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The design of a mini game for the inheritance and promotion of the culture of oracle bone inscriptions

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Abstract: *Oracle Bone Inscription Characters (OBICs) are the source of Chinese characters. However, understanding OBICs requires multi-disciplinary knowledge, which makes it extremely difficult for the general public to be interested in it. In order to mitigate the problem, we attempts to promote the Oracle Bone Inscription (OBI) culture through serious games. The game in this work uses Pinyin and comparison tables of OBIC and mordern Chinese characters (MCCs) as auxiliary information, aiming at helping players subtly establish the corresponding relationship between MCCs and OBICs. The game involves 220 recognized OBICs, uses different game modes, and encourages the competence between players. It has low entry requirements, making it suitable for people above elementary school students. Compared to the existing Oracle-themed games, it is more interesting and suitable for the inheritance and promotion of OBI culture.*

Keywords: *Serious game, Oracle bone inscription character, Modern Chinese character, Lianliankan-typed game, Culture promotion*

1. Introduction

Oracle-bone inscriptions (OBIs), the oldest hieroglyphs in China, were excavated from Yin Ruins in Anyang City, Henan Province, China. They were mainly carved on cattle scapulas and tortoise shells, as well as other animal bones, recording making divination and praying to gods by late Shang people from 1400 B.C.-1100 B.C.. OBIs represent the earliest mature writing system discovered in China, which are viewed as the the source of the development of Chinese characters and the symbol of Chinese civilization for thousands of years [1]. On Oct. 30, 2017, OBIs were selected into the ”Memory of the World Register”, marking that OBI’s position in the inheritance of human culture has been recognized by the world.

Therefore, in recent years, many researchers have begun to pay attention to the study of OBIs. In traditional OBI studies, most of the works focused on the interpretation of OBIs and the study of Yin and Shang culture, e.g., the exploration of correlations between different divination parameters such as original coloration, crack numerals, crack notations, and the content of OBIs [3]. In recent years, with the application of computer technology in this field, the automatic recognition of OBI characters (OBICs) has been paid more attention. Li [2] put forward a recognition method of OBICs based on graph theory, considering that OBICs are glyph drawings and the rudiment of modern Chinese character (MCC) system. Jun Guo etc. [4] viewed the recognition of OBICs as some kind of sketch-related works and built hierarchical representations to describe them. Lin Meng [5] employed line features to recognize OBICs in a two-stage framework. Mengting Liu etc. [6] used SqueezeNet to recognize incomplete OBIC images. We [7] combined deep convolutional networks and clustering technology to retrieve OBIC images. There are also some works exploring the automatic detection of OBICs from rubbing images. Lin Meng [8] tried to detect OBICs based on SSD [9]. We also made a survey of OBIC detection methods [10] and proposed to detect OBICs by using spatial pyramid block [11]. More recently, some works began to study OBICs by simultaneously exploiting knowledge from different domains. Junheng Gao and Xun Liang [1] tried to distinguish different variants of OBICs by combining deeplearning-based methods with the prior knowledge matching using the knowledge of parataxis, oracle characters and graph theory. Jing Xiong etc. [12] utilized multi-modal knowledge graph to organize and manage the basic data to serve the research of OBI information processing. All these methods have improved the efficiency of automatic detection and recognition of OBICs to varying degrees, provided some help for the general public to

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understand OBICs, and effectively promoted the inheritance and promotion of the OBI culture.

However, due to the difficulties of the recognition of OBICs, even ancient character devotees need to complete the basic recognition of OBICs with the help of professional reference books and experts [1]. The general public only regards OBICs as some kind of graphic symbols, and very few people are really interested in them, which resulting in the crisis of the inheritance of OBI culture. In China, the study of OBIs is considered a lost knowledge of Chinese culture, which means few people want to devote themselves in this field. Therefore, the leader of Chinese government, Jinping Xi, called on more people to participate in the study and heritage of OBIs [13]. In order to make more people interested in this area, this article attempts to spread and promote OBI culture in the form of a mini game, which belongs to serious games designed for educational objectives [14]. Serious games support the player to achieve learning targets through a fun experience, and appear as a new tool to learn cultural content in an engaging way. Such a feature makes it possible for their application on the promotion and inheritance of OBI culture.

