
AI translation · View original & related papers at
chinaxiv.org/items/chinaxiv-202304.00602

The Impact of Information Representation on Reading Effectiveness of Mobile Health APP Privacy Policies: A Cognitive Load Theory Study (Postprint)

Authors: Zhang Yue, Wang Jian, Yu Shu, Zhu Qinghua

Date: 2023-04-01T00:00:00+00:00

Abstract

[Purpose/Significance] Privacy protection in mobile healthcare scenarios is a critical issue requiring urgent attention. Research on the effectiveness of user privacy policy reading can not only stimulate users' willingness to read privacy policies and enhance their privacy protection awareness, but also facilitate the popularization and application of mobile healthcare. [Method/Process] From a perspective that facilitates user reading and comprehension, and based on cognitive load theory, this study employs virtual experiments and multi-factor analysis of variance to measure the subjective cognitive load and objective performance of different types of users when reading different forms of privacy policies, thereby investigating the impact of information representation on the reading effectiveness of mobile healthcare APP privacy policies. [Results/Conclusion] The results indicate that graphic-based privacy policies can effectively reduce the subjective cognitive load of visual users. Moreover, compared with text-based privacy policies, graphic-based privacy policies balance both readability and comprehensibility, and can significantly improve users' objective performance after reading.

Full Text

Preamble

Special Issue: Research on User Online Health Information Behavior

Editor's Note: In recent years, with the rapid development of "Internet + Healthcare," an increasing number of users have turned to the internet, particularly online health communities, to obtain health information. The factors influencing users' health information seeking and medical service selection have become

a recent research hotspot. This issue features five selected articles from accepted submissions, including: “Research on the Influence of Information Representation on the Reading Effect of Mobile Medical APP Privacy Policies—Based on Cognitive Load Theory,” “Research on User Influence in Online Health Communities Integrating PageRank and Comment Sentiment Tendency,” “The Impact of Conflicting Health Information on Users’ Health Information Seeking: An Exploration Based on the Perspective of Uncertainty,” “Research on Influencing Factors of Patients’ Online Medical Team Service Selection Behavior—Taking Haodf.com as an Example,” and “Research on Influencing Factors of Online Health Information Seeking Behavior among Elderly Users from the Perspective of Mobile Terminals.” We hope to present readers with the latest research findings on user online health information behavior from different perspectives, facilitating learning, discussion, and exchange.

Research on the Influence of Information Representation on the Reading Effect of Mobile Medical APP Privacy Policies—Based on Cognitive Load Theory

Zhang Yue, Wang Jian, Yu Shu, Zhu Qinghua

School of Information Management, Nanjing University, Nanjing 210023

Abstract: [Purpose/Significance] Privacy protection in mobile health scenarios is an important issue that needs to be urgently addressed. Research on the reading effectiveness of user privacy policies for mobile health applications can stimulate users’ willingness to read privacy policies and enhance their awareness of privacy protection, which is conducive to the long-term development and application of mobile health applications. [Method/Process] This study attempts to measure the subjective cognitive load and objective performance of different types of users when reading different forms of privacy policies from the perspective of user-friendly reading and understanding, based on cognitive load theory, through virtual experiments and multifactor analysis of variance, and to study the influence of information representation on the reading effect of mobile medical APP privacy policies. [Result/Conclusion] The results showed that compared with the textual privacy policy, the graphical privacy policy is more readable and comprehensible, which can effectively reduce the cognitive load of visual users and significantly improve users’ reading achievement.

Keywords: M-Health APP; privacy policy; information representation; cognitive load theory

2 Literature Review

This section elaborates on relevant domestic and international research from three aspects: mobile medical APP privacy policy research, information repre-

sentation research, and cognitive load theory.

2.1 Mobile Medical APP Privacy Policy Research

Mobile health applications (mobile health application) are healthcare software that integrates medical services and information management based on mobile operating systems such as Android and iOS. The statements and terms formulated by such mobile medical APPs regarding the collection, storage, use, sharing, and transfer of user information constitute mobile medical APP privacy policies. APP platforms establish data exchange and usage regulations with users through privacy policy agreements, and protect, standardize, and use users' personal information data accordingly. Academic research on mobile medical APP privacy policies mainly involves four aspects: legal effectiveness and application status, content quality and technical practice, usage intention and adoption, and reading effectiveness.

