

The Interaction Design of Mobile Apps for Chinese Early Education

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Abstract. Based on the current status of children's abundant exposure to mobile devices and the massive using apps as early education method in our daily life, this research explores the relationship between preschool children's cognitive characteristics and styles and interaction design of early education applications, with different qualitative research methods, to evaluate the interaction design for some representative apps. And then guidelines for the interaction design of mobile apps for early Chinese education is proposed and evaluated. This research aims to supply a reference for interaction design for early education apps, hoping that better and appropriate early education apps for children will be provided in the future.

Keywords: Interaction design · Cognitive style · Early education · Mobile apps

1 Introduction

As the fast development of science technology and the improvement of Chinese people's daily life, preschool children nowadays have more opportunities to using some of the modern mobile devices and the apps as well. According to the data of 2015, there were more than billion preschool children in China. With the traditional value that don't let children lose at the starting point, parents always put hopes on their children. So they pay more attention to education, especially the early education for preschool children. Parents not only spend much money on children's learning and training at school or from other agencies, but also prefer buying devices or tools to help children to learn. People believe that good preschool education will promote children's development and get better learning in the future. It's not strange that the preschool children can use smart phones or ipad very well. They can play games and get learning with many different apps.

Human beings get the fundamental learning through the intuitive cognition process which combines the external and internal information got by individual sensors. Children, especially the preschool children develop their abilities of independent and abstractive thinking after they have perceptions. Thus, they can learn through interacting with the interactive devices such as smart phone and iPad. These digital and interactive education products should meet the needs of natural learning, comfortable using and satisfaction. Early education products for preschool children usually combine the

advantages of modern digital technology, with the benefits of promoting intelligence, enlightenment, and teaching. There is huge needs and potential in the early education product market. However, compared with other digital products, early education products for preschool children are mostly CDs which should be played with a computer and a screen. The problems such as lacking proper development, less and bad interaction design, limitation in time and place, lacking good guideline for product design, have existed for a long time. Apps not only own the advantages of mobile devices which are light and easy to take with, but also are flexible to be used at any time and any place. So it is necessary and important to develop more useful apps for early education to attract children's attention and improve learning effects.

Until the end of 2016, there have been 1.08 billion children in China, and more than 10,000 mobile apps both on Android and iOS platforms for preschool children's early education. It is estimated that more than 70% of these apps are designed by foreign companies mostly in North America and Europe. The ones developed by Chinese companies occupied small percentage in the market even through the app industry develops well in recent several years. This gives rise to a problem that not all the apps are suitable for preschool children in China. Since there are not only the language differences, but also some other problems such as different cultures, values, different living environment, various education types both at school and home, and behavior models, which may have influence in preschool children's cognitive development and the effect of early education. Thus, it should be taken into account that the general characteristics of cognitive development and the difference between Chinese children and children in western countries when making the interaction design for Chinese preschool children' early education.

In this paper, it aims to make research for interaction design of mobile apps for early education for Chinese children based on the cognitive development and Chinese preschool children's particular characteristics, through multiple research methods including both qualitative and quantitative research methods. The guidelines for interaction design of early education apps are proposed and tested with the hope to provide a reference for app interaction design, so that the preschool children in China can enjoy happy use and good learning by using these apps.

2 Related Literature Research

2.1 Cognitive Process and Cognitive Style Models

Children usually can be classified into five different groups: infant group (from 1 to 1 year old), baby group (from 1 year to 3 years old), children (from 4 years old to 6 years old), pupil (from 7 years old to 12 years old), and middle school children (from 13 years old to 18 years old). Preschool children usually include children from 5 to 6 years old.

In Psychology, cognition is the process of information acquisition and processing, organization, and application [1]. American cognitive psychology scholars believe that it is the information processing psychology and can be analog by a computer as the process of information input, code, processing, save and output. Jean Piaget holds the opinion that the cognitive process is the one during which human beings' adaptation of

needs, so it is necessary to pay importance to psychological factors such as intelligence and thinking [1]. In cognition process, there are three phrases: feeling—perception—classification, feeling means human being get contact with the information in the environment through the sensory system. Feeling is the real impression from external stimulates. Perception is awareness activities which mean information obtaination and application. For children, the process of absorbing meaningful information is perception, and it is influenced by attention and previous experience. The accuracy of perception improves as children grow up. Attention as one of the critical checkpoints in information process is divided into three different types including selective attention, distributive attention, and sustained attention. The selective attention means filtering information, and then memory can save subjective experience. Wicken (1992) propose the information processing model means cognition is a complicated process [1].

Cognitive psychologists stress active learning process, and the cognitive styles influenced by individual character, motivation, emotion and cognitive ability which have a high impact on information process. Cognitive style is generalization methods in cognition and individual stable psychological inclination [1]. Allport proposed that cognitive style is the model of personal solving problems, thinking, perception and memory. We present the cognitive style model as Fig. 1 shows.

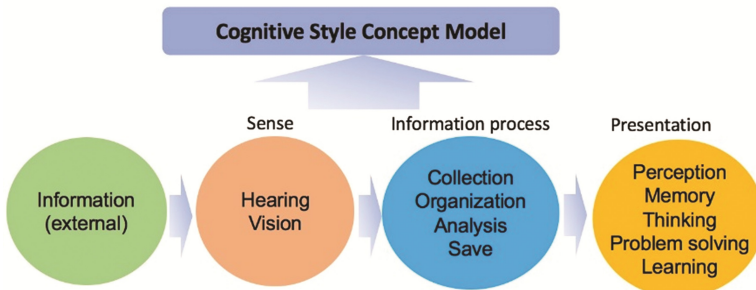


Fig. 1. Cognitive style concept model

There are different classifications of cognitive styles such as field independent-dependent type,

Analysis—non-analysis type, text-image type. Ridding and Cheema (1991)proposed two-dimensional cognitive style mode: [Whole-Analysis]-[Text-Image] [2], as Fig. 2 shows. In [Whole-Analysis] dimension, Whole means viewing information as whole; Analysis means dividing information into different groups and people usually only pay attention to one or two groups once. In [Text-Image] dimension, Text means people incline thinking about what they see, read and hear in a text, however, image means people prefer images to understand what they get from the external environment. Ridding also came up with CSA tool to analyze cognitive styles.

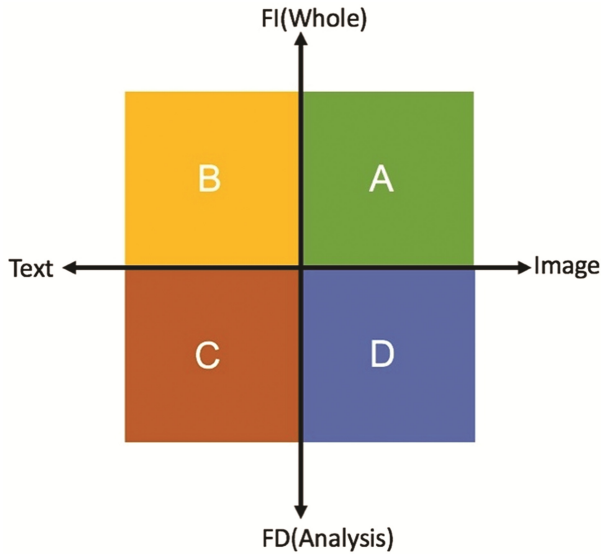


Fig. 2. FI-FD and text-image two dimensional model

2.2 The Cognitive Development of Preschool Children

In Piaget cognitive development theory, there are four stages in children's cognitive development process: Sensorimotor stage (from birth to 2 years old), Preoperational

| Characteristics of Preschool children in Preoperational Stage |
|--|
| 1. Focus on one characteristics of an object |
| 2. One-way thinking, lacking reversibility |
| 3. The sign system starts to form |
| 4. Can choose middle size objects out of different ones with various sizes |
| 5. Own memory for one to two years |
| 6. Can distinguish red, yellow, blue and green colors |
| 7. Can describe the lacking part in one picture |
| 8. Can make supplement of the lacking parts in a human figure |
| 9. Can distinguish right and left, sunny day and cloudy day |