There are very few OBI-themed games on the Internet, except for two recently developed ones: “Oracle Match” [15] and “Oracle Lianliankan” [16]. Both of them are Lianliankan-typed games, which are popular for young and old ages. In the course of the games, players can recognize a part of OBICs and acquire elementary understanding of Chinese characters, so as to achieve the purpose of learning through play. However, these games ignore the fact that the general public can only see OBICs as graphic symbols, and will only match characters with the same glyphs. In most cases, even the players can get rather high game scores, they still do not understand the true meaning of the OBICs involved in the game. In other words, a player who does not know certain OBICs still does not know them after playing the game. Therefore, such serious games cannot really serve to promote and inheritance the OBI culture.

For the promotion and inheritance of OBI culture, we should help the general public learn more knowledge about OBICs, among which the corresponding information between OBICs and MCCs belongs to the key knowledge that they should master. Therefore, encouraging players to master the correspondence between OBICs and MCCs should be the main learning target of OBI-themed serious games. Accordingly, for the Lianliankan-typed games, the matching task should not be carried out between OBICs but between OBICs and MCCs, so as to help players unconsciously build the relationship through play. In this paper, we developed a novel Lianliankan-typed mini game to carry out the matching between OBICs and MCCs, where two kinds of correspondence information are employed. First of all, Chinese Pinyin is exploited to provide hints about the correspondence between OBICs and MCCs. Secondly, comparison tables between OBICs and MCCs are also provided to assist players to remember the correspondence in advance.

The main contributions include: (1) We have developed a mini smartphone game, called ”OBI Lianliankan”, to help the general public learn about OBICs by matching them with MCCs on their smart phones. (2) Both Chinese Pinyin and comparison tables between OBICs and MCCs are employed to help players understand more relationships between these two character systems. (3) Our game uses modes of different difficulty levels to train new players to gradually recognize OBICs, so as to achieve the purpose of promoting and inheriting OBI culture.

This paper is organized as follows. In Section 2, the related works are briefly listed. In Section 3, the detailed information about our method is described. In Section 4, some evaluations and discussions are presented. Section 5 concludes the paper.

2. Background

As a serious game, every OBI-themed and Lianliankan-typed game should take both the fun aspect and the learning aspect into account. The former provides engagement, while the latter acts like a teacher. And both aspects should serve the purpose of promoting game players to master more OBICs. In the following, we will briefly compare the two popular OBI-themed games mentioned above. Their screenshot images are shown in Fig.1.

The game “Oracle Match” [15] was developed in Flash and can only be used in a web browser, resulting in relatively poor experience. The strategy it uses is relatively simple, with only one game mode, including six levels. Player’s scores are directly ranked to provide compelling experience. However, OBICs are too blur and the font size is too small in the game, which makes matching difficult. At the same time, because there is too little prompt information about the associated information between OBICs and MCCs, players mainly rely on character glyphs for matching, which seriously affects players

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interest and is not good for the promotion and inheritance of OBI culture.

The game “Oracle Lianliankan” [16] is an app on smart phones and available on Google Play. After installation, users can use their smartphones for experience. There are two game modes to choose from in this game: the clearance mode and the endless mode. The clearance mode has a total of six levels, each consists of 24 small off. In the endless mode, the game will go on until the Council’s time runs out. Game scores of the endless mode can be used for ranking. Compared to “Oracle Match”, the game interfaces are more friendly, with clearer OBICs. However, players are limited to match between OBICs in both of these two games. In the process of completing the matching, they have to pay more attention to the similarity between OBI glyphs. Although some simple prompts about MCCs can be obtained, it is still difficult for them to recognize the involved OBICs.

“Oracle Match” “Oracle Lianliankan”

Figure 1. Screenshot images of two OBI-themed games.

Pinyin is an official plan of the Peoples Republic of China for the Latinization of the phonetic transcription of MCCs. It refers to spelling a modern standard phonetic syllable inMandarin with the letters and spelling specified in the “Hanyu Pinyin”. It is fully used as a basic content in mainland China and Singapore [17], and is an important content of compulsory education. Most people in China can spell an unknown MCC by using the assistant of Pinyin. Therefore, in our point of view, by adding Pinyin to OBICs as auxiliary information, it can help game players recognize OBICs easily. Some examples are shown in Fig.2. Besides, we believe that before the game starts, forcing game players to try their best to memorize the correspondence between OBICs and MCCs within limited time will also be helpful for them to learn more OBICs.

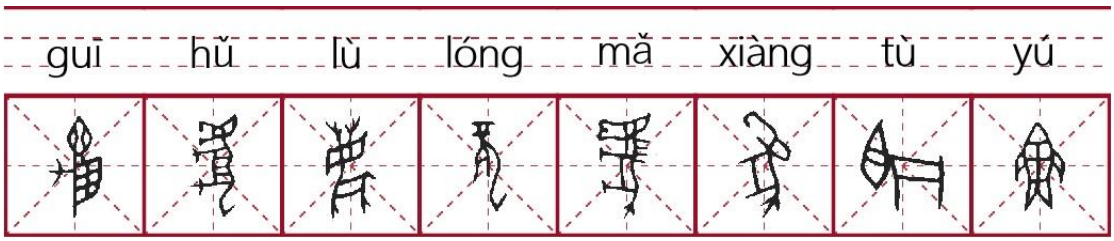

Figure 2: Some examples of adding Pinyin to OBICs.

3. Methodologies

3.1. OBICs labeled with Pinyin

Different from all the other OBI-themed games, the matching procedure in ours occurs between

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OBICs and MCCs with the auxiliary information, e.g., Pinyin. If Pinyin is used as the prompt messages of OBICs, three problems are involved in our Lianliankan-typed game: (1) How to display OBICs? (2) How to use Pinyin as the auxiliary information? (3) How to match OBICs and MCCs?

For the first problem, most OBI-themed works, e.g., websites [20] [18] [19], employ scanned images to show OBICs. However, for a smartphone game, storing the image data of OBICs will bring great storage and transmission consumption. Therefore, in this work, we use OBIC font instead. In recent years, different OBIC fonts were created to promote the study of OBIs. The more representative OBIC fonts include the font of CHANT [21], the font of Beijing Normal University [22], Han Yi Chen Ti OBIs [23], and the font of Anyang Normal University [24]. Among them, the font of Anyang Normal University, containing 4030 OBICs, is the most up-to-date, and was employed to show OBICs in our game.

As for employing Pinyin as the auxiliary information, we select a very simple way that labels each OBIC using the Pinyin of its counterpart of MCCs. Just like what have shown in Fig. 2, even players who know nothing about the OBICs can guess their counterparts of the MCCs with the help of Pinyin.

Now let's consider the last problem. In order to achieve exact matching, we encode each OBIC by using the same Unicode of its counterpart of MCC. If the two consecutive characters selected by a game player (one is an OBIC and the other is a MCC) have the same Unicode and there exists a passable path between their positions, the matching is considered successful. Some examples of the correspondence between OBICs and their counterparts are shown in Fig. 3. The third row in the figure shows their Unicode in hexadecimal.

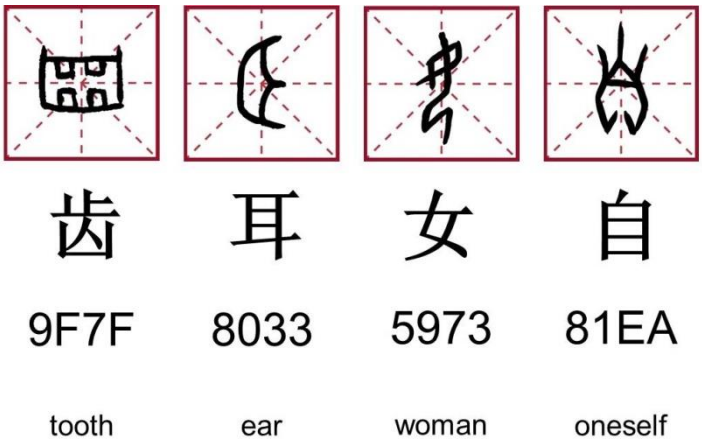

Figure 3: Examples of the correspondence between some OBICs and MCCs. The first row shows the OBICs, the second row shows their counterparts of the MCCs, the third row are their sharing Unicode in hexadecimal, and the last row lists the meaning of each OBI character in English.

3.2. Game map generating

A game map is used to define how to put OBICs, MCCs, and background symbols in the game scene. It can be simply viewed as a two-dimensional array, whose size depends on the number of characters to be shown. Let the 2D array be denoted as $S = \{(i,j)|1 \le i \le M, 1 \le j \le N\}$, where (M,N) defines the size of game scene, and a single element $(x_i, x_j) \in S$ be denoted as x for brief. Among all game map generating algorithms, template-based method is of the most popular, because it takes up less resources, can easily control the difficulty of game levels, and produces game maps with good randomness. Therefore, in this work, we employ popular templates for Lianliankan-typed games to generate game maps.