(1) Legal Effectiveness and Application Status of Mobile Medical APP Privacy Policies: Yu Wenqing et al. [14] studied the legal and regulatory system of mobile medical privacy policies from a legal perspective; He Xiaolin et al. [15] compared and researched privacy data generated by wearable devices in mobile healthcare with traditional medical privacy in terms of data security, legal provisions, and application status; Liu Qiankun et al. [16] used content analysis to analyze the completeness of privacy protection and found that 14 out of 15 popular health APPs had insufficient privacy policy provisions, recommending improvements in evaluation standards and legal environments; B. Martinez-Perez et al. [17] conducted a retrospective study on existing privacy terms and security practices of mobile medical APPs in the EU and USA, providing relevant policy recommendations.

(2) Content Quality and Technical Practice of Mobile Medical APP Privacy Policies: J. Benjumea et al. [18] used scales to detect whether mobile medical APP privacy policies comply with the General Data Protection Regulation (GDPR); K. Knorr et al. [19] studied 154 mobile medical APPs from the Android app store through automatic code and metadata analysis, finding that many APPs did not provide basic input validation tests; H. Huang et al. [20] used the context-integrated Nissenbaum framework to detect privacy policies, terms of use, and service procedures in mobile applications of six genetic testing companies to address contextual privacy dilemmas in mobile medical privacy policies; S. Sadki et al. [21] used an analytic hierarchy process to resolve conflicts in privacy policy content in mobile medical environments, employing the S4P formal privacy policy language as a standard language to help detect and resolve conflicts.

(3) Research on Usage Intention and Adoption of Mobile Medical APP Privacy Policies: Zhu Guang et al. [22] used evolutionary game theory to study the behavioral strategies of privacy accountability and compensation among game participants composed of patients, mobile medical APP platforms,

and the government, establishing an evolutionary game model between patients and APP platform parties, and thus studied users' willingness to use mobile medical APPs under privacy concerns; X. Guo et al. [23] took the "privacy-personalization paradox" as an independent variable and trust as a mediating variable, constructed an attribute-perception-intention model, and conducted in-depth research on users' privacy adoption intentions in mobile medical platforms; Yuan Jinqiao [24] divided mobile medical users into youth, middle-aged, and elderly groups based on privacy calculation theory, exploring the similarities and differences in mobile medical service adoption intentions among different age groups; Zhang Yue et al. [25] used grounded theory research methods to construct a cognitive influence model of mobile medical APP privacy policies based on users' privacy policy usage intentions and adoption.

(4) Research on Reading Effectiveness of Mobile Medical APP Privacy Policies: A. C. Powell et al. [26] analyzed 70 diabetes and mental health medical APPs using 15 indicators such as word count, reading ease, and automatic readability index to study the complexity of privacy policy reading effectiveness; L. Parker et al. [27] analyzed privacy policies of 61 mental health APPs from four dimensions: accessibility and readability, data collection, information leakage complaints, and GDPR regulations; J. M. Robillard et al. [28] used online readability calculators to study the reading effectiveness of privacy policies for 319 iOS and 69 Android mental health APPs. Currently, there is not much domestic research specifically focusing on the reading effectiveness of mobile medical privacy policies, but relevant research in other fields provides valuable references. Yao Shengyi et al. [29] evaluated the friendliness of privacy policies for shopping APPs and further analyzed the reading effectiveness of relevant privacy policies; Zhu Hou et al. [30] found seven issues in privacy policies of multiple social media APPs, such as excessive length, too many clicks required, and non-concise introductions, which lead to poor user reading effectiveness; Wang Ying [31] studied privacy policies of library associations in some countries or regions through content analysis, focusing on analyzing the reading effectiveness of privacy policies.

2.2 Information Representation Research

The concept of information representation originates from cognitive psychology and refers to the expression method of information during processing and recording [32]. From the perspective of cognitive participation, information representation can be divided into external representation and internal representation [33-34]: External representation is the manifestation form of information recording, mainly existing in forms such as voice, text, symbols, pictures, or actual scenarios; internal representation refers to the corresponding cognitive structure and mental structure in learners' minds when facing specific information, including personal symbol construction, meaning assignment to mathematical symbols, and visual imagination and spatial representation.

Unlike external representation, internal representation cannot be directly ob-

served and needs to be obtained through cognitive and memory systems. Therefore, exploring the cognitive and information processing processes related to internal representation and studying their connections with external representation and human behavior patterns have become the focus of scholars in this field. Scholars have long reached a consensus that information in different external representation forms is processed in different regions of the brain. For example, the brain adopts non-linear processing for graphic information and linear processing for text information [38-39]. At the same time, individuals have relatively stable personal preferences in selecting cognitive units during internal information processing. Cognitive psychology refers to this stable preference in internal representation as cognitive style [40], among which “visual cognition” and “verbal cognition” are the two most important cognitive units in information internal representation. The former mainly processes representations through reading perception of non-text objects and event images [41], while the latter specifically processes linguistic information such as words and sentences [42]. The ILS scale developed by R. M. Felder and L. K. Silverman mapping different cognitive styles from four aspects of information processing, perception, input, and understanding [43] has been used by scholars for analyzing and measuring internal representation preferences. R. Riding et al. [44] examined EEG α -wave changes in 15 different brain regions of individuals with different internal representation preferences during information processing through experiments, finding that both verbal and visual preference individuals showed obvious cognitive style hemispheric lateralization effects, with verbal subjects having higher α -wave suppression in the left hemisphere and visual subjects having higher α -wave suppression in the right hemisphere.

