Exploring User Preferences in Haptic-Driven Serious Card Games for Older Adults Cognitive Rehabilitation

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Abstract

Background: Cognitive rehabilitation (CR) is an essential intervention for older adults with cognitive impairment, aiming to restore or compensate for cognitive decline. Traditional methods, such as paper-and-pencil exercises, often lack ecological validity and engagement. Serious games have emerged as a promising alternative, especially those incorporating haptic feedback technology. Haptic feedback enhances user interaction by simulating the sense of touch, potentially improving cognitive performance while reducing reliance on visual information. However, there is limited research on the preferences for haptic feedback in serious card games designed specifically for cognitive rehabilitation in older adults.

Objective: The study aims to investigate older adults' preferences for haptic feedback in mobile serious card games and to assess its potential for enhancing cognitive function.

Methods: The present study recruited a total of 250 participants from Dangtu County, Anhui Province, China, with an average age of 70 years. A descriptive survey was conducted among older adults, and structured questionnaires were distributed and data collected via the Wenjuanxing mobile application. Reliability and validity analyses were performed using the Statistical Package for the Social Sciences (SPSS) software. The questionnaire investigated older adults' basic understanding of card games and serious games, the integration of card games with mobile devices, the potential impact of combining card games with haptic feedback technology, as well as suggestions and opinions.

Results: The results showed that 63.2% of the older adults liked the mild haptic feedback mode, and 78.4% of the participants believed that combining haptic feedback technology with mobile card games would help improve cognitive abilities. The study found that 73.6% of the older adults believed that this technology could reduce their reliance on visual information. This confirms that the combination of serious card games and haptic feedback can alleviate sensory impairments in the older adults. Qualitative analysis revealed the potential of haptic feedback to reduce visual fatigue and provide an engaging cognitive training experience.

Conclusions: Older adults have shown great interest in incorporating haptic feedback into mobile serious card games, believing that this could enhance their cognitive abilities while reducing their reliance on visual information. However, limitations include limited sample size. Longitudinal studies are recommended to evaluate the long-term effects of mobile serious card games with haptic feedback on cognitive abilities. Such investigations could provide valuable insights for game developers, rehabilitation institutions, and the development of cognitive training tools for older adults.

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Keywords: Serious games; older adults; Haptic feedback; Mobile card games; Cognitive abilities

Introduction

Cognitive Rehabilitation (CR)[1] is an intervention strategy designed to assist individuals with brain injury or cognitive impairments in compensating for or restoring impaired cognitive functions. In clinical practice, CR can be categorized into two primary types: (i) Restorative Cognitive Rehabilitation, which aims to facilitate the recovery of cognitive domains through specific cognitive exercises; (ii) Compensatory Cognitive Rehabilitation, which advocates for the use of assistive tools to compensate for cognitive deficits. Furthermore, CR techniques can be further divided into traditional (paper-and-pencil exercises) and computer-assisted neurorehabilitation, both of which

employ cognitive strategies to address impairments in executive functions, reasoning and problem-solving, visual processing, language, memory, attention, and concentration[2]. Neuroplasticity[3] is the brain's ability to change its neural structure through interaction with the external environment, and it forms the theoretical basis of CR. This concept emphasizes the potential of targeted interventions to promote adaptive neural changes and thus enhance cognitive function[4]. In this study, we leverage the principles of neuroplasticity to explore the potential of combining haptic feedback technology with serious games. By providing a multimodal sensory experience, haptic technology can mobilize multiple neural pathways and enhance the effectiveness of cognitive training. This approach is consistent with the principles of neuroplasticity and emphasizes the importance of interactive and stimulating environments to promote cognitive recovery and enhancement.

Given the pivotal role of CR in the well-being of the older adults, interventions targeting cognitive health are becoming increasingly significant. One such intervention is the use of serious games[5], which have shown potential in enhancing cognitive abilities and mitigating cognitive decline, particularly within the contexts of cognitive rehabilitation and healthcare. Serious games are a suite of solutions designed to make a range of rehabilitation sessions more engaging and less tedious. The application and development of serious games extend far beyond cognitive rehabilitation and healthcare[6]. At the medical level, there is a spectrum of educational games that can educate patients about their diseases, as well as the potential adverse effects of treatments and therapies. In fact, a substantial body of evidence indicates that the more informed patients are about the potential negative impacts of treatments, the more likely they are to adhere to them[7]. As a form of serious game, card games have a long history, are easy to simulate, have relatively simple rules, and are popular among players of all ages[8] Moreover, card games can aid in the diagnosis and tracking of cognitive impairments, reducing the burden on both patients and physicians, thus potentially providing a more comprehensive and clearer cognitive profile[9]. They can also serve as an effective cognitive intervention to maintain certain cognitive functions[10]. After several months of training, improvements in cognitive abilities such as work capacity, memory, and verbal memory are reasonable and clinically significant[11].

