Knowledge Sharing of Online Health Community Based on Cognitive Neuroscience

Jiang Shen¹, Panpan Zhu²*, Man Xu³

ABSTRACT
Knowledge sharing of online health community is very important to relieve the shortage of medical resources and distribution imbalance problem. Based on cognitive neuroscience, this paper analyzes cognitive evolution and decision-making mechanism of knowledge sharing among patients in online health communities, discuss subconscious influence factors that dominate patient's cognitive. Results show that perceived benefit coefficient has positive influence and perceived risk coefficient has negative influence on cognitive effects of knowledge sharing, but information absorption coefficient and information conversion coefficient have no orientation influence on patient’s cognitive effects of knowledge sharing.

Key Words: Cognitive Neuroscience, Online Health Community, Knowledge Sharing

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Introduction
Cognition is a complex system composed by all human mental abilities and a process of understanding and acquisition of knowledge, including perception, representