

Research on Smart Speaker Speech Interaction in the Therapy of Senior with Early Dementia

Chawchen Ting *

Department of New Media, Beijing
Institute of Fashion Technology,
Beijing, China
ding@bift.edu.cn

Zhi Li

College of Animation and Digital
Arts, Communication University of
China, Beijing, China
463951237@qq.com

Yixin Zhang

Department of New Media, Beijing
Institute of Fashion Technology,
Beijing, China
dreamer_zyx@hotmail.com

ABSTRACT

As China enters an aging society, aging diseases such as dementia are increasingly plaguing the patients. The clinical data show that non-drug reminiscence therapy has a positive effect on the relief of early age dementia. Since intelligent speakers can provide content such as music and videos, it is beneficial to forming a nostalgic content library. With the speech interaction on the speakers, it can simulate reminiscence therapy scenarios. First, speech interaction makes it easier for senior patients to learn how to use it. Second, speech interaction can help the patients speak and communicate frequently, make reminiscence therapy at high frequency, and alleviate the deterioration of dementia. Intelligent speakers are expected to assist in caring of the patients and reduce the labor costs. Based on reminiscence therapy and combination of senior's interaction features of intelligent speech, this paper studies the design of speech.

CCS CONCEPTS

• **Human-centered computing** → Interaction design; Interaction design process and methods; Activity centered design; • **Applied computing** → Life and medical sciences; Consumer health.

KEYWORDS

Intelligent Speaker, Dementia, Reminiscence Therapy, Artificial Intelligence, Speech Interaction

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1 INTRODUCTION

The Predictive Research Report on the Development Trend of China's Population Aging shows that, as of the end of 2018, there are

*† Corresponding Author

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167 million seniors over 65 in China [1]. At present, the percentage of dementia patients in China is 6.5%, and it is estimated that there will be 300,000 new patients each year [2]. Therapy for dementia includes drug therapy and non-drug therapy. In the non-drug therapy, reminiscence therapy and music therapy are commonly used to effectively improve the symptoms of patients. As a non-drug therapy, reminiscence therapy is designed to improve the patient's mental state by recalling past events, experiences and feelings to achieve emotional relief and improve happiness [3]. The emergence of dementia in the senior is mainly contributed to the degradation of brain function. In fact, the lack of communication, loneliness and the resulting anxiety, depression and other symptoms are also indirect reasons of brain degradation in the senior [4]. The survey shows that the communication between the senior and their families in China is scarce. Nearly 10 percentage of senior and their families have no communication [5]. In addition, the seniors in the empty-nest family are susceptible to unhealthy emotions such as depression, dismay, loss of appetite, and internal self-blaming. The lack of feelings and feelings of belonging seriously endanger the physical and mental health of the senior. The reminiscence therapy is designed to help the senior recall the good life of the past, activate the senior's brain thinking, and help achieve self-integrity [6](Fig. 1). Meanwhile, early detection and therapy of this disease, giving the full play to the superiority of non-drug therapy, is an important way to reduce medical pressure on patients and their families. With the development of information technology and artificial intelligence, one of the important directions of medical development is becoming popular, i.e. the application of intelligent speech equipment to improve the construction of medical systems. In recent years, most of intelligent products developed for seniors are companion devices, such as Zenbo large robots, ELLI-Q senior companion robots, CogX Ai by Accenture. In terms of nostalgic therapy, related foreign institutions have designed smart products and games, such as prescription medical products DTHR-ALZ[7], Mario's autonomous companion robot[8], music games MINWia [9]etc. However, in China, there are fewer products that combine nostalgic therapies with new technologies. Therefore, this study designs a nostalgic assistive application through the integration of nostalgic music and intelligent speech technology; and discusses the design principles and design paths for the construction of speech interaction application that is nostalgic therapy-oriented based on the characteristics of users of early dementia.

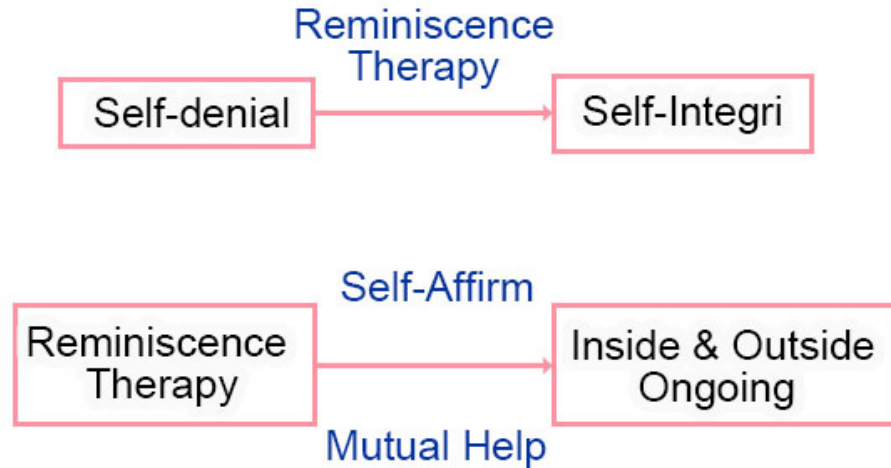


Figure 1: Therapeutic Principle of Nostalgia

2 THEORETICAL BASIS OF REMINISCENCE THERAPY FOR DEMENTIA

Studies have shown that reminiscence therapy has a good effect on the following factors such as improving cognitive function, quality of daily life and mental state of the senior [10][11][12]. With the reminiscence therapy, it is repeatedly required patients to recall the past, while playing related music, pictures and videos.

2.1 Reminiscence Therapy and its Clinical Experience

The reminiscence therapy is designed to guide patients to recall their old experiences, thus stimulating and activating the brain cells [13](Fig. 2). Since the patients with dementia cannot learn new knowledge, and their memories are degenerating in the recent period and have no long-term memory, reminiscence therapy is used to encourage the patients to recall long-term memory and activate brain storage areas to effectively improve the self-cognitive ability, relieve and improve the symptoms of dementia [14]. According to research at home and abroad (refer to [15] [16] [17]), reminiscence therapy has a positive effect on depression, memory, cognitive level, mood, aggressive behavior and quality of life of seniors with dementia (Fig. 2).

2.2 Advantages of Intelligent Speech Technology in Reminiscence Therapy

As a part of the non-interface interaction method, speech interaction is suitable for application in the elderly care scenario, which can effectively remove seniors' barriers of using products. As we know that the seniors are characterized with gradual vision loss, slow action or trembling, and degraded perception and intelligence. As the graphical user interface requires the seniors to learn new interaction logic and rules, the senior users who are slow to learn new things are prone to resist using the product. Although tactile

interaction is similar to life experience, it is not friendly to the senior with poor vision and trembling body. In contrast, speech interaction has a natural way of interaction, and is simple and fast in waking up smart devices and entrusting tasks. What's more, it is friendly to seniors who have slightly deteriorated listening and language skills. In fact, speech platforms including Amazon's Alexa and Baidu's DuerOS are examples with open speech technology. The method of speech interaction expands the category of the senior using the product, provides more opportunities to people with difficulty in text recognition and low literacy [13], and removes the application barriers arising from the decline of physical sensory capabilities. Since the starting of intelligent speech products are situated mostly in a home environment, the natural speech interaction enable senior users to complete the activation of the intelligent products without moving hands like they used to [18]. This flexibility of interaction significantly improves the user experience, and makes a hypothetical design of intelligent assisting for reminiscence therapy [19].

3 THE IDEA OF USING INTELLIGENT SPEECH TECHNOLOGY TO TREAT PATIENTS WITH EARLY DEMENTIA

During the implementation of traditional reminiscence therapy, the therapist will use an object or a task to help the patient conduct a divergent conversation. The divergent conversation content can form a memory network to activate brain cells [20]. Therefore, the therapist faced the same patient and the queried contents have high repetitive nature [21]. Since repeated labor causes a waste of therapists' resources, the shortage of therapists limits the effectiveness of therapy. Computer that is used to replace low-difficult, high-frequency work is a popular method in the combination of intelligent speech technology and reminiscence therapy.