Serious games have played a positive role in the field of cognitive rehabilitation, achieving certain effects[12]. With the advancement of technology, the integration of haptic feedback technology has further expanded the impact of serious games[13], providing patients with a new way of sensation through haptic experience, thereby enhancing users' cognitive abilities. Haptic technology is a sensory feedback technology that simulates the sense of touch by applying force, vibration, or motion to the user. It enables users to experience physical sensations in virtual environments, thereby enhancing their interaction with digital content[14]. These technologies can be used to create virtual objects in computer simulations, control virtual objects, and enhance remote control of machines and equipment. Haptic feedback technology provides an immersive experience for older adults by combining their sense of touch with what they see, hear, or interact with[15]. At the same time, the use of haptic technology has great advantages because it can provide realistic and intuitive interactions with virtual objects, improve the usability and accessibility of applications, enhance the cognitive abilities of end users, and make human-computer interaction more interesting[16]. The application of haptic feedback technology not only enhances user experience, but also enriches their entertainment activities. For example, the use of a haptic suit that provides haptic feedback further enhances the user's sense of immersion[17].

Serious games combined with haptic feedback technology have shown the potential to significantly improve cognitive abilities[18]. For example, in mobile serious games, the interaction method developed by Kangas et al. that combines eye tracking and haptic feedback also significantly

improves the user's operation accuracy and task completion rate. By providing haptic feedback on mobile devices, the user's error rate in interactive tasks is significantly reduced, indicating that serious games combined with haptic feedback can effectively enhance the user's understanding and control abilities in cognitive abilities[19].

Although existing serious game research has provided valuable insights, unresolved issues remain. In particular, the area of combining serious card games with haptic feedback technology to enhance cognitive abilities in older adults remains underexplored. There is limited research on older adults' preferences for haptic feedback in game-based rehabilitation. The overall objective of this study was to evaluate the potential and acceptability of combining haptic feedback technology with mobile card games to improve cognitive abilities in older adults. The specific objectives were to explore older adults' preferences for haptic feedback in mobile card games and to evaluate the potential of mobile card games as a cognitive training tool, especially in the older adult. There were two research hypotheses: First, the combination of haptic feedback technology with mobile card games would improve cognitive abilities in older adults compared to traditional card games. Second, older adults would show higher engagement and satisfaction with haptically enhanced mobile card games.

The structure of the remainder of this paper is as follows. Section 2 reviews the impact of serious games on the cognitive field of older adults, but there is still a need for improvement centered on older adults. Section 3 outlines the research methodology and highlights the reliability and validity of the questionnaire. Section 4 presents the findings and details the integration of haptic feedback into a mobile card game. Section 5 discusses the results and analyzes their validity. Finally, Section 6 summarizes the paper's main findings, discusses the study's limitations, and suggests future research directions.

Methods

The study has been approved by the ethics committee before it was carried out. The respondents were selected by purposive sampling. A total of 250 older adults’ aged 60 to 80 years old in Dangtu County were surveyed. 64 were male and 186 were female. Among them, 155 were 60 to 64 years old, accounting for 62%; 57 were 65 to 69 years old, accounting for 22.8%; 29 were 70 to 74 years old, accounting for 11.6%; 9 were 75 to 80 years old, accounting for 3.6% (Table 1). The participating older adults people have basically used mobile phone software with different haptic settings. Among them, socio-demographic characteristics are usually regarded as independent variables, such as: gender, age, region, work status, etc. are independent variables, and the dependent variables include participants' views on card games, acceptance of new technologies, and their views on the potential benefits of combining card games with new technologies.

Table 1 Sociodemographic characteristics of the participants

Total(*N*=250)		
Demographic		
Gender:		
Male	64	25.6%
Female	186	74.4%
Age group:		
60-64	155	62%
65-69	57	22.8%
70-74	29	11.6%
75-80	9	3.6%
Area:		
DangTu County	250	100%

Work or retired:		
Work	5	2%
Retired	245	98%

This study adopted a descriptive survey design[20] to investigate the preferences and opinions of the older adults regarding haptic feedback in mobile card games. Data were collected through a structured questionnaire and the older adults using the Wenjuanxing[21][22] mobile app, aiming to quantitatively and qualitatively assess the respondents' acceptance of haptic-enhanced serious games. The questionnaire consisted of four parts. Part I: Basic cognition about card games and serious games. Part II: Combination of card games with mobile devices. Part III: Potential impact of combining card games with haptic feedback technology. Part IV: Suggestions and opinions. The 14 questions in the questionnaire were analyzed for reliability and validity using SPSS data analysis software[23]. The coefficient obtained by Cronbach's reliability[24] analysis was 0.729, which was between 0.7 and 0.8, indicating good reliability (see Table 2). The results of the validity analysis are shown in Table 3. The Kaiser-Meyer-Olkin (KMO)[25] value was 0.824, and the KMO value was greater than 0.8, indicating that the research data was very suitable for information extraction.