2.3 Cognitive Load Theory

Cognitive load theory, proposed by J. Sweller in 1988 [45], refers to the total amount of cognitive resources consumed during information processing in learning or task completion. This concept, originating from cognitive psychology, is now widely applied in multiple fields such as educational psychology [46], educational technology [47], and systems science [48]. In recent years, many scholars in the field of information management and information systems have tended to apply this theory to interface design in human-computer interaction processes and research on electronic reading effectiveness evaluation. For example, J. Gwizdka studied the changes in cognitive requirements and cognitive load during web search task completion [49]; J. H. Hu et al. discussed the moderating effect of cognitive load and website functions [50]; Fang Hao and Hou Guanhua explored electronic reading interface design and visual search in mobile applications based on cognitive load theory [51-52]; D. Destefano specifically studied the presentation and reading effectiveness of hyperlinks in mobile reading [53].

In summary, there is currently relatively little domestic research on the reading effectiveness of mobile medical APP privacy policies. However, compared with privacy policies of APPs in other fields, mobile medical APPs involve more sen-

sitive and complex information (such as electronic medical records, diagnosis and treatment data, social security numbers, bank account numbers, insurance records, etc.) that requires real-name authentication for functions like appointment registration and medical consultation. If users cannot clearly understand how platforms collect and use this personal information, it will greatly increase resistance during usage, not only bringing huge obstacles to the application and popularization of mobile medical services but also greatly reducing the effectiveness of mobile medical management and services. At the same time, existing research on the reading effectiveness of privacy policies mostly evaluates directly from indicators recognized by experts and platforms, rarely focusing on readers' psychological load during the reading process and final reading effectiveness from the perspective of information content. Therefore, this study attempts to start from the perspective of information representation, drawing on cognitive load theory to conduct virtual experimental design on reading terms of different external representation forms in mobile medical APP privacy policy reading scenarios, measuring the subjective feelings and objective effects of users with different internal representation tendencies reading these privacy policy terms, in order to explore external representation forms of mobile medical APP privacy policies that stimulate users' reading willingness and improve reading effectiveness.

3 Experimental Design and Data Acquisition

This study explores the influence of information representation on users' privacy policy reading in mobile medical APP contexts through virtual experiments. The pre-experiment phase includes selecting reading material sources, designing graphical reading materials, and restoring the mobile medical privacy policy reading virtual scenario in three steps. The formal experiment includes five steps: prior knowledge level detection, internal representation testing, mobile medical APP privacy policy reading, subjective cognitive load measurement, and objective performance measurement.

3.1 Reading Material Source and Design

All privacy policy reading materials in this experiment were sourced from the "WeDoctor APP," as this platform is a representative comprehensive health service platform among domestic mobile medical APPs. It primarily uses IoT and artificial intelligence technologies to help medical institutions and pharmaceutical companies achieve intelligence and cloud-based services, providing users with mobile medical and health services. It was selected for the "2019 Forbes China Most Innovative Enterprises List" [54], and the platform's privacy policy completeness and update frequency are relatively high, making it representative.

Based on J. D. Novak's concept map theory [55] and R. E. Mayer's multimedia learning cognitive principles [56-57], this experiment conducted corresponding graphical design on the selected WeDoctor APP privacy policy text materials, and used the MockingBot prototyping software to highly restore both textual

and graphical external representation forms of privacy policy reading materials on mobile terminals (see Figure 1 [Figure 1: see original paper]) to construct a virtual environment for mobile medical APP privacy policy reading. The left side shows the text form, and the right side shows the graphical form.

3.2 Experimental Procedure and Data Acquisition

In the experiment, individuals with different internal representation preferences (verbal vs. visual) and different external representation policy materials (textual vs. graphical) were set as independent variables, while participants' cognitive load during privacy policy reading (including subjective perception and objective performance) was set as the dependent variable. The experiment attempted to examine the preferences and adoption of different external representation forms of privacy policy information (graphical and textual) by mobile medical APP users with different internal representation tendencies (visual and verbal). The specific experimental procedure is shown in Figure 2 [Figure 2: see original paper]:

- (1) **Prior Knowledge Level Detection.** To prevent participants' prior knowledge of mobile medical APP privacy policies from affecting the experimental process, balance differences in prior knowledge among participants, and control other interfering factors, this experiment designed a pre-test questionnaire based on basic knowledge of mobile medical APP privacy policies. The questionnaire screened participants from two main parts: "basic personal information" and "understanding of mobile medical APP privacy policies," removing individuals whose prior knowledge would significantly impact the experimental process.
- (2) **Internal Representation Testing.** Based on the ILS scale developed by R. M. Felder and L. K. Silverman mentioned above [43], an internal representation test questionnaire was designed to investigate "users' personal habits in using textual and graphical materials." According to the test results, participants were divided into two groups based on visual and verbal types.
- (3) **Mobile Medical APP Privacy Policy Reading.** Different types of participants were randomly assigned to different groups according to "visual participants - graphical materials," "visual participants - textual materials," "verbal participants - graphical materials," and "verbal participants - textual materials" for cross-reading of experimental materials.
- (4) **Subjective Cognitive Load Measurement.** Starting from participants' subjective feelings, the NASA-TLX evaluation scale [58], commonly used in the cognitive load field, was adopted to measure the subjective load size when participants read the materials. The greater the subjective cognitive load during reading, the stronger the reading resistance. All participants filled out the scale according to their own situation after reading the mobile medical APP privacy policy experimental materials.

- (5) **Objective Performance Measurement.** Objective performance is not only a direct reflection of users' reading effectiveness but also an important measurement indicator of objective cognitive load. If users' objective performance is lower, it indicates higher objective cognitive load during the reading process and less understandable content. This experiment subdivided users' objective performance into recognition performance, recall performance, and transfer performance [59], corresponding to three question types in the objective test: multiple-choice, fill-in-the-blank, and short-answer questions.

Forty college students who passed the prior knowledge level detection were recruited as participants through public channels. According to the "2020-2026 China Medical Mobile Application (APP) Industry Development Status Survey and Market Supply and Demand Forecast Report" [60], the 18-24 age group is the main user group of China's mobile medical platforms, with females in the majority. In this study, participants aged 18-24 accounted for 78% of the total sample, with a male-to-female ratio of 3:7, basically matching the characteristics of China's medical APP user group being younger and female-dominated. The basic sample statistics are shown in Table 1 .

All participants in the experimental research participated voluntarily with no privacy ethics risks; all participants had no language or vision barriers; the experiment promised confidentiality of all user information; participants completed the experiment by scanning QR codes, which generally took 15-25 minutes for ordinary users. The male-to-female ratio among all participants was 3:7, and the ratio of visual to verbal types was 1:1. The 40 participants were randomly divided into four groups according to different types, forming a 2\$×\$2 multifactor mixed experimental matrix. The grouping situation is shown in Table 2 .

4 Data Processing and Analysis

4.1 Prior Knowledge Level Detection

To prevent the influence of prior knowledge level on reading effectiveness, participants' prior knowledge levels were tested according to the 70% screening standard used in previous research [56]. The statistical results (see Table 3) showed that the $M \pm SD$ values of all groups were below 70 points, meeting the prior knowledge detection standard.

4.2 Multifactor Analysis of Variance

4.2.1 Subjective Load Analysis The descriptive statistical results of subjective cognitive load measurements for participants with different internal representation tendencies reading privacy policies in different external representations (see Table 4) showed that the mean subjective cognitive load of visual participants reading graphical materials

(77.500 \pm 14.144) was significantly lower than when reading textual materials (95.900 \pm 10.246). For verbal participants, the difference was not significant.

A multifactor between-subjects effect test with subjective cognitive load as the dependent variable and internal representation and external representation as independent variables (see Table 5) showed that neither the main effect of internal representation ($F=0.087$, $p>0.05$) nor the main effect of external representation ($F=3.379$, $p>0.05$) was significant, but the interaction effect between internal representation and external representation ($F=7.137$, $p<0.05$) had a significant impact on subjective cognitive load. Therefore, further analysis of the total subjective cognitive load of users with different internal representation tendencies (visual and verbal) on different external representation information (see Table 6) found significant differences in subjective cognitive load within the visual participant group ($F=10.169$, $p<0.01$), but not in the verbal participant group ($F=0.347$, $p>0.05$).

Multiple comparison analysis after subdividing external representation showed (see Table 7): visual participants' subjective cognitive load when reading textual materials was significantly higher than when reading graphical materials ($p<0.01$), while there was no significant difference in subjective cognitive load for verbal participants reading the two different external representation materials ($p>0.05$).

The interaction plot (see Figure 3 [Figure 3: see original paper]) can more intuitively show that compared with textual materials, graphical materials can significantly reduce the subjective cognitive load of visual participants, while the advantage is not very obvious for verbal participants.

4.2.2 Objective Performance Analysis In addition to subjective cognitive load measurement, objective performance analysis is also an important basis for cognitive load measurement. Therefore, the objective performance of participants with different internal representation tendencies reading mobile medical APP privacy policies in different external representations was measured. The descriptive statistical results (see Table 8) showed that overall, participants' objective performance after reading graphical materials (65.501 \pm 12.752) was higher than after reading textual materials (50.167 \pm 13.870). However, compared with verbal participants, the difference was more pronounced.

A multifactor between-subjects effect test with objective performance as the dependent variable and internal representation and external representation as independent variables (see Table 9) showed that both the main effect of internal representation ($F=7.828$, $p<0.01$) and the main effect of external representation ($F=15.682$, $p<0.001$) were significant, but the interaction effect between internal representation and external representation was not significant ($F=1.158$, $p>0.05$). Therefore, subdividing users with different internal tendencies into visual and verbal types and further analyzing their total objective performance on two different external representation information (see Table 10) found sig-

nificant differences in both visual participants ($F=12.682$, $p<0.01$) and verbal participants ($F=4.158$, $p<0.05$).

Finally, multiple comparison analysis showed (see Table 11): although there were some differences in degree, both visual and verbal participants' objective performance after reading textual materials was significantly lower than after reading graphical materials.

Figure 4 [Figure 4: see original paper] also more intuitively shows that whether for visual or verbal participants, from the perspective of improving readers' objective performance, graphical materials have an absolute advantage over textual materials.

5 Research Results and Discussion

The data analysis results show that participants with different internal representation tendencies require different subjective cognitive loads and achieve different objective reading effects when reading mobile medical privacy policies in different external representations.

(1) From the perspective of subjective cognitive load measurement results: Neither external representation nor internal representation alone can produce differential effects on participants' subjective cognitive load, but they can interactively affect participants' subjective cognitive load; In the visual participant group, the cognitive load of the graphical material group was significantly lower than that of the textual material group, so for visual users, graphical materials can effectively reduce their subjective cognitive load, reducing the psychological resources and effort consumed when reading such privacy policies, helping them read more easily and understand more efficiently; For verbal users, the difference in subjective cognitive load between the graphical material group and textual material group was not significant. This result leads us to consider whether graphical materials might also reduce the subjective cognitive load of verbal users, because based on their original internal representation cognitive tendencies, they should be more willing and adept at reading textual materials, but the measurement results did not show this difference. Therefore, we speculate that graphical materials may have a positive effect in reducing the subjective load of verbal users, although this speculation requires further experimental verification and research.

(2) From the perspective of objective performance measurement results: Both external representation and internal representation independently affect participants' objective performance, especially the graphical form of external representation, which can effectively improve users' overall objective performance, that is, effectively improve the efficiency and gains of users reading such privacy policies, helping users accurately and efficiently identify the content of health privacy statements, thereby helping users correctly understand their role in mobile medical services and how their privacy data is used and protected; In visual participants, the objective performance of the graphical material group

was significantly higher than that of the textual material group. Graphical mobile medical APP privacy policies can help them effectively recognize and recall the content mentioned in the policies; In verbal participants, the objective performance of the graphical material group was also higher than that of the textual material group. Graphical materials can help them effectively recall the content in the policies, but the significance level was obviously lower than that of visual participants.

Based on the above conclusions, it can be seen that independent internal representation and external representation elements do not have significant effects on users' subjective cognitive load, but they have interactive effects. That is, in the design and practical application of mobile medical APP privacy policies, recommending external representation reading materials that match users' internal representation to different types of users will effectively reduce users' subjective cognitive load during reading and reduce reading resistance. At the same time, from the perspective of users' actual understanding after reading, graphical privacy policies can not only subjectively reduce users' cognitive load but also effectively improve reading effectiveness, enabling users to accurately and efficiently obtain relevant content of privacy policies, thus greatly exerting the protective role of privacy policies.

At the same time, during the virtual experiment, we also found that whether textual or graphical privacy policies, as long as the information is too complicated or lengthy within the limited reading horizon (such as dense text or long charts), it will cause users to develop reading resistance and affect reading effectiveness. Therefore, we also recommend that mobile medical APP platforms segment relevant privacy policy content based on reading stages and interactive operations, provide it to users in a modular form, and adopt graphical external representation forms to improve users' unit reading efficiency. Moreover, mobile medical APP privacy policies contain more medical and health terminology than general privacy policies. During the experiment, some participants asked about terminology. Therefore, we recommend annotating and explaining health privacy and professional terms based on different information representation forms to improve the reading comprehension effectiveness of privacy policies in mobile medical scenarios.

Based on cognitive load theory, this study used concept map methods to classify and design reading materials for mobile medical APP privacy policies in different external representation forms, and used virtual experiments and multifactor analysis of variance methods to obtain data and conduct analysis. It found that internal representation and external representation interactively affect users' subjective cognitive load during privacy policy reading, while clarifying the positive role of graphical privacy policies on users' subjective cognitive load and reading effectiveness.

Due to the high requirements of virtual experiments for participants' prior knowledge levels and adaptability to virtual simulation scenarios, the research subjects were limited to college students. Subsequent research will further expand the

occupational distribution of participants. At the same time, since the user population of mobile medical APPs includes middle-aged and elderly users, and this group was not involved in this virtual experiment due to various reasons such as age and vision health levels, subsequent research will also conduct targeted studies on such specific groups.

In the future, with the development of multimedia and mobile technologies, the main forms of information external representation will not be limited to graphics and text. Video animation, voice, and various mixed forms will become inevitable trends for subsequent research. At the same time, in the evaluation process of user privacy policy reading effectiveness, various advanced equipment such as eye trackers and brain wave devices can not only detect participants' physiological conditions but also obtain more intuitive physiological and emotional data. Therefore, subsequent research will expand the external representation forms of mobile medical privacy policies from a diversified perspective, attempting to use different technologies to measure users' physiological indicators and emotional states to enhance the objectivity and accuracy of research.

References

- [1] ISTEPANIAN R, JOVANOV E, ZHANG Y T. Introduction to the special section on M-Health: beyond seamless mobility and global wireless health-care connectivity[J]. IEEE transactions on information technology in biomedicine, 2005, 8(4): 405-414.
- [2] Zhang Min, Luo Meifen, Nie Rui, et al. Analysis of influencing factors of user trust in mobile medical APPs for consultation—Based on multi-dimensional research perspectives of process, institution, and characteristics[J]. Modern Information, 2017, 37(5): 72-78.
- [3] iMedia Data Center. Number of APP applications in Apple App Store from 2015 Q2 to 2019 Q2[EB/OL]. [2020-03-14]. <https://data.iimedia.cn/page-category.jsp?nodeid=13181061>.
- [4] SECURITY CENTER. Patient home monitoring service leaks private medical data online[EB/OL]. [2020-11-14]. <https://kromtech.com/blog/security-center/patient-home-monitoring-service-leaks-private-medical-data-online>.
- [5] HIPAA JOURNAL. April 2019 healthcare data breach report[EB/OL]. [2020-11-14]. <https://www.hipaajournal.com/april-2019-healthcare-data-breach-report/>.
- [6] CNR. Over 500,000 newborn baby and pregnant woman information in Chengdu downloaded and resold by insiders[EB/OL]. [2020-11-13]. http://china.cnr.cn/xwwgf/20180119/t20180119_524105839.shtml?from=groupmessage&isappinstalled=1.
- [7] FDA. Policy for device software functions and mobile medical applications[EB/OL]. [2020-11-13]. <https://www.fda.gov/media/80958/download>.

- [8] CNNIC. Regulations on the protection of personal information of telecommunications and internet users[EB/OL]. [2020-11-29]. http://www.cac.gov.cn/2012-07/29/c_133142088.htm.
- [9] STEINFELD N. “I agree to the terms and conditions” : (how) do users read privacy policy online? an eye-tracking experiment[J]. *Computers in human behavior*, 2016, 55(part B): 992-1000.
- [10] FABIAN B, ERMAKOVA T, LENTZ T. Large-Scale readability analysis of privacy policies[C]//IEEE/WIC/ACM international conference on Web intelligence. New York: ACM, 2017: 18-25.
- [11] RUTTER J. Understanding the decision to click on the internet privacy policy[D]. California: College of Business Administration of Touro University International, 2007: 3-87.
- [12] Tencent. After reading 200+ App privacy policies, we found most Apps simply don't care about you[EB/OL]. [2020-11-14]. <https://new.qq.com/omn/20190403/20190403A00ER500>.
- [13] CROUSE H L, MACIAS C G, CRUZ A T, et al. Utilization of a mobile medical van for delivering pediatric care in the bateys of the dominican republic[J]. *International journal of emergency medicine*, 2010, 3(4): 227-232.
- [14] Yu Wenqing, Deng Yong. Discussion on the construction of mobile medical information security protection and legal supervision mechanism[J]. *Chinese Hospitals*, 2016, 20(9): 53-56.
- [15] He Xiaolin, Qian Qing, Wu Sizhu, et al. Research progress on data security and privacy of health medical wearable devices[J]. *Chinese Journal of Medical Library and Information Science*, 2016, 25(10): 32-37.
- [16] Liu Qiankun, Liu Haopeng, Qin Ziang, et al. Research on the development status of user privacy protection policies for health APPs based on content analysis method[J]. *Chinese Hospitals*, 2019, 23(9): 20-23.
- [17] MARTÍNEZ-PÉREZ B, DE LA TORRE-DÍEZ I, LÓPEZ-CORONADO M. Privacy and security in mobile health apps: a review and recommendations[J]. *Journal of medical systems*, 2015, 39(1): e181.
- [18] BENJUMEA J, DORRONSOR E, ROPERO J, et al. Privacy in mobile health applications for breast cancer patients[C]//IEEE. Berlin: Springer, 2015: 571-584.
- [19] KNORR K, ASPINALL D, WOLTERS M. On the privacy, security and safety of blood pressure and diabetes apps[C]//30th IFIP TC 11 international information security and privacy conference. New York: IEEE, 2015: 634-639.
- [20] HUANG H, BASHIR M. Direct-to-Consumer genetic testing: contextual privacy predicament[J]. *Proceedings of the association for symposium on computer-based medical systems*. New York: IEEE, 2019: 63-639.

- [21] SADKI S, ELBAKKALI H. Resolving conflicting privacy policies in M-health based on prioritization[J]. Scalable computing, 2015, 52(1): 1-10.
- [22] Zhu Guang, Liu Hu, Du Ximeng. Research on mobile medical APP usage intention under privacy concerns—Based on a tripartite game perspective[J]. Data Analysis and Knowledge Discovery, 2019, 3(5): 93-106.
- [23] GUO X, ZHANG X, SUN Y, et al. The privacy-personalization paradox in mHealth services acceptance of different age groups[J]. Electronic commerce research and applications, 2016, 16(1): 55-65.
- [24] Yuan Jinqiao. Research on mobile medical service user adoption intention based on privacy calculation theory[D]. Harbin: Harbin Institute of Technology, 2013.
- [25] Zhang Yue, Wang Jian, Zhu Qinghua. Research on the cognitive influence factor framework model of mobile medical APP privacy policies—Based on grounded theory method[J]. Information Studies: Theory & Application, 2019, 42(6): 105-110.
- [26] POWELL A C, SINGH P, TOROUS J. The complexity of mental health app privacy policies: a potential barrier to privacy[J]. JMIR mHealth and uHealth. 2018, 6(7): 158.
- [27] PARKER L, HALTER V, KARLIYCHUK T, et al. How private is your mental health app data? an empirical study of mental health app privacy policies and practices[J]. International journal of law and psychiatry, 2019, 64(3): 198-204.
- [28] ROBILLARD J M, FENG T L, SPORN A B, et al. Availability, readability, and content of privacy policies and terms of agreements of mental health apps[J]. Internet interventions, 2019, 17(9): 1-7.
- [29] Yao Shengyi, Wu Dan. Research on user friendliness evaluation of APP privacy policies[J]. Journal of Information Resources Management, 2021, 11(1): 30-39, 58.
- [30] Zhu Hou, Zhang Mingxin, Lu Yonghe. Empirical research on social media users' privacy policy reading intention[J]. Journal of the China Society for Scientific and Technical Information, 2018, 37(4): 362-371.
- [31] Wang Ying. Longitudinal analysis of privacy policies of library associations in several countries or regions[J]. Library Theory and Practice, 2020(4): 28-34, 80.
- [32] ZHANG J, DONALD A. Representations in distributed cognitive tasks[J]. Cognitive science, 1994, 18(1): 87-122.
- [33] Zhu Chai. Connotation, methods and characteristics of information representation[J]. Journal of Shanxi Library, 2009(4): 69-71.