A template is a two-dimensional array defined on S with the value of each element being manually set. For a template matrix $X = \{(x_i, x_j)|(i,j) \in S\}$, if its element $x \in X$ takes the value 1, the position (x_i, x_j) will be used to place a character image. Hence, in order to generate an initial game map according to the provided template matrix, we randomly select two 1-valued elements from X, and place an OBIC-MCC pair in the corresponding positions. After this, we need to further determine whether there is a solution to the map using the basic game rules described in next section. The whole process will not stop until all 1-valued positions have been occupied. An example template and the generated game map are shown in Fig.4.

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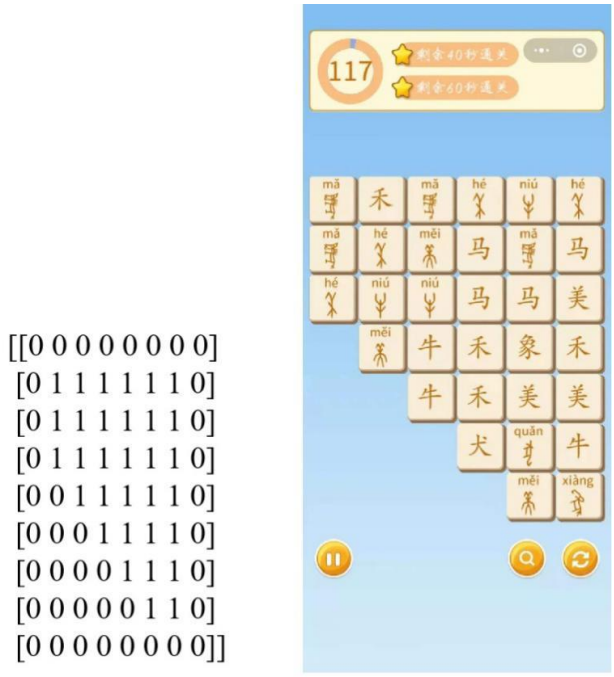

Figure 4: An example template and its corresponding generated map of our game: (a) an example template; (b) the generated map based on (a).

3.3. Matching Algorithms

Assume a matching operator is conducted between a start point $A = (A_i, A_j) \in S$ and an end point$B = (B_i, B_j) \in S$. Among all the paths from A to B (each path is only consisted of vertical and horizontal line segments), only those with less than 2 corners are considered as passable. In other words, after a player has selected points A and B, we need to find whether there is a passable path between them. The number of corners takes value from $\{0,1,2\}$, where 0 indicates a zero-corner path comprising a vertical or horizontal line segment, 1 means a one-corner path composed of a vertical line segment and a horizontal line segment, and 2 implies a two-corner path consisting of a one-corner path and a zero-corner one. Therefore, the detection of a one-corner path can be decomposed into the detections of two zero-corner ones, and the detection of a two-corner path can be decomposed into the detections of a zero-corner one and a one-corner one. In the following, we will successively introduce the detection methods of the passable paths with no corner, one corner, and two corners.

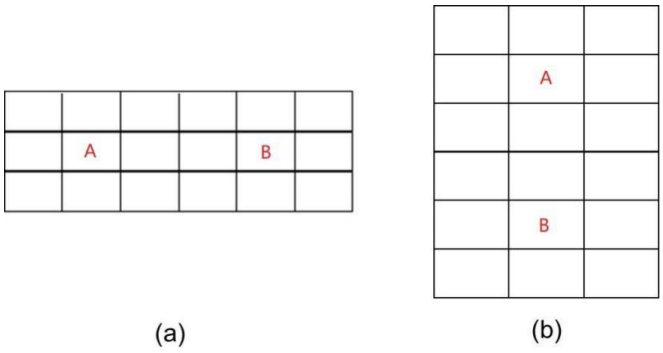

Figure 5: Two cases of passible paths with no corners: (a) horizontal case; (b) vertical case.

As shown in Fig.5, to detect a passable zero-corner path, there are two different cases: vertical detection (Fig.5 (a)) and horizontal detection (Fig.5 (b)). For both cases, we can determine the path between A and B by using Alg.1.

An example of detecting passable paths with only one corner is shown in Fig. 6(a). We select an intermediate point C1 or C2 to convert the task into detections of two zero-corner paths by using Alg.1.

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The detection algorithm is described in Alg.2.