Table 2 Questionnaire reliability analysis

Cronbach reliability analysis			
name	Corrected Total Correlation (CITC)	α coefficient with item *deleted*	Cronbach alpha *coefficient*
Do you know serious games?	0.174	0.728	0.729
Are you familiar with card games?	0.307	0.719	
Why do you like playing card games?	0.228	0.739	
Do you think card games can exercise your brain?	0.301	0.726	
What abilities of the brain do you think card games can train?	0.324	0.720	
Would you like to try mobile card games?	0.414	0.712	
Are you willing to try a mobile card game that reduces visual fatigue?	0.424	0.714	
Which haptic feedback do you prefer?	0.402	0.714	
Which mode of haptic feedback are you comfortable with?	0.438	0.703	
Would you like to try a card game with haptic feedback technology?	0.520	0.706	
Do you think that card games incorporating haptic feedback technology could reduce the need to use vision to obtain information?	0.520	0.707	
Do you think card games combined with haptic feedback technology are a good combination?	0.557	0.705	

Cronbach reliability analysis			
name	Corrected Total Correlation (CITC)	α coefficient with item *deleted*	Cronbach alpha *coefficient*
Do you think card games combined with haptic feedback technology can help improve your cognitive abilities?	0.576	0.706	
What aspects of your cognitive abilities do you think card games combined with haptic feedback technology can improve?	0.497	0.692	

Note: Standardized Cronbach α coefficient = 0.812

Table 3 Questionnaire validity analysis

Validity analysis results					
name	Factor loading *coefficient*				Commonality (common factor variance)
	Factor 1	Factor 2	Factor 3	Factor 4	
Do you know serious games?	-0.001	0.207	-0.107	0.752	0.620
Are you familiar with card games?	0.183	0.018	0.147	0.742	0.606
Why do you like playing card games?	0.004	0.183	0.608	-0.185	0.437
Do you think card games can exercise your brain?	0.151	0.668	-0.111	0.163	0.507
What abilities of the brain do you think card games can train?	0.012	0.806	0.154	0.004	0.673
Would you like to try mobile card games?	0.668	0.032	-0.022	0.269	0.520

Validity analysis results

name	Factor loading *coefficient*				Commonality (common factor variance)
	Factor 1	Factor 2	Factor 3	Factor 4	
Are you willing to try a mobile card game that reduces visual fatigue?	0.671	0.098	0.089	0.023	0.468
Which haptic feedback do you prefer?	0.175	-0.039	0.653	0.414	0.629
Which mode of haptic feedback are you comfortable with?	0.273	0.080	0.684	0.060	0.553
Would you like to try a card game with haptic feedback technology?	0.843	-0.018	0.139	0.082	0.738
Do you think that card games incorporating haptic feedback technology could reduce the need to use vision to obtain information?	0.792	0.073	0.140	0.074	0.657
Do you think card games combined with haptic feedback technology are a good combination?	0.850	0.147	0.112	0.002	0.757
Do you think card games combined with haptic feedback technology can help improve your cognitive abilities?	0.809	0.166	0.165	0.012	0.710
What aspects of your cognitive abilities do you think card games combined with haptic feedback technology can improve?	0.194	0.695	0.349	0.079	0.648
Eigenvalue (before rotation)	4.509	1.661	1.250	1.103	-
Variance explained% (before rotation)	32.207%	11.864%	8.932%	7.880%	-

Validity analysis results					
name	Factor loading *coefficient*				Commonality (common factor variance)
	Factor 1	Factor 2	Factor 3	Factor 4	
Cumulative variance explained% (before rotation)	32.207%	44.071%	53.003%	60.883%	-
Eigenvalue (after rotation)	3.812	1.727	1.542	1.442	-
Variance explained% (after rotation)	27.228%	12.338%	11.014%	10.303%	-
Cumulative variance explained% (after rotation)	27.228%	39.565%	50.580%	60.883%	-
KMO *value*	0.824				-
Bart spherical *value*	1161.161				-
df	91				-
p - value	0.000				-

Note: If the numbers in the table are colored: blue means the absolute value of the load coefficient is greater than 0.4, and red means the commonality (common factor variance) is less than 0.4.

This study aims to quantitatively analyse and insight respondents' acceptance of new serious game designs by distributing questionnaires through the Wenjuanxing platform[21][22]. The questionnaire data were summarized as percentages and modularly analyzed using the platform to assess familiarity with card games and responses to other closed questions.

While this study provides valuable insights, certain limitations must be acknowledged. The relatively small sample size and regional focus on Dangtu County limit the generalizability of the investigation. Additionally, respondents had varying levels of familiarity with digital technology, which may have influenced responses to haptic feedback.

Results

Familiarity with card games

In the study population, 49.6% of the older adults individuals were familiar with card games, with 31.2% of those aged 60 to 64 years, 11.6% of those aged 65 to 69 years, and further, the proportion of those aged 70 to 74 years familiar with card games was 6%, while for those aged 75 to 80 years, the proportion was 0.8%.

Willingness to try mobile card games

Within the scope of our survey, approximately 58.8% of older adults individuals indicated a willingness to try mobile card games. The distribution of willingness across age groups, from highest to lowest, is as follows: those aged 60-64 years accounted for 38.8%, those aged 65-69 years accounted for 12%, those aged 70-74 years accounted for 5.6%, and those aged 75-80 years accounted for 2.4%. Concurrently, 78.4% of older adults individuals expressed a willingness to try mobile card games designed to alleviate visual fatigue. Among them, the proportion of those aged 60-64 years was approximately 49.6%, those aged 65-69 years was approximately 17.6%, those aged 70-74 years was approximately 8.4%, and those aged 75-80 years was approximately 2.8%.