Fig. 3. Characteristics of preschool children in preoperational stage

stage (from 2 to 7 years old), Concrete operational stage (from 7 to 12 years old), and Formal operational stage (from 12 to 15 years old) [3]. Piaget believes that psychological development is a successive internal organizing or reorganizing process. Through it is a continuous process, children's mental development includes four stages due to the interaction of different factors. These stages can come earlier or later because of difference in the environment, education and motivations. But the sequence of the four stages cannot be changed. Preschool children are in Preoperational stage, and they have their characteristics in color, shape and other aspects of cognition, which has been summarized in Fig. 3 shows.

2.3 Early Education for Preschool Children

Learning is an abstract thinking activity. For preschool children, their abstract thinking ability is limited. So it calls for special attention to their learning methods. There are three popular education theories for children, which explore education for children from different perspectives. The first one is Theory of multiple intelligences (MI or MQ) proposed by Howard Earl Gardener (1993). In his book *Frames of Mind*, an intelligence is the ability with which people can solve problems or create useful products under a value criteria in a distinctive social and cultural environment. The eight abilities to meet the criteria include verbal-linguistic, musical-rhythmic, logical-mathematical, visual-spatial, bodily-kinesthetic, interpersonal, intrapersonal, and naturalistic [4]. MI theory, been viewed as the guideline of education innovation in many western countries, emphasize that the period from birth to 7 years old is the crucial time for children's development, thus it is very vital for children's future life.

The second one is Maria Montessori's education theory, which has two core principles: children engage in psychological self-construction through interaction with their environments, and children, especially under six years old, have an innate path of mental development [5]. This theory advocates that children's driving behavior in sensitive periods are significant and education for children should respond to and facilitate their expression. The third one is Fredrich Forbel's education theory, which laid the foundation for modern education [6]. He created the first kindergarten and developed learning toys known as Froebel Gifts [6]. In his theory, children have unique needs and capabilities [6], and the education should make use of games to guide children's activities, development and social involvement. All of the education theories lay emphasis on the role of games for education. As researchers' expression of games as happy and exciting activities which can be adaptive with children's cognition development, games are the most important method for children's socialization and cognition development. Games are the primary method for the children's education.

The literature review gives us inspiration for the interaction design of educational apps. It can be explained in two aspects: one aspect is that it should focus on children's cognition development and different cognitive styles. Preschool children are in such a special stage that they have intense curiosity in everything. Games can meet their interest and help their cognition development through personal involvement in games. Another aspect is that children's education should be designed as edutainment [7] which is the combination of entertainment and teaching. Games with multiple forms are the tool of

children's development and a good style of edutainment. In a word, the interaction design of early education apps should be based children's cognition characteristics and make full use of games to attract children's interest to help children easily and happily to learn through edutainment.

3 Research Method and Process

In this research, there are several steps including existing products investigation, expert evaluation, interview, questionnaire and children's cognitive style test. Both qualitative and quantitative research methods such as observation, interview, questionnaire have been used. It is designed like this aiming to explore the relationship between preschool children's cognitive style and interaction design of early education apps, so that the guideline for interaction design can be proposed and demonstrated.

3.1 Existing Apps Investigation

There are five kinds of early education apps: apps for mathematics, apps for language learning, apps for identification and memory, apps for logic training and apps of integrated functionalities. These apps are designed both on iOS iPhone, iPad and Android devices. In recent many years, as mobile devices are available for everyone, apps have become the best way for children's early education. According to the results of some online survey, children in the major cities in China get more contact with early education apps compared with the ones in other small and rural areas. The apps for early education parents choose for their children mostly focus on storytelling, literacy, arithmetic, and music. Data also shows that until the end of 2015, children use these apps twice a day on average and 12 min every time.