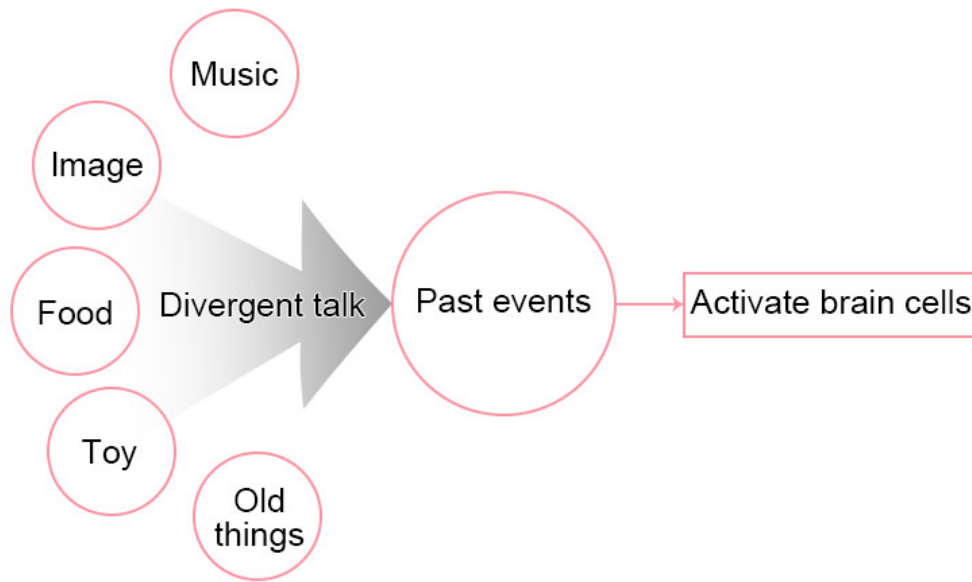


Figure 2: Main Contents of Reminiscence Therapy

3.1 Opportunities of Speech Interaction Technology for Reminiscence Therapy

Speech interaction devices can store music, pictures, and video content, support users to retrieve these contents by speech, provide the possibility of replacing manual inquiries. The advantages of a speech interaction device are: first, the device can provide a multimedia playback mode. Compared with static display, patients with dementia are more sensitive and curious about the pictures and videos displayed dynamically[22]; secondly, speech interaction equipment is simple to operate. The device can directly use the language to display reminiscence content, which reduces the learning costs of the users and improves the acceptance of the product. Furthermore, the device can obtain a large amount of reminiscence related content over Internet such as music, sound, and news. It is also expected the device uses cloud storage functions to form a user therapy library, and actively works on the construction of a patient speech library and the development of quantitative data research on reminiscence therapy.

3.2 Intelligent Speech Products with Human-Machine Companionship

Speech interaction products have the opportunity to play a role of "machine therapist", accompanying patients at any time, and simulating one-on-one therapy scenarios to create a memorable atmosphere by activating the brain of the patients and improving cognitive ability [23]. The semi-automated speech-assisted products can reduce the therapeutic burden on patients and families. A product like intelligent speaker only needs the patient’s family to bear the cost of purchasing device without large economic costs. Long-term and repeated therapy carried out by the speaker may

shorten the duration of illness and provide patients’ families with psychological comfort.

3.3 Intelligent Speech Products with Deep Learning Capabilities for Emotion Recognition

An intelligent speech interaction product can perform recognition of user emotion and increase language accuracy through learning. Reminiscence therapy requires the creation of activating emotional content [24]. The speech interaction product can mark emotions by asking to form a customized library of nostalgic content including music, and a library of machine-asked questions. During the selection of the reminiscence music, the product judges the emotional state (positive, negative and neutral emotions) by asking a patient “whether the current music reminds you to recall something”, etc., and aggregates the music marked with emotional reactions, and creates a customized playlist.

4 INTELLIGENT SPEECH THERAPY DESIGN FOR PATIENTS WITH EARLY DEMENTIA

As an intelligent speaker app, Time Chicken relies on reminiscence therapy developed for patients with dementia. With the Baidu Xiaodu speaker and Duer OS system, this App builds a therapeutic platform with memory waking-up functionality through playing music to the patients. An active music therapy touches the patient’s sensory nerves and have a proven therapeutic effect.[25].