Motivations for playing card games

In the survey regarding the reasons for enjoying card games, 23.6% of older adults individuals chose to play card games with friends, 43.2% believed that playing card games could exercise their brains, 19.6% selected playing card games to pass the leisure time, 7.2% cited personal interest, and 6.4% of the older adults selected other reasons (as shown in Figure 1).

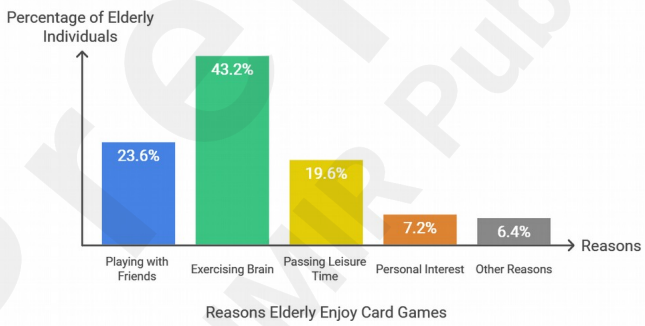

Fig.1 Motivation of older adults playing card games

Preference for haptic feedback

In the third section of this paper, we focus on the preferences and perceptions of older adults individuals towards haptic feedback in mobile card games. The study revealed that 77 respondents (comprising 30.8% of the total sample) exhibited a preference for haptic feedback akin to the vibration experienced when a smartphone receives a call in silent mode. Regarding age distribution, 42 respondents aged between 60 and 64 years accounted for 16.8% of the total sample; 23 respondents aged between 65 and 69 years constituted 9.2% of the total sample; 8 respondents aged between 70 and 74 years represented 3.2% of the total sample, and 4 respondents aged between 75 and 80 years made up 1.6% of the total sample. Notably, 131 respondents (52.4% of the total sample) expressed uncertainty regarding the type of haptic feedback. Twenty-four respondents (9.6% of the total sample) opted for tremor feedback, which resembles the involuntary hand tremors characteristic of Parkinson's disease. Additionally, 12 participants chose shaking feedback (similar to shivering in the cold) and 6 participants selected jiggle feedback (akin to the fine adjustments needed when attempting to open a lock with inappropriate force), representing 4.8% and 2.4% of the total sample,

respectively (Fig.2).

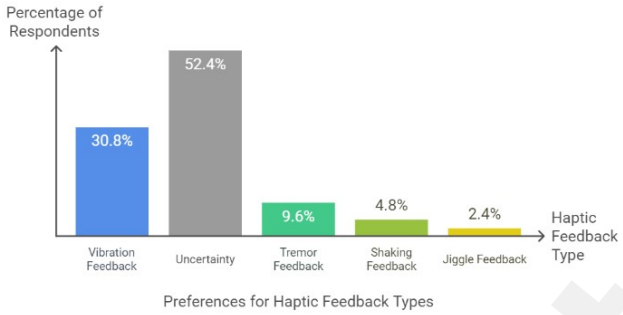

Fig.2 Haptic feedback preferences of the older adults

Haptic feedback mode

The survey findings indicate that 158 individuals (comprising 63.2% of the total sample) selected a slight haptic feedback mode, analogous to the subtle vibration experienced when a smartphone receives a text message. In terms of age distribution, there were 100 respondents aged 60-64, representing 40% of the total sample. For those aged 65-69, there were 32 respondents, accounting for 12.8% of the total sample. The 70-74 age group had 21 respondents, constituting 8.4% of the total sample, and the 75-80 age group had 5 respondents, making up 2% of the total sample. Furthermore, 43 individuals (17.2% of the total sample) opted for a slightly and continuously haptic feedback mode, similar to the gentle, persistent vibration of an electric toothbrush. Ten participants (4% of the total sample) chose a strong haptic feedback mode, akin to the intense vibration of a high-speed spinning washing machine, while another five participants (2% of the total sample) selected a strongly and continuously haptic feedback, reminiscent of the strong and continuous vibrations felt when cycling or motorcycling over rough terrain (Fig.3).

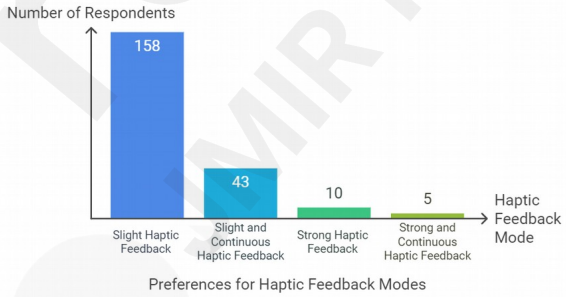

Fig.3 Haptic feedback mode preference of the older adults

Haptic feedback and card games integration

The survey revealed that 163 older adults individuals (65.2% of the total sample) expressed a willingness to try this mobile card game. Notably, within the 60-64 age group, 97 respondents (38.8% of the total sample) indicated a readiness to engage with the game. For the 65-69 age group, 39 respondents (15.6% of the total sample) showed a willingness to participate. In the 70-74 age bracket, 19 respondents (7.6% of the total sample) expressed an interest in playing the game. Lastly, within the 75-80 age range, 8 respondents (3.2% of the total sample) indicated their willingness to participate in the game. Regarding the integration of haptic feedback technology with mobile card games, 187 older adults individuals (approximately 74.8% of the total sample) deemed this combination to be an excellent pairing. In the 60-64 age group, 115 respondents (46% of the total

sample) considered this combination to be very favorable. Among the 65-69 age group, 41 respondents (16.4% of the total sample) held this view. In the 70-74 age bracket, 24 respondents (9.6% of the total sample) expressed agreement with this combination. Lastly, within the 75-80 age range, 7 respondents (2.8% of the total sample) concurred with this pairing.