However, even though early education apps on mobile devices have been very popular, good and bad ones mix. The low threshold of app development results in products' homogeneity. Parents show their concerns that which app should be chosen for children. Parents, who can decide whether to use apps and which one should be used for children, prefer the education apps with excellent functionalities and more user-friendly interfaces.

Results from an online survey and a questionnaire, 15 apps for early education have been recommended as the best choice for Chinese children and parents: (1) BabyBus (the best recommended app in App store in China, which using sound, text and images to develop children's multiple cognition development); (2) PlayKids (prevalent in more than 26 countries, with good stories and games); (3) Magikid (an app developed by Chinese company, stressing color, shape, number and logic development); (4) Montessori Crosswords (a proper application of Montessori education theory to help children to read, spell and pronunciation); (5) Elmo Loves 123s (a good application of edutainment through games, cartoons and free creation); (6) Agnitus Kids Learning Program (a comprehensive application of English enlightenment); (7) Moose Math (an app to help train children's interest in math with games); (8) Donut's ABC (especially for children's English learning); (9) Music 4 Kids (an app for developing children's music learning);

(10) Scribble My Story(an app to help children create their own stories); (11) Distant Suns Lite (an app to help children to get to know Astronomy and the nature); (12) Smartots App(Smartots is the biggest mobile education platform for children. There are a series of useful apps); (13) Hay Day(an app analog management through games); (14) Wisdom Apps(one of the best popular early education apps in Apple store in China); (15) The Robot Factory(an app for 6 years old children to make their own robots).

3.2 Interview with Preschool Teachers and Parents

An interview aiming at getting more details of preschool children’s cognition characteristics and opinions on existing early education apps was made in the same kindergarten. Five teachers with two years’ working experience on average participated in the interview. 30 parents took part in the questionnaire research. The results show that there are some unique cognitive characteristics for preschool children, for example, preschool children can focus on stimulus for a long time, they have already known how to sequence, how to make classification, they can name colors, they have interest in words and graphs, and they can distinguish reality and imagination. According to Piaget’s theory, preschool children’s cognitive styles have been developed enough to own their individual characteristics. It gives us support to make research of the relationship between children cognitive style and early education apps interaction design.

3.3 Expert Evaluation

The 15 apps have been chosen out as recommended best early education apps. Giving the age and unique cognitive characteristics of preschool children, not all of them are suitable for preschool children. Then five apps (as Fig. 4 shows, BabyBus, Smartots app, Playkids, Magikid, and Montessori Crosswords) were chosen out for an expert evaluation. Five experts with three years’ interaction design experience on average were invited for evaluation. The evaluation is designed to a 5-point scale adapted from

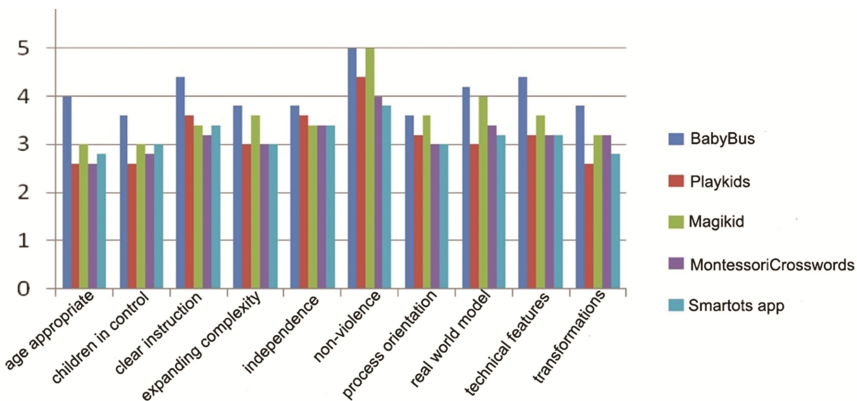


Fig. 4. Experts’ evaluation result

Haugland/Shade’s criterion for children’s education software/applications [8]. The scale covers ten main aspects for children’s interaction with software and applications, including age appropriate, children in control, explicit instruction, expanding complexity, independence, non-violence, process orientation, real world model, technical features and transformations. Combined with the results of think aloud during the evaluation and the means of the five apps, three apps (BabyBus, PlayKids, and Magikid) were chosen out as the samples for test, as Fig. 4 shows.