4.1 Preliminary User Survey

At the initial phase of this design, in addition to literature research, field survey was also conducted. The survey used three methods,

including participatory observation, unstructured user interviews and expert evaluation. Data were collected and analyzed from three dementia treatment sites, including Taiwan Shuang-Ho Hospital, Qingyunli Community Dementia Group, and Community Care Center of Beijing. The number of data samples was: 12 patients in the outpatient department for dementia of Shuang-Ho Hospital, 24 moderate and mild patients in the dementia group in Qingyunli Community, and 3 patients in the Community Care Center of Beijing.

The survey found that the characteristics of the senior with dementia receiving adjuvant therapy are: the meditation period lasts 30 to 45 minutes, and they can basically cooperate with the instructions of the treatment staff, and most patients show passive communication; The caregiver shall repeat the same instruction or request multiple times and remind the patients to go to the toilet and drink water, encourage and praise them after completing operations; In the simulation of applying interventional nostalgia therapy through speech products (smart music equipment playing music and surveyor telling the background of the material), the results of the acceptance of the speech device of demented patients are: moderate to mild patients without aphasia can perform human-machine speech interaction, generate emotions by listening to music, and make relevant divergent memories under the help of surveyor.

Based on the physiological characteristics of the demented seniors, analysis of the results of field investigations, and multiple iterations of program design, the design principles of Time Chicken are summarized as shown below.

4.2 Design Principles of Time Chicken Emotion Motivation

The basic principle is to motivate the emotions of users. Emotional materials in the content library are effective contents. Therefore, the core function of the App is to screen out effective content that can motivate the patient's emotions for different users and exert the greatest therapeutic effect. The contents that motivate emotion include: music, pictures, videos, speech communication such as dialogue and vocabulary etc. In the process of designing the Time Chicken App, the questions are used to screen out the effective content and eliminate the invalid one. Meanwhile, the library of content stores mostly encouraging vocabularies, which helps add positive emotions to the senior and improve the patient's self-confidence [26].

4.2.1 Intimacy and Repetitive Care. As for the interface design, the App takes into account the aesthetic needs of the senior, demonstrating its gentle and soft function and expressing the warm and intimate impression. As for designing interaction, the App shall initiate exchanges to encourage senior to use language to express ideas, emotions, and build human-machine trust. Speech interaction shall consider building characters with gentle and caring speeches to make the user experience more comfortable, promote the curiosity of senior users, and increase the care for senior users.

4.2.2 Aging-oriented Experience. Due to the physical and cognitive deterioration of senior dementia patients, the App has easy-to-use interaction and content. Awaken words and semantic expressions shall be smooth and concise, supplemented with visual cues.

They shall contain text and picture; minimize the frequency of touch screen and recognition difficulty. As for outputting machine speech, efforts shall be made to simplify the guidance problem, reduce options, and use straight forward questions to avoid ambiguity.

4.3 Functional Modules of Time Chicken

Several functions are available in Time Chicken to provide the patients with customized reminiscence music and visual cues and to flag emotions through speech interaction autonomously

4.3.1 Digital Content Library. The App has total 200 songs which has consisted of 100 1930s-1960s Chinese songs, 50 Red songs, 30 Taiwanese songs and 20 Japanese songs (Fig. 3). In addition, an "emotional playlist" is sorted out based on the results of speech Q&A.

4.3.2 Interactive Library. The role of the Library is to screen music content that causes emotions, provide music-related background information, and interact with speech commands. The library is designed based on the premise that the seniors are familiar with. It is prohibited to use Internet slang, popular words, and professional terms to prevent the senior from confusion. When setting up explanatory library of reminiscence content, in addition to providing background information to users, it is also imperative to guide them through simple questions. The App supports customized waking-up words, provides the "senior guidance language"[27], as well as has a querying library when the confusing questions are posed. After the App is used for a period of time, it shall have the ability of reminding user to drink water, to access toilet, as well as to notify nursing staff to take care of patients.

4.3.3 Playback and Content Filtering Process. The App generates customized emotional playlists based on different users. The process of generating emotional playlists is: playing music, assessing emotional ratings, marking emotions, and creating customized emotional playlists. During the screening process, the App will use the speech queries method to guide user interaction and provide responses. It establishes a speech recognition failure process, and actively asks user's selection result multiple times when a user fails to feedback or pauses. Meanwhile, the App records the user's usage information (selected content and its type, emotional state etc.), detects the user session content, automatically identifies the emotion categories disclosed in the text content, and returns the recognized emotions to the front end with corresponding values.

4.3.4 Assistance Visual Interface. In addition to the speech interaction function, the App has equipped with a visual interface to assist information display. The limitation of speech lies in the unidirectionality of information output, meaning that the speech cannot be read back, and the seniors may have difficulty hearing and recognize speech information. Therefore, the App is built on a touch screen module. The design of the touch screen should act as an extension of speech interaction with graphical interfaces. When playing the content library, it has displayed synchronously with related pictures, and reduced the number of touching the screen.

In the process of assessing emotions, based on speech prompts, three facial expressions (positive, negative, and neutral) are displayed (Fig. 4). The anthropomorphic visual image can awake the

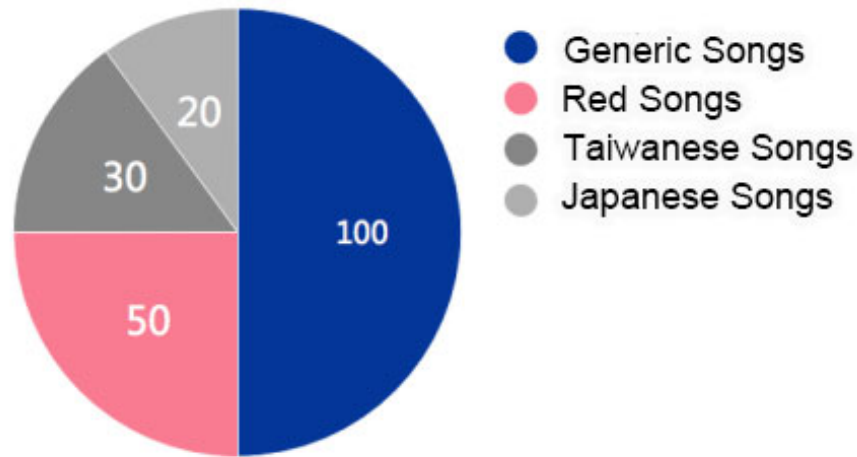


Figure 3: Song Distribution of Time Chicken Content Library

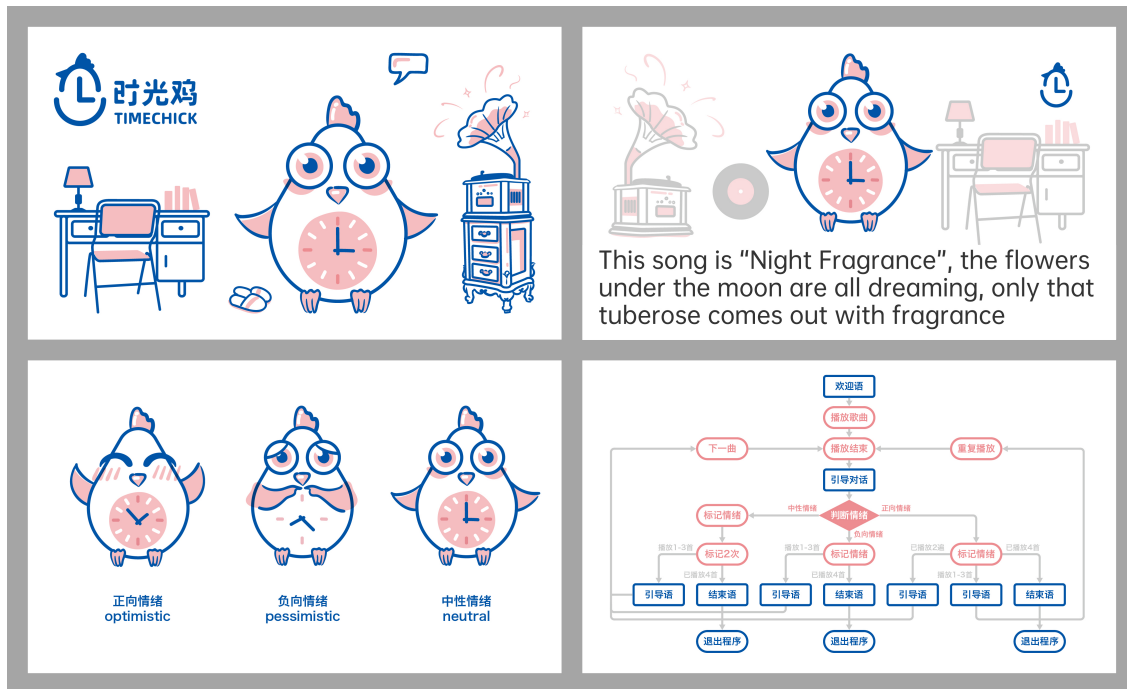


Figure 4: Speech Interactive Interface of Time Chicken

enthusiasm of the patients, narrow the emotional distance, and express the humanistic care.