- [34] Deng Zhu, Yu Jiayuan. External and internal representation of problems in problem solving[J]. *Advances in Psychological Science*, 2001(3): 193-200.
- [35] KASSIN S M, DUNN M A. Computer-animated displays and the jury: facilitative and prejudicial effects[J]. *Law & human behavior*, 1997, 21(3): 269-281.
- [36] IGARTUA J J, CHENG L, LOPES O. To think or not to think: two pathways towards persuasion by short films on AIDS prevention[J]. *Pubmed*, 2003, 8(6): 513-528.
- [37] Tang Zhiwei, Han Xiao, Li Jie. Research on the influence of information external representation forms on individual decision-making framework effects[J]. *Journal of Intelligence*, 2015, 34(3): 171-175, 185.
- [38] ZHANG J. The nature of external representation in problem solving[J]. *Cognitive science*, 1997, 21(2): 179-217.
- [39] Zhang Jingyu. The influence of health information external representation forms and information frameworks on college students' health behavior decision-making[D]. Chongqing: Southwest University, 2016.
- [40] RIDING R, RAYNER S. Cognitive styles and learning strategies: understanding style differences in learning and behavior[M]. London: David Fulton, 1998.
- [41] Zhang Yue, Zhao Tian. Research on cultivation strategies of deep reading literacy on mobile internet based on sense-making theory[J/OL]. *Information Studies: Theory & Practice*: 1-10[2021-03-22]. <http://kns.cnki.net/kcms/detail/11.1762.g3.20210323.1912.002.html>.
- [42] Li Lihong. Research on information representation preferences in memory systems of college students with verbal and imaginal cognitive styles[D]. Changchun: Jilin University, 2005.
- [43] FELDER R M, SILVERMAN L K. Learning/teaching styles in engineering education[J]. *Engineering education*, 1998, 78(7): 674-681.
- [44] RIDING R, CHEEMA I. Cognitive styles—an overview and integration[J]. *Educational psychology: an international journal of experimental educational psychology*, 1991, 11(3): 193-215.
- [45] SWELLER J. Cognitive load during problem solving: effects on learning[J]. *Cognitive science*, 1988, 12(2): 257-285.
- [46] PAAS F G W C, VAN MERRIËNBOER J J G. Instructional control of cognitive load in the training of complex cognitive tasks[J]. *Educational psychology review*, 1994, 6(4): 351-371.
- [47] COOPER G. Cognitive load theory as an aid for instructional design[J]. *Australasian journal of educational technology*, 1990, 6(2): 108-113.
- [48] QUIROGA L M, CROSBY M E, IDING M K. Reducing cognitive load[EB/OL]. [2020-11-14]. <http://csdl2.computer.org/comp/proceedings/hicss/2004/2056/05/205650131a.pdf>

- [49] GWIZDZKA J. Distribution of cognitive load in web search[J]. Journal of the American Society for Information Science & Technology, 2010, 61(11): 2167-2187.
- [50] HU J H, HU H F, FANG X. Examining the mediating roles of cognitive load and performance outcomes in user satisfaction with a website: a field quasi-experiment[J]. MIS quarterly, 2017, 41(3): 975-987.
- [51] Fang Hao, Chen Yinchao, Zhao Ying, et al. The influence mechanism of information design elements of mobile news platforms on visual search efficiency[J]. Library and Information Service, 2019, 63(22): 58-67.
- [52] Hou Guanhua, Ning Weining, Dong Hua. Research on digital reading interface experience design for middle-aged and elderly people from the perspective of cognitive load[J]. China Journal of Information Systems, 2019(1): 15-26.
- [53] DESTEFANO D, LEFEVRE J A. Cognitive load in hypertext reading: a review[J]. Computers in human behavior, 2007, 23(3): 1616-1641.
- [54] Forbes China. 2019 Forbes China Most Innovative Enterprises List[EB/OL]. [2020-11-14]. <https://www.forbeschina.com/lists/1715>.
- [55] NOVAK J D. Concept learning in science[J]. College of Education, the Ohio State University, 1971, 10(2): 129-133.
- [56] MAYER R E. Multimedia Learning[M]. Beijing: Commercial Press, 2005: 105-144.
- [57] MAYER R E. Research-based principles for the design of instructional messages: the case of multimedia explanations[J]. Document design, 1999, 1(1): 7-19.
- [58] HART S G. Development of NASA-TLX (task load index): results of empirical and theoretical research[J]. Advances in psychology, 1988, 52(6): 139-183.
- [59] Sun Chongyong. Theoretical and empirical research on cognitive load[M]. Shenyang: Liaoning People's Publishing House, 2014: 153-155.
- [60] Zhiyan Consulting Group. 2020-2026 China Medical Mobile Application (APP) Industry Development Status Survey and Market Supply and Demand Forecast Report[EB/OL]. [2020-11-13]. <https://www.chyxx.com/research/202006/873585.html>.

Author Contribution Statement:

Zhu Qinghua: Provided paper revision suggestions and finalized the manuscript.

Wang Jian: Responsible for experiment implementation, data analysis, and paper writing.

Yu Shu: Responsible for data compilation, paper revision, and proofreading.

Zhang Yue: Designed the paper framework and research approach, guided paper writing and revision.

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv –Machine translation. Verify with original.