3.4 Children’s Cognitive Style Test

Thirty preschool children (fifteen boys and fifteen girls) took part in this test. All of them are five to six years old with normal intelligence and vision, from the same kindergarten in one of the big cities in China. The cognitive style analysis tool (CSA), which has been viewed as one of the best tools with good reliability and validity, was adapted with a combination of the two dimensions of [Whole-Analysis] and [Text-Image]. In [Text-Image] test, different units of images, pictures, texts, and numbers were presented to these thirty preschool children and asked them to find out the right ones. The time was recorded for comparison as Fig. 5 shows.

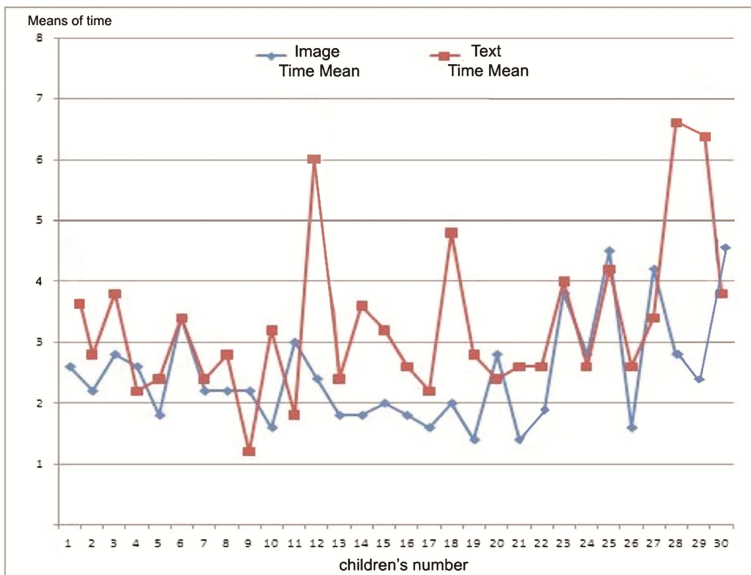


Fig. 5. Time means of [Text-Image] test

In [Whole-Analysis] test, field independence and field dependence are the two dimensions. Embedded Figure Test was used to ask the children to find out the embedded simple graphs. The one using less time to find out the right graphs gets higher points. More than 80% accuracy is viewed as field independent style.

After these two tests, the results and distribution in four quadrants of these 30 children’s cognitive styles are presented in Fig. 6. In FI and FD dimension, there is no superior for one to the other one. It only shows individual cognition style. Preschool children have already experienced development in cognition and acclimated experience from daily life. With some other factors such as personal character, living environment together, there are a different distribution in FI and FD dimension. For the children with FI style, they prefer independent activities, while FD style children need external help and guide which means more interaction with the external environment. For interaction design of early education apps, it is necessary to pay attention to this difference as

well as the external cultural influence, since there are differences in the behavior and interaction with external environment for Chinese children and children in western countries. Generally speaking, Chinese children mostly follow the rules, thus, more outer tips or remind can encourage their interaction. It means in the apps’ interaction design, interactive feedback and effective feedback should be attached attention. In [Text-Image] dimension, more children are image style. Preschool children, even though, most of them can read text and characters, they prefer the concrete images which are easy to understand.