Based on Alg.1 and Alg.2, we can easily detect passable paths with 2 corners, because the detection task can be decomposed into a combination of two successive detections: one for zero-corner paths and the other for one-corner ones. To complete such decomposition, we also need to find some intermediate points. As shown in Fig. 6(b), these points can be selected from vertical or horizontal lines crossing A or B. The selected points, such as C and D, should satisfy one of the following conditions: (1) there exists a line segment jointing A and C and simultaneously exists a one-corner path jointing C and B; (2) there exists a one-corner path jointing A and D and also exits a line segment jointing D and B. The algorithm is described in Alg. 3 in details.

Algorithm 1 PathNoCorner(A, B)

Input parameters: the start point A, the end point B
Output: true or false
1: if $A_i \neq B_i$ and $A_j \neq B_j$ then
2: return false
3: end if
4: for each point p on the line AB do
5: if p is blocked then
6: return false
7: end if
8: end for
9: return true

Algorithm 2 PathOneCorner(A, B)

Input parameters: the start point A, the end point B
Output: true or false
1: if $A_i \neq B_i$ or $A_j \neq B_j$ then
2: return false
3: end if
4: Set $C1 = (A_i, B_j)$ and $C_2 = (B_i, A_j)$
5: if (PathNoCorner(A, C1) and PathNoCorner(C1, B)) or (PathNoCorner(A,C2) and PathNoCorner(C2, B)) then
6: return ture
7: end if
8: return false

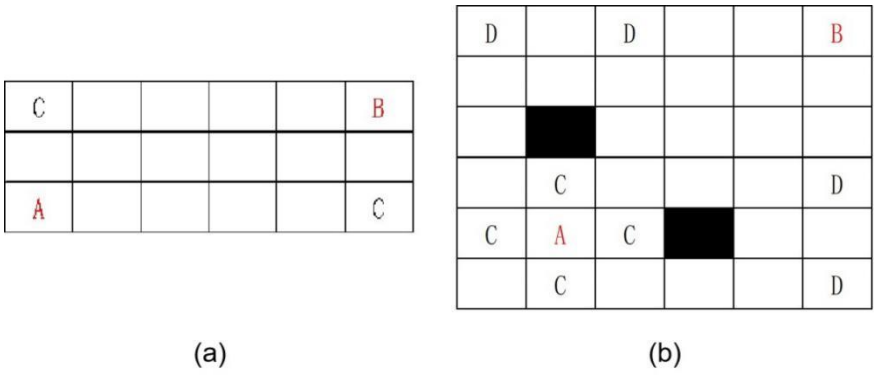

Figure 6: Intermediate points used for detecting passible paths with corners: (a) one corner; (b) two corners. The black rectangles in (b) indicate that they are blocked.

3.4. Three modes of different difficulty levels

There are two basic rules for our matching game: (1) Successful matching only occurs between MCC blocks and the OBIC blocks in the game scene; (2) Only paths with less than two corners are determined as passable paths by the game council. All of these rules are applied to three game modes with increasing difficulty levels: simple mode, difficult mode, and challenge mode, aiming at helping the players learn more OBICs gradually.

In the simple mode, we set up 60 different game levels, where each OBIC is labeled with a Pinyin to

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help players build the relationship between OBICs and MCCs, just like in Fig. 2. In order to encourage players to recognize as many OBICs as possible, in each level, they need to complete the character matching within a specified time. And those who successfully break through a game level will receive a star as rewards.

Algorithm 3 PathTwoCorners(A, B)

Input parameters: A and B are the start point and the end point, respectively.
Output: true or false

```
if A_i == B_i or A_j == B_j then
    return false
end if
C = {}
for j=1:N do
    Set C = C ∪ {(A_i, j)}
end for
for i=1:M do
    Set C = C ∪ {(i, A_j)}
end for
for P ∈ C do
    if PathNoCorner(A,P) and PathOneCorner(P,B) then
        return ture
    end if
end for
D = {}
for j=1:N do
    Set D = D ∪ {(B_i, j)}
end for
for i=1:M do
    Set D = D ∪ {(i, B_j)}
end for
for P ∈ D do
    if PathOneCorner(A,P) and PathNoCorner(P,B) then
        return true;
    end if
end for
```

In the difficult mode, Pinyin is not used to provide auxiliary information any more. Instead, a comparison table between MCCs and OBICs, as shown in Fig. 7, is employed to serve the similar role. However, after a given time, the table will disappear, prompting players to remember the modern meaning of OBICs as much as possible. There are also 60 game levels in this mode, and the same policy as in the simple mode is used to ensure the fun aspect of the game.

In the challenge mode, any auxiliary information is no longer provided. Players need to complete character matching based on their own OBICs knowledge. In order to increase the difficulty of the game, we designed a time-independent method that whether the game is over is no longer judged based on time. In other words, there isn't a time limit in the game, but a more faster-paced judgment method. We set a cycle countdown timer. And after a countdown is completed, a row of new character blocks will be generated and added to the game. The game only stops when some character blocks exceed the top of the game area. In order to further increase the players' feeling of tension during the game, the time setting of the countdown timer is not fixed. When game scores reach certain thresholds, the period will be shortened, and the speed of block generation will increase. Beside, we also take some steps to ensure the fun aspects of the game. For example, the scores of players will be posted to the standings for ranking to promote competition among players. This kind of competition can attract more players to participate in the game. At the same time, if players want to achieve higher rankings, they need to repeatedly improve their OBICs knowledge through the simple mode and the difficult mode. Therefore, the game can help players learn OBICs through play, so as to complete our original intention of the inheritance and promotion of OBI culture.

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Figure 7: An example comparison table used in the difficult mode for providing auxiliary information. The last column describes each OBIC in English.

4. Evaluation and discussion

In this paper, we developed an OBI-themed game for smart phones in the framework of Cocos Creator, which is a game development tool with content creation as the core. It has realized the characteristics of thorough scripting, componentization and data driving based on Cocos2d-x. Compared with "Oracle Lianliankan" [16], our game is also developed for mobile game players, but the difference is that our's is a WeChat mini game, not an App. We chose to develop the game based on the platform of Wechat because of two reasons. Firstly, in China, almost all smartphone users are using WeChat, so with the huge user base of this platform, game promotion will be more convenient. In addition, WeChat cloud development techniques provide a complete one-stop back-end cloud service by adopting a serverless development model, which results in the simple development and maintenance of the game.

As we stated above, the simple mode has the auxiliary information of Pinyin, the difficult one has a comparison table between OBICs and MCCs, while the challenge one has no such information. Both the simple mode and the difficult mode have similar interfaces except for the different manner of providing auxiliary information. Therefore, only the interfaces of the simple mode and the challenge mode are introduced in Fig.8. As shown in Fig. 8(a), there is a countdown timer in the upper left corner. If the countdown is over, but character blocks are not completely cleared, the game will fail. It also shows the reward information in the upper right area. If the countdown does not reach zero when all character blocks have been cleared, players will obtained reward stars, with one star for breaking through one level. There is a pause button on the bottom left side of the game area. Press this button to pause the game and view the basic character matching rules that the game employs. When players cannot find any matching pair, a magic tool is provided at the bottom right of the game area. Clicking on the left button of the tool will automatically clear a pair of OBIC and MCC that meet the matching rules, and clicking on right button will rearrange all of the character blocks in the game area.

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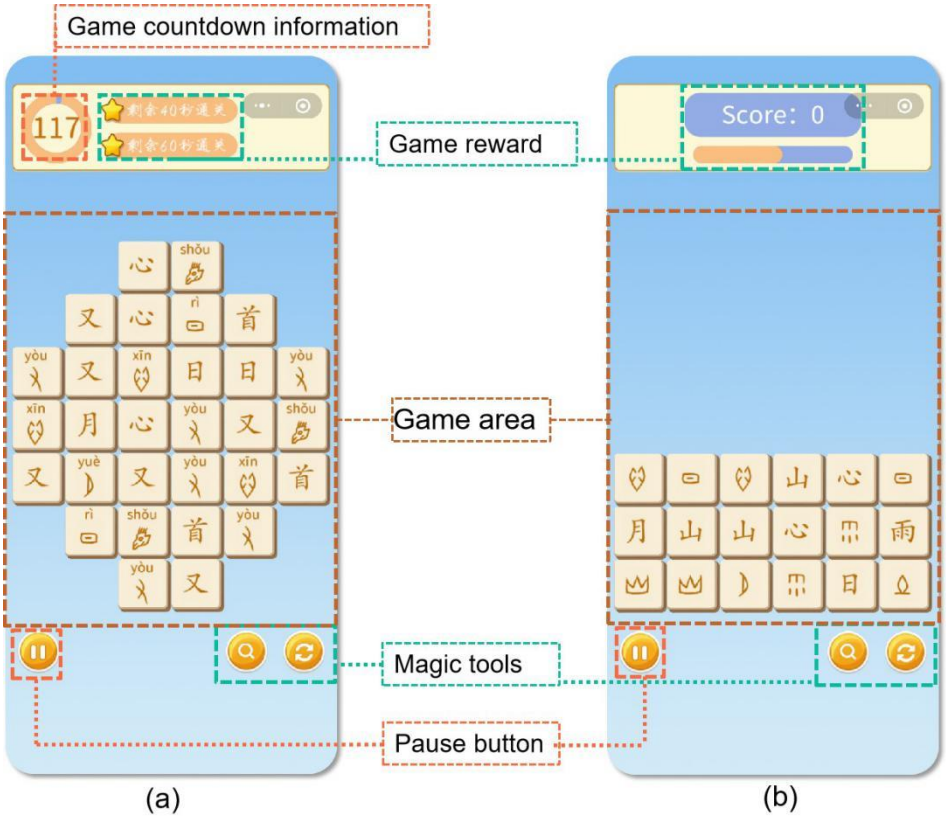