Enhancing cognitive abilities

This study observed that 196 older adults individuals (comprising 78.4% of the sample) believed that the combination of haptic feedback technology with mobile card games is beneficial for enhancing cognitive abilities, a viewpoint that was uniformly recognized across all age groups. Notably, among respondents aged 75-80, 8 individuals (3.2% of the sample) held this opinion. Following closely, 25 respondents aged 70-74 (approximately 10% of the sample) agreed with this combination, and 40 respondents aged 65-69 (approximately 16% of the sample) also believed that this integration could improve cognitive functions. Furthermore, 123 respondents aged 60-64 (approximately 49.2% of the sample) concurred that this combination could enhance cognitive performance.

Reducing reliance on visual information

In the exploration of older adults individuals' perceptions towards mobile card games integrated with haptic feedback technology, our study found that 184 (73.6%) older adults participants believed that this technology could reduce their dependence on visual information. Among them, 115 individuals aged 60-64, accounting for 46% of the respondents in that age group, held this view. In the 65-69 age group, 39 participants, representing 15.6% of the respondents in that age group, shared this perspective. Within the 70-74 age bracket, 22 older adults individuals agreed with this combination, constituting 8.8% of the total sample. Lastly, in the 75-80 age group, 8 older adults individuals concurred with this combination, representing 3.2% of the total sample.

Technological Integration

In the survey, the positive views of older adults individuals regarding the integration of haptic feedback technology in mobile card games for enhancing cognitive abilities were evident, with specific findings as follows: 108 older adults individuals (approximately 43.2%) believed that the technology could improve their reaction capabilities, 66 older adults individuals (approximately 26.4%) thought it could enhance their memory, and 47 older adults individuals (approximately 18.8%) felt that it could improve their thinking abilities.

Opinions and Suggestions

In the final stage of the study, since this was not a mandatory question, the research team collected qualitative feedback from 31 older adults respondents to investigate their opinions and suggestions on incorporating haptic feedback technology into mobile card games. We categorized the qualitative responses into five distinct groups. The first category of participants emphasized the importance of regular engagement in card games for maintaining cognitive function, highlighting the need for such activities to "keep the mind sharp." Another group expressed a willingness to explore methods that could enhance memory and improve their lifestyle, indicating an openness to new cognitive tools. A third group considered that serious games could enrich the daily lives of the older adults, making their experiences "more colorful and enjoyable." Furthermore, there was enthusiasm for the integration of haptic technology, with the fourth category of participants noting their excitement about the potential fun it could bring. The final group of participants expressed a belief that these games have the potential to enhance memory and may help prevent dementia.

Discussion

Principal Results

The popularity of card games among older adults in China can be attributed to their long cultural history and acceptance. Chinese playing cards originated in the late Southern Song Dynasty[26] and have been documented since 1294 during the Yuan Dynasty[27]. Although the exact rules and design of early card games remain unclear, the Mahjong game[28] of the late Ming Dynasty[29] has similarities to Indian and European games, highlighting the historical spread of card games across cultures[30]. This cultural familiarity may have facilitated the widespread adoption of card games among older adults. Card games have significant health benefits, particularly in improving sleep quality. A study of 4,718 older adults showed that 62% reported good sleep quality, and those who played Mahjong daily were more likely to report better sleep quality than those who did not play Mahjong[31].

The integration of new technologies, such as artificial intelligence (AI) and haptic feedback, has further enhanced the appeal of card games to older adults[32]. The multiplayer card game Dou Di Zhu[33] remains the most popular game in China with its optimal player characters, deck composition, and scoring system[34]. Innovations such as haptic feedback in mobile card games provide a more realistic experience, reduce visual fatigue, and encourage older players to adopt digital platforms. In virtual reality (VR)[35], immersive experiences such as CardsVR promote social interaction and provide realistic haptic sensations, significantly enhancing presence indicators such as action possibilities, realism, and touch[36].

In-depth interviews revealed that older adults were particularly receptive to vibration-based haptic feedback. Their familiarity with mobile phone vibrations (e.g., call alerts and message notifications) also contributed to this preference. In addition, slight vibrations were perceived as comfortable and beneficial for relieving muscle stiffness and addressing age-related muscle and joint mobility decline[37]. These findings highlight the adaptability of older adults to new technologies when they combine them with familiar elements.

Haptic feedback technology also enhances cognitive engagement in card games, offering great potential for cognitive intervention. Card games combined with haptic sensations simulate real-world interactions and increase realism and immersion. This innovation is consistent with research highlighting the role of card games in maintaining cognitive function and tracking cognitive impairment[9][10][11]. In addition, the slight vibrations in the haptic feedback can further support cognitive health by reducing physical discomfort and promoting sustained engagement.

