easy understanding the icons and props or scenes in the games. Their significant are less than 0.1 ($p \leq 0.1$), indicating these four independent variables and dependent variables (visual perception) all have a strong correlation. This result shows that Application icon design has a positive impact on the seniors' visual perception.

Regression analysis, following correlation analysis, is the predictive model for construction, being used for exploring the stability of the prediction model with an appropriate level and other related issues. The seniors' visual perception is the dependent variable in this study, and the R² value of regression analysis is 0.385, the significant is less than 0.05, which indicates that the model is predictable. Table 9 shows the results of regression analysis. According to the R² data, the independent variables have 38.5% of power to influence the preference level of the senior consumers, while the remains 61.5% of other variables are not included in this study.

Table 9 Results of regression analysis

R Square 0.385 Sig. 0.000**

variable	Beta weight	Sig.
realistic game characters	0.307	.000**
cute and fun game characters	0.335	.000**
props or scenes in the games	0.165	.001**
easy understanding the icons	0.125	.001**

The results of regression analysis show: realistic figurative game characters, cute and fun characters, props and scenes in the games and he understanding of the icons can all affect the seniors' visual perception of application icons.

V. RESEARCH RESULTS

5-1 Results

The digital content industry has been placed with a high value in the global world. Business in Taiwan should not only pay great attention to the business opportunities caused by the seniors but also develop the global aging market. According to the statistics results, the seniors' visual recognition for application icons has a strong correlation among the four variables: "realistic game characters", "cute and fun game characters", "props or scenes in the games" and "easy understanding the icons". This shows that the seniors' visual recognition for game icons can be improved if the icons are mainly presented in realistic shapes. For example, when the icons are mainly about the facial and half-body parts, the characteristics of the roles are clearly shown, and the content of the games can be easily connected. For the seniors, it is easy to recognize the characteristics of the roles and the features of the icons are emphasized.

The game developers may create the roles in a realistic way to enhance the characteristics of them, and to increase the seniors' recognition of the game application icons. The higher of the visual recognition is, the higher of the preference level of the icon is. In this study, the principles of application icons design can affect the seniors' visual recognition toward the game icons, and affect their primary choice of using the applications.

5-2 Recommendations for Further Research

For further understanding of the impacts on the seniors' visual recognition caused by the icon design, this study provides several suggestions for researchers interested in this issue. The suggestions are listed as follow:

1. The studying area may be broadened into other districts or countries for further related studies.
2. More questions may be added into the questionnaire in order to obtain the reliability and validity, which can enhance the accuracy of the study.
3. Further related studies may focus on elements of application icon design for more detailed information.
4. Due to the fast variation of mobile devices and application software, long-term observation research should be considered in order to obtain great amounts of data, so that the relationship between the two can be proven and that the main principles to affect the seniors' visual recognition can be concluded.

5-3 Conclusion

An application icon brings the first visual image of software to the users. An icon is the only way to run an application, which represents the visual image of the application, affecting the visual cognition of the users and the web-downloaded rate. All application companies are faced with an obstacle: how to get the users' attention then make them interested in understanding and downloading the applications among other various applications? Application icons have gradually become mature with social and cultural development. Nowadays, they are no longer restricted by languages or cultures but have become more international. To stand out from other applications from the global market, application icon design can be a serious issue.

The results of this study can be used as suggestions for visual icon design elements of game applications which are suitable for the seniors. Also, related designers and industry may refer to the results in the future. Visual icon design can be customized according to different target consumers, characteristics of the products or preferences of the consumers when the results are applied to related game industry. This can attract more seniors into using game applications, create profits and provide business opportunities in a win-win situation.

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