Figure 8: The game interfaces of the simple mode and the challenge mode: (a) the simple mode; (b) the challenge mode.

In the challenge mode, the auxiliary information of both Pinyin and comparison table are not used any more, and players' scores are displayed in the upper part of the screen (Fig. 8(b)). Every time, a pair of character blocks are cleared, ten points are accumulated, and the countdown will speed up when the scores reach a certain value, e.g., 100 in the game. In order to increase the difficulty, at the end of the countdown, the game will generate a row of character blocks at the bottom of the game area and restart the timer. Besides, if the character block reaches the top of the game area and has not been correctly matched and cleared, the game is over.

Table 1. Comparison between three Lianliankan-typed games.

	Oracle Match[15]	Oracle Lianliankan[16]	Ours
Clicking sound	Deep	Brisk	Brisk
Background sound	No	Retro	Brisk
Game modes	1	2	3
OBI characters	400	Unkown	220
Auxiliary information	Short display of MCC	Short display of MCC	Pinyin OBIC-MCC table
Easy to promote	Browsers only, without installation	Android system, must be installed	Wechat platform, without installation
Suitable players	Above high school level	Above high school level	Teenagers

In order to make an accurate evaluation of our game, we compared the game with both Oracle matching [15] and Oracle Lianliankan [16] from three aspects: the fun aspect, the learning aspect, and the aspect of ease to promote. The detail comparisons are shown in Tab. 1. The first three rows describe the fun aspects of them. Our game uses brisk background music and clicking sounds to make game playing a happy procedure. At the same time, more game modes also allow players to choose freely according to their personal background, which increases the fun of the game. The fourth and fifth rows show the learning aspects of these games. By employing Pinyin and OBIC-MCC table as auxiliary information, players can implicitly establish the correspondence between OBICs, pinyin and MCCs through play, so as to achieve the purpose of recognizing OBICs. The second last row gives the information about the promotion of these games. Our game does not need to be installed, as long as the

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player has WeChat installed on his smartphone. It is easily to be found that our game is most suitable for promoting OBI culture in China, because of the extremely large amount of Wechat users. The last row describes the suitable players for different games. The two competitive games require players to have a certain background of MCC knowledge, so it is more suitable for people above high school. However, our game provides auxiliary information such as Pinyin and OBIC-MCC tables, and anyone who has learned Pinyin can play it. Therefore, it is suitable for teenage students and even elementary school students to play. In short, our game is more suitable for the inheritance and promotion of OBI culture in China.

5. Conclusions

In this paper, we tried to use WeChat mini-games for the purpose of the inheritance and promotion of OBI culture, and designed and developed an OBI-themed WeChat mini-game for education. Taking full account of the fact that almost all Chinese smartphone users use WeChat, the game is developed based on the WeChat developer platform and can be used without installation, making it extremely convenient to promote OBI culture. It should be emphasized that this game uses Pinyin and OBIC-MCC comparison table as auxiliary information for Oracle-themed games for the first time, so that anyone who has learned Pinyin can participate in the learning of OBICs. In addition, the game uses three different game modes of different difficulty and ranks game scores in the challenge mode, which inspires competition among players as well as enhances the fun of the game. In the future work, we will further increase the number of OBICs involved and further enhance the fun aspects of the game.

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