Older adults of all ages rated the combination of haptic feedback and mobile card games as a beneficial innovation. These technologies improve the gaming experience for visually impaired users[38] and help alleviate vision-related challenges associated with aging. By providing an alternative way to receive game information, haptic feedback enhances accessibility and cognitive stimulation. Overall, these innovations suggest that mobile card games with haptic feedback can have a positive impact on cognitive function and overall quality of life in older adults by promoting engagement and enjoyment.

Limitations

Several limitations of this study should be acknowledged. First, the sample size was relatively small and focused on a specific region (Dangtu County), which may limit the generalizability of the findings. Future studies should consider larger and more diverse populations to validate these results.

Second, participants had varying levels of familiarity with digital technology, which could have influenced their preferences and acceptance of haptic feedback. Third, the study relied on self-reported data, which may be subject to biases. Finally, the study did not assess the long-term effects of using haptic feedback in serious games on cognitive abilities. Longitudinal studies are needed to evaluate the sustained impact of this technology on cognitive rehabilitation.

Comparison with Prior Work

This study extends the existing literature by focusing on older adults' preferences for haptic feedback in serious card games, an area that remains underexplored. Previous studies have highlighted the potential of serious games for cognitive rehabilitation but often overlook the specific needs and preferences of older adults[1]. Our findings are consistent with these studies, demonstrating the positive response of interactive technologies on cognitive function[2].However, this study uniquely identifies the potential of haptic feedback in reducing visual dependence in older adults, a new contribution to the field.

In addition, the high acceptance rate of haptic feedback technology by participants supports previous findings that older adults are more likely to accept new technologies when they are combined with familiar activities[3]. This study also builds on the research of Abd-Alrazaq[4] et al. who reported that serious games can improve cognitive performance in older adults with mild cognitive impairment[5]. Our results suggest that haptic feedback technology can further enhance these benefits by providing a more immersive and accessible gaming experience.

Conclusions

This study investigated the effects of integrating haptic feedback into a mobile serious card game on cognitive abilities of older adults. The results showed that older adults showed strong interest in this combination, believing that it could enhance their cognitive abilities while reducing their reliance on visual information. The uniqueness of this study lies in the integration of haptic feedback technology with mobile card games to improve cognitive functions without exacerbating visual degradation, a common problem in traditional serious games for older adults. The study concluded that haptic feedback-integrated mobile card games provide a new direction for serious games targeting older adults, effectively supporting cognitive abilities without burdening their sensory organs. However, limitations include a limited sample size from Dangtu County, China, and the varying digital literacy of respondents, which may affect the generalizability of the findings.

Future studies should expand the sample size to enhance the generalizability of the results and explore the adaptability and preference of haptic feedback technology among older adults with different digital literacy levels. Longitudinal studies are also recommended to evaluate the long-term effects of haptic feedback mobile card games on cognitive abilities. Such investigations can provide valuable insights for game developers, rehabilitation institutions, and the development of cognitive training tools for older adults.

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Conflicts of Interest

none declared

Abbreviations

CR: Cognitive rehabilitation
SPSS: Statistical Product and Service Solutions
KMO: Kaiser-Meyer-Olkin
VR: Virtual Reality

References

[1] Guo, YS; Sun, TT; Qiu, FX; Li, XY; Cui, WW; Liao, ZH; Yao, JJ. 2025.Electroacupuncture combined with cognitive rehabilitation outperforms cognitive rehabilitation alone in treating post-stroke cognitive impairment: a randomized controlled trial. Frontiers in Neurology, vol:16.Doi:10.3389/fneur.2025.1507475

[2] De Luca, R.; Calabrò, R. S.; & Bramanti, P. 2016. Cognitive rehabilitation after severe acquired brain injury: current evidence and future directions. Neuropsychol Rehabil, 25, 1e20.Doi: https://doi.org/10.1080/09602011.2016.1211937

[3] Saleki, K; Banazadeh, M; Saghazadeh, A; Rezaei, N. 2023. Aging, testosterone, and neuroplasticity: friend or foe? Reviews in the Neurosciences, vol:34, Issue:3,pp:247-273. Doi: 10.1515/revneuro-2022-0033

[4] Maria Grazia Maggio; Giuseppa Maresca; Rosaria De Luca; Maria Chiara Stagnitti; Bruno Porcari; Maria Cristina Ferrera; Franco Galletti; Carmela Casella; Alfredo Manuli; Rocco Salvatore Calabrò.2019.The Growing Use of Virtual Reality in Cognitive Rehabilitation: Fact, Fake or Vision? A Scoping Review. Journal of the National Medical Association, Volume 111, Issue 4, August 2019, Pages 457-463. Doi: 10.1016/j.jnma.2019.01.003.

[5] Huang, X.; Ali, N.M.; Sahrani, S. Evolution and Future of Serious Game Technology for Older Adults. Information 2024, 15, 385.Doi: 10.3390/info15070385.

[6] Abt, C.C. Serious Games; Viking Press: New York, NY, USA, 1970.

[7] Bruno Bonnechère; Serge Van Sint Jan. 2019. DHM and Posturography, Chapter 39 – Rehabilitation, pp: 541-547. Doi:10.1016/B978-0-12-816713-7.00039-8.

[8] Gao, YX; Li, WX; Xiao, YH; Khalid, MNA; Iida, H.2020. Nature of Attractive Multiplayer Games: Case Study on China's Most Popular Card Game—DouDiZhu. Information, vol:11,issue:3.Doi:10.3390/info11030141.

[9] Gielis, K; Kennes, J; De Dobbeleer, C. 2019. Collecting Digital Biomarkers on Cognitive Health Through Computer Vision and Gameplay: an Image Processing Toolkit for Card Games. 2019 IEEE International Conference on Healthcare Informatics, pp:127-138. Doi:10.1109/ichi.2019.8904511.

[10] Estrada-Plana, V; Montanera, R; Ibarz-Estruga, A; March-Llanes, J; Vita-Barrull, N; Guzmán, N; Ros-Morente, A; Arriola, RA; Moya-Higueras, J. 2021.Cognitive training with modern board and card games in healthy older adults: two randomized controlled trials. International Journal of Geriatric Psychiatry, vol:36, issue:6, pp:839-850. Doi:10.1002/gps.5484.

[11] Hampshire, A; Sandrone, S; Hellyer, PJ. 2019. A Large-Scale, Cross-Sectional Investigation Into the Efficacy of Brain Training. Frontiers in Human Neuroscience, vol:13. Doi:10.3389/fnhum.2019.00221.

[12] González-González, CS; Toledo-Delgado, PA; Muñoz-Cruz, V; Torres-Carrion, PV. 2019. Serious games for rehabilitation: Gestural interaction in personalized gamified exercises through a recommender system. Journal of Biomedical Informatics, vol:97.

Doi:10.1016/j.jbi.2019.103266.
[13] Deng, SJ; Chang, J; Zhang, JJ. 2014.A Survey of Haptics in Serious Gaming. Lecture Notes in Artificial Intelligence. Vol:8605,pp:130-144. Doi:10.1007/978-3-319-12157-4_11.
[14] Gay, SL; Truong, NT; Romeo, K; Pissaloux, E. 2021.Using Force-Feedback Haptic Effects to Develop Serious and Entertainment Games Accessible for Visually Impaired People. ICT for Health, Accessibility and Wellbeing, IHAW, vol:1538, pp:185-197. Doi:10.1007/978-3-030-94209-0_16.
[15] Li, YX; Yoo, Y; Weill-Duflos, A; Cooperstock, JR. 2021. Towards Context-aware Automatic Haptic Effect Generation for Home Theatre Environments. Proceedings of 27th acm Symposium on virtual reality software and technology.Doi:10.1145/3489849.3489887.
[16] Kaklanis, N; Votis, K; Tzovaras, D.2015. Adding haptic feedback to web applications towards improving end-users' cognitive capabilities. International Conference on Cognitive Infocommunications.
[17] Saint-Louis, C; Hamam, A. 2021. Survey of Haptic Technology and Entertainment Applications. SoutheastCon 2021, pp:493-499. Doi:10.1109/SOUTHEASTCON45413.2021.9401939.
[18] Pacheco-Barrios, K; Ortega-Márquez, J; Fregni, F. 2024. Haptic Technology: Exploring Its Underexplored Clinical Applications—A Systematic Review. Biomedicines, vol:12, Issue12.Doi:10.3390/biomedicines12122802.
[19] Shujie Deng; Julie A. Kirkby; Jian Chang; Jian J. Zhang. 2014.Multimodality with Eye tracking and Haptics: A New Horizon for Serious Games? International Journal of Serious Games, Vol. 1 No. 4. Doi: https://doi.org/10.17083/ijsg.v1i4.24.
[20] Hofers, W, Jorgensen, V, Sallstrom, S, Vege, KM. 2022. Organisation of services and systems of care in paediatric spinal cord injury rehabilitation in seven countries: a survey with a descriptive cross-sectional design. Spinal Cord, vol:60, Issue:4, pp:339-347. Doi:10.1038/s41393-021-00726-1.
[21] WJX.cn.https://www.wjx.cn/html/aboutus.aspx.
[22] Wang Weidong. 2018. Network Survey and Data Integration. Wuhan University Press 2018 pp:39
[23] Becker, H; Bialasiewicz, AA; Schaudig, U; Schäfer, H; von Domarus, D. 2002. Final clinical indication and etiology in 1023 cases of enucleation:: data bank analysis using SPSS software in variable response mode. Ophthalmology, vol:99, Issue5, pp:367-374.Doi:10.1007/s003470100539.
[24] Karakaya, SPY; Alparslan, ZN. 2022. Sample Size in Reliability Studies: A Practical Guide Based on Cronbach's Alpha. Psychiatry and Behavioral Sciences, vol:12, Issue3,pp:150-157. Doi:10.5455/PBS.20220127074618.
[25] Kaiser–Meyer–Olkin test. https://en.wikipedia.org/wiki/Kaiser%E2%80%93Meyer%E2%80%93Olkin_test.
[26] Kong, NN. 2024. Competition in Imperial Edict Writing in the Southern Song Dynasty. Frontiers of History in China, vol:19, Issue4, pp:460-487.Doi:10.3868/s020-013-024-0020-0.
[27] Zhang, J. 2021.The Undercurrent of Proto-Nationalism in the Yuan Dynasty. Bulletin of the Institute of History and Philology Academia Sinica, vol:92, pp:91-150,part1.
[28] Lu, YL; Li, WX; Li, WL. 2023. Official International Mahjong: A New Playground for AI Research. Algorithms, vol:16, Issue5.Doi:10.3390/a16050235.
[29] Zhang, ZX; Du, J. 2023. Cultural migration and development of painting art in the Ming and Qing dynasties. Voprosy Istorii, vol:12,Issue:2,pp:134-145. Doi:10.31166/VoprosyIstorii202212Statyi74
[30] Lo, A. 2000.The game of leaves: An inquiry into the origin of Chinese playing cards. Bulletin of the School of Oriental and African Studies-University of London, vol:63, pp:389-406, part:3. Doi:10.1017/S0041977X00008466.
[31] Lee, YH; Chang, YC; Shelley, M; Liu, CT. 2020. Sleep and Biological Rhythms A panel analysis

of the Mahjong card game and social activity with sleep-related measurements among Chinese older adults. Sleep and Biological Rhythms, vol:18, issue:2, pp:109-119. Doi:10.1007/s41105-019-00249-6.

[32] Pookkuttath, S; Abdulkader, RE; Elara, MR; Veerajagadheswar, P. 2023. AI-Enabled Vibrotactile Feedback-Based Condition Monitoring Framework for Outdoor Mobile Robots. Mathematics, vol:11,Issue18.Doi:10.3390/math11183804.

[33] 17 Kong, Y; Shi, HY; Wu, XC Rui, YF. 2023. Application of DQN-IRL Framework in Doudizhu's Sparse Reward. Neural Processing Letters, vol:55,Issue:7,pp:9467-9482. Doi:10.1007/s11063-023-11209-0.

[34] Gao, YX; Li, WX; Xiao, YH; Khalid, MNA; Iida, H. 2020. Nature of Attractive Multiplayer Games: Case Study on China's Most Popular Card Game—DouDiZhu. Information, vol:11, issue:3. Doi:10.3390/info11030141.

[35] Gao, BY; Shao, T; Tu, HW; Ma, QZ ; Liu, ZT; Han, T. 2024. Exploring Bimanual Haptic Feedback for Spatial Search in Virtual Reality. IEEE Transactions on Visualization and Computer Graphics, vol:30, Issue5, pp:2422-2433. Doi:10.1109/TVCG.2024.3372045.

[36] Huard, A; Chen, MY; Sra, M. 2022. CardsVR: A Two-Person VR Experience with Passive Haptic Feedback from a Deck of Playing Cards. 2022 IEEE International Symposium on Mixed and Augmented Reality (ISMAR), pp:538-547. Doi:10.1109/ISMAR55827.2022.00070.

[37] Liu Hongliang.2024. Slightly shaking your head? To explore the common causes of the elderly. https://m.youlai.cn/yyk/hnote/076061mqAmg.html.

[38] Gay, SL; Truong, NT; Romeo, K; Pissaloux, E.2022.Using Force-Feedback Haptic Effects to Develop Serious and Entertainment Games Accessible for Visually Impaired People. ICT for Health, Accessibility and Wellbeing, vol:1538, pp:185-197. Doi:10.1007/978-3-030-94209-0_16.

[1] Guzmán, DE; Rengifo, CF; García-Cena, CE. 2024. Serious Games for Cognitive Rehabilitation in Older Adults: A Conceptual Framework. Multimodal Technologies and Interaction, vol:8,Issue8.Doi:10.3390/mti8080064.

[2] Leung, C; Wong, KC; Shum, DHK. 2022. The application of technology to improve cognition in older adults: A review and suggestions for future directions. PsyCh Journal, vol:11, Issue4, pp:583-599.Doi:10.1002/pchj.565.

[3] Vaportzis, E; Clausen, MG; Gow, AJ. 2017. Older Adults Perceptions of Technology and Barriers to Interacting with Tablet Computers: A Focus Group Study. Frontiers in Psychology, vol:8.Doi:10.3389/fpsyg.2017.01687.

[4] Abd-Alrazaq, A; Alhuwail, D; Al-Jafar, E; Ahmed, A ; Shuweihdi, F; Reagu, SM; Househ, M. 2022. The Effectiveness of Serious Games in Improving Memory Among Older Adults With Cognitive Impairment: Systematic Review and Meta-analysis. Jmir serious games,vol:10,Issue3.Doi:10.2196/35202.

[5] Fadzil, NHM; Shahar, S; Rajikan, R; Singh, DKA; Ludin, AFM; Subramaniam, P; Ibrahim, N ; Vanoh, D; Ali, NM.2022. A scoping review for usage of telerehabilitation among older adults with mild cognitive impairment or cognitive frailty.International Journal of Environmental Research and Public Health, vol:19, Issue7.Doi:10.3390/ijerph19074000.