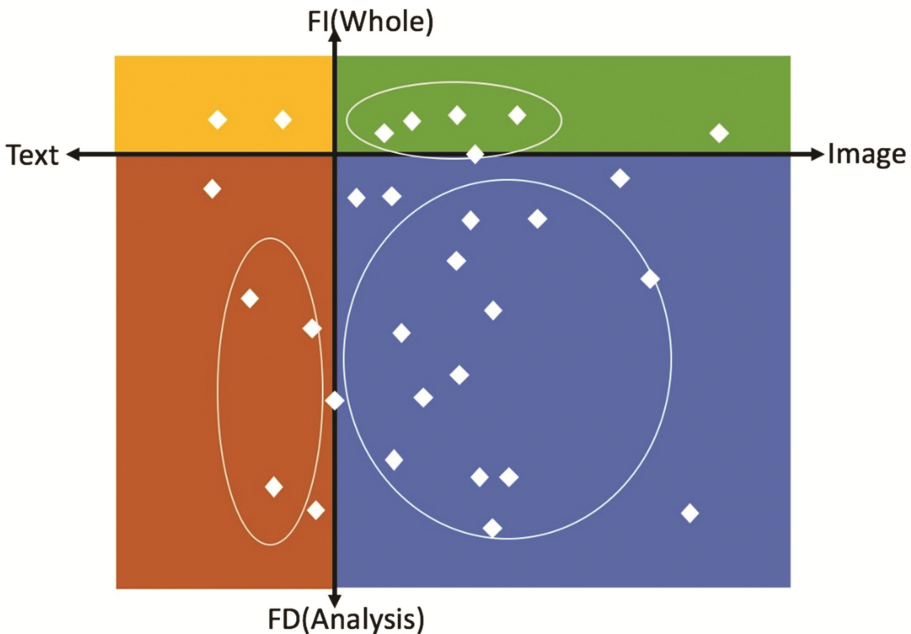


Fig. 6. Distribution in four quadrants of these 30 children’s cognitive styles

It told us that when making interaction design for preschool children, images should be given priority to, supplemented with simple text or sound help. Concrete images have similarity with their real life, which can help children to imagine and learn. The interface

should be designed with vibrant colors, which can attract children’s attention easily because children are sensitive to warm and bright colors.

3.5 Guidelines for Interaction Design of Early Education Apps

We came up with guidelines for interaction design of early education apps based on children’s cognitive style test and the typical characteristics of cognition development in three aspects with a more detailed explanation as Fig. 7 shows.

| Aspects | Guidelines | Explanation |
|--|-------------------------------------|---|
| 1. Information Architecture | 1.1 Clear navigation | 1.11 Easy to get in and out, easy to be back |
| | | 1.12 Navigation is clear and easy to understand |
| | 1.2 Simple hierarchy | Appropriate number of hierarchy (2 to 3 is enough) |
| | 1.3 Classify information | Appropriate classification of information based on reality |
| 2. Information presentation | 2.1 Information Visualization | 2.11 Present information in real and concrete images |
| | | 2.12 Present selections in graphical style |
| | | 2.13 Vivid animations, good interaction |
| | | 2.14 Rich colors(using brighter colors, high purity colors) |
| | | 2.15 Delicate design for graphs |
| | | 2.16 Icons and symbols should designed easy to understand |
| | 2.2 Operation Instruction | 2.21 Give hints or help in simple and clear graphs or icons |
| | | 2.22 Icons are big enough to recognize |
| | | 2.23 Voice help |
| | | 2.24 Avoid using menu list |
| 3. Efficiency of interaction | 3.1 Effective Feedback | 3.11 Every operation is visible |
| | | 3.12 Objects moving and change in size, color and shapes is visible |
| | | 3.13 Rapid and clear feedbacks |
| | | 3.14 Feedback should be designed in graphs or images, less text |
| | | 3.15 Voice feedback |
| | | 3.16 Give feedback in an encouragement style. |
| | | 3.17 Learning gradually step by step, from easy to difficult. |
| | 3.2 Feel of control | 3.21 Children can using independently. |
| | | 3.22 Customization of difficulty levels, numbers and languages |
| | 3.3 Happy experience in interaction | 3.31 Attractive, support constant use |
| 3.32 Pleasure in using | | |
| 3.33 Teaching useful concepts and values | | |