4.4 Design Iteration of Time Chicken

Time Chicken had conducted three user tests. During the testing process, the designer received important user feedbacks. First, the filling of personal background information interferes the intuitive interactive experience, and the requirement on the user to fill in personal information is needless; second, there will be a clear sense

of participation if the user uses screened smart speakers, which is way better than non-screen speakers; finally, users' participating in multi-level human-machine dialogue will have a poor experience and even fail to obtain emotional assessment results. Therefore, the designer made the following iterative improvements to Time Chicken: In the first iteration, deleted the module for filling user background information; simplified APP functions. In the second iteration, screened smart speakers were selected, and a warm and cute cartoon visual image was designed. Nostalgic information

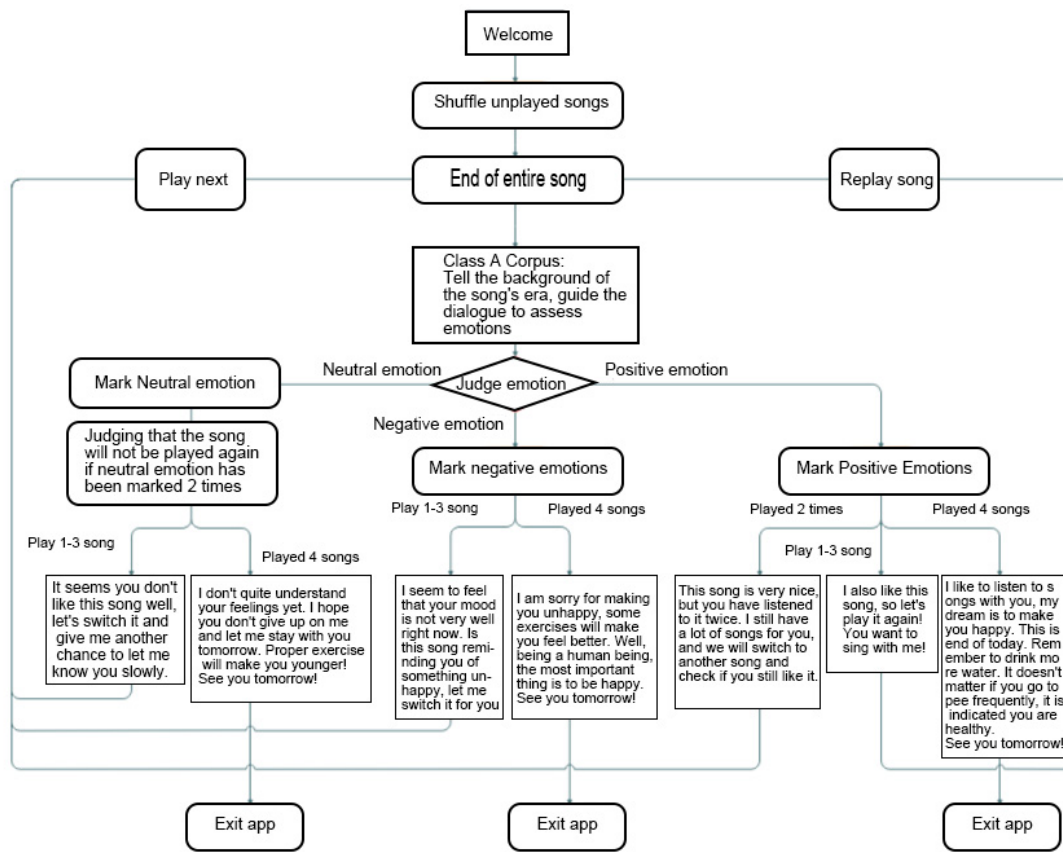


Figure 5: Interactive Design Flow Chart of Time Chicken

was presented by the methods of "listening" and "watching" to mobilize the emotions of the senior. Thanks to two version updates on dialogues, it had simplified the emotion screening logic. In the version 1.0, two rounds of dialogue were set: introduce the song background before playing, and then ask if you have heard it after playing (if you haven't heard it, it will not play this music again. Otherwise, an emotional tag is attached to it). Upon evaluation, it was confirmed that this dialogue in this version causes a response burden when the user interacts and increases the recognition error rate. Therefore, iteration was made in version 2.0 (Figure 5), a fault recognition mechanism for speech was added, and the question was simplified from multiple choice questions into either-or question.

In the third iteration, the designer reduced the music library and collected 200 nostalgic songs fully activating the memory. Based on the features of the longer sitting time of the demented senior, the single-play duration was set to 20 minutes (4 songs in a cycle). If the senior provided no positive feedback on the music, the App presented seniors with comfortable voice response, and took the initiative to care for them, reminded them to take a rest, drank water and did exercises.

4.5 Clinical Study on the Use of Time Chicken

Time Chicken has not yet completed clinical evaluation in medicine. Therefore, the design team will later cooperate with Taiwan Shuang-Ho Hospital, Qingyunli Community Dementia Group, and Community Care Center of Beijing. The evaluation methods include participatory observation, semi-structured interview, setting up the System Usability Scale (SUS), diary records, and quantitative research method for setting a control group. It is expected that 20 non-aphasia patients with mild dementia are selected for testing, and experienced therapists are invited to participate in observation and recording. While evaluating patients' software experience (software functions, interactive functions, nostalgic content), clinical observations of control groups are performed simultaneously.

5 CONCLUSIONS

Time Chicken, an App built with independent emotion screening of reminiscence music, generation of customized playlists, and active playback of music, has experimental and significance in terms of replacing repetitive therapeutic work via speech interaction. Thanks to the integration of intelligent speech and reminiscence therapy, it provides a meaningful and iterative concept, but the product built with this concept is indeed in a trial phase. In fact, it is not recommended to replace the reminiscence therapy with an

intelligent speaker. There are still major challenges to redesign the App such as the shortage of a corresponding library, quantification of therapeutic effects, and system data. We hope that following tasks are effectively implemented to optimize next version of Time Chicken, including reconstructing library, building intelligent skills to diverge questions, and creating detail course plan for the therapy.