Fig. 7. Guidelines of interaction design for early education apps

3.6 Evaluation for the Guidelines

To evaluate the feasibility and validity of the guidelines, the same 30 children took part in the test by using the three apps selected by expert evaluation. Researchers asked the

children with different cognitive styles to using apps and recorded the whole process with video. Considering the children are too young to finish a five-point scale, researchers gave the points according to the observation of the process and interview as a supplement. Then the guidelines were evaluated by descriptive statistic analysis and ANOVA analysis in SPSS. The results show that all the P numbers are bigger than 0.05 and there is no significant difference. It means all the 27 guidelines are suitable for preschool children with different cognitive styles.

4 Conclusion

Interaction design of early education apps not only influences children's using experience but also is viewed as a weighting factor for the success of app design. The conclusions of this research are drawn as follows:

Firstly, there is a significant influence of cognition development and cognitive style to early education apps' interaction design. To some extent, the development of these apps can meet the cognitive requirements based on different cognitive styles. Even though there are limited children for the test, the results of cognitive styles are enough and representative. No matter what kind style a preschool child will have, there is a limitation in their ability of cognition and understanding for most preschool children, so their cognitive styles tend to be image and field-dependent. Thus, interaction design of early education apps should be guaranteed to be suitable for most of the cognitive styles. It is valuable to propose the interaction design guidelines which can support reference for design practice.

Secondly, due to the immaturity and instability of children's cognition, they have a higher dependence on concrete images and graphs. The presentation of pictures, icons, charts and so on should be taken seriously in interaction design, which means these visual symbols for feedback and operation should be designed in a concrete and straightforward style to reduce children's cognitive burden.

Thirdly, rapid and efficient feedback and interaction are necessary and important. Not only images, sound, and voice should also be advised to use. The feedback in an encouragement style can trigger children's more interaction with the apps.

Lastly, the significance of interaction is to bring happiness, attraction and flow to users, which can influence users' decision of using again or not and control whether and how much they can get. Compared with adults, preschool children with limited patients, are curious with new, concrete and interactive things, so attractiveness should be taken into account in interaction design. As the development of mobile technology, more productive interactions can be considered to use to meet the needs of attractiveness.

5 Discussion and Limitation

In this research, existing early education apps are investigated, guidelines for interaction design are proposed and evaluated. Due to the limited time, the available number of children and some other factors, there is still limitations in three aspects:

Limitation 1. Cognition is part of psychological research, which is a concept with personal influence. Classification of individual cognitive style can be decided only by statistical data. Cognitive style has uncertainty because of individual difference. The results in subjectivity in research purpose and can only be solved by using the accepted cognitive style testing method.

Limitation 2. The reason for choosing preschool children as the research target lies in the importance of cognition development in preschool period and lacking related research achievements. Researchers hope to fill the gaps in this field. However, preschool children are too young to express themselves clearly and accurately, which resulted in the difficulty in the evaluation. The researcher can only give the assessment based on the observation of children's facial expression and their behaviors. It may influence the rigor of the research to some extent.

Limitation 3. Strictly speaking, the better result usually needs a large number of samples to support. However, we can only get thirty children for the test due to various reasons. We only focus on Chinese children because we believe there are some differences in early education and children's cognition in China and western countries because of a different cultural environment. However, there is not enough deep research in this aspect to be used as strong support.

This research focuses on visual aspects of interaction design. There is still space for research of interaction design based on other sensory organs such as acoustics and touch, or multiple combinations. The proposed guidelines can be used as reference or support when making interaction design not only for preschool children but also for all the children in Preoperational stage since there is much similarity in children's cognition in this stage. Researchers have already made plans for the next step. The application of the proposed guidelines did not be applied in researchers' interaction design projects due to limited time. It will be implemented and improved in the next research plan.

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