REFERENCES

- [1] Yuzhuo Gao, Shulao Liu. Research on the Intelligent Design of the Living Space for the Seniors [J]. Furniture & Interior Design, 2019(07): 14-16.
- [2] Shuang Liu. Analysis and Research of the Design of Care Products for Senior with Dementia [J]. Design, 2016(21): 52-54.
- [3] Mackinlay E, Trevitt C. Living in aged care: using spiritual reminiscence to enhance meaning in life for those with dementia [J]. Int J Ment Health Nurs, 2010, 19(6):394-401.
- [4] Jianping Jia, Ting Ting Hou. Pathogenesis and Therapy Progress of Alzheimer's Disease [J]. Chinese Journal of Medical Science, 2018, 98(29):2351-2356.
- [5] JieLi. A Study of Contemporary Chinese Urban Elderly Culture [M]. Shanghai People's Publishing House, 2012: 50-51.
- [6] Yinhua Zhao, Ying Zhang. Effect of Nostalgic Therapy on Cognitive Function in Elderly Patients with Alzheimer's Disease [J]. Nursing Research, 2018, 32 (11): 1736-1740.
- [7] DTHR-ALZ is a prescription digital medical product that has been awarded the title of breakthrough device by the US Food and Drug Administration for "alleviating the inflammatory and depressive symptoms of neurocognitive disorders like Alzheimer's disease." However, U.S. is not ready for commercial use.
- [8] Mario's autonomous companion robot from Europe is under development as a cognitive stimulation tool for adjuvant treatment of dementia. Existing digital applications of nostalgia therapy are mainly reflected in the use of smart devices to provide nostalgic content, and the specific interactive guidance still needs to be completed by the caregivers of the demented senior. Recent research has focused on intelligent voice dialogues, trying to enable robots to talk to patients independently.
- [9] MINWii is a simple music therapy game for demented senior based on Nintendo Wii designed by researchers such as Benveniste. It is suitable for patients with mild to moderate dementia. Patients can use Wiimotes to improvise music or play the recorded songs on the virtual keyboard displayed on the screen, most users have a strong interest in MINWii in the test.
- [10] Mo Li, Jihui Lu, Zhihui Hao, et al. The Effect of reminiscence therapy On the Cognitive and Self-Esteem Levels of Patients with Alzheimer's Disease [J]. Beijing Medical Journal, 2014 (10):809-811.
- [11] Tao Rong, Cheng Qi. Effects of Reminiscence Nursing Therapy on Cognitive Function and Quality of Life in Elderly Patients with Dementia [J]. China Continuing Medical Education, 2017, 9(22):263-264.
- [12] Jianping Jia, Tingting Hou. Pathogenesis and Treatment Progress of Alzheimer's Disease [J]. Chinese Journal of Medical Science, 2018, 98 (29): 2351-2356.
- [13] Weiyu Luo, Biqi Mei, Lingzhong Liu, et al. Current Clinical Application Of reminiscence therapy [J]. Chinese Journal of Clinical Nursing, 2013, 5(6):540-543.
- [14] Yuanhong Mao, Bin Xu, Guiling Geng. Evidence-based Analysis of the Effects of reminiscence therapy on Patients with Dementia [J]. Modern Preventive Medicine, 2017, 44(13):2475-2480.
- [15] Yuchun Zhou, Yuhui Lan, Shuyuan Zhao. Nursing Experience of Using Individual reminiscence therapy to Alleviate Anxiety of A Senior With Dementia [J]. Journal of Nursing, 2008(4):105-110.
- [16] Ran Xiao. Effects of Reminiscence Therapy On Cognitive Function and Daily Living Ability of Patients with Alzheimer's Disease [J]. General Practice Nursing, 2019, 17(19):2350-2352.
- [17] Mackinlay E, Trevitt C. Living in aged care: using spiritual reminiscence to enhance meaning in life for those with dementia [J]. Int J Ment Health Nurs, 2010, 19 (6): 394-401.
- [18] Yanan Ni. Research on Speech Interaction Design of Smart Speakers for the Senior [J]. Industrial Design, 2019, (09):37-38.
- [19] François Portet, Michel Vacher, Caroline Golanski, Camille Roux, Brigitte Meillon. Design and evaluation of a smart home voice interface for the elderly: acceptability and objection aspects [J]. Personal and Ubiquitous Computing, 2013(01):127-144.
- [20] Hashim A, Rias R M, Kamaruzaman M F. The Use of Customized Digital Memory Book as a Reminiscence Therapy for Alzheimer's Disease (AD) Patients [J]. Advances in Visual Informatics, 2013(8237):508-515
- [21] Yang Yang, Mingren Liu. Research progress on the application of reminiscence therapy in patients with Alzheimer's [J]. Health Vocational Education, 2016, 34(19):142-143.
- [22] Huanhuan Zhang, Jiao Sun, Pengcheng Liu, Shouqi Wang, Jie Ying, Meiling Zhang, Ying Shi, Jing Wu. Progress in The Application of Information and Communication Technology in Reminiscence Therapy for Patients With Dementia [J]. Chinese Nursing Management, 2016, 16(11):1548-1551.
- [23] Minlong Tang, Ning An, Yunhua Jie. Research and Implementation of Digital Reminiscence Therapy [J]. Computer Knowledge and Technology, 2016, 12(10):88-91.
- [24] Mingyan Li. Research Progress of Non-drug Therapy for Patients with Dementia [J]. Modern Clinical Nursing, 2016, 15(06):75-78.
- [25] Han Zhang. The Effect of Active Music On the Therapy of Senior's Alzheimer [J]. Contemporary Music, 2018(08):147-148.
- [26] Hongmei Gong. Case Analysis and Strategic Exploration of Music Therapy In Guangxi Senior Care Service [J]. Think Tank Era, 2019:147-148.
- [27] YananNi. Research on Speech Interaction Design of Smart Speakers for the Senior [J]. Industrial Design, 2019(09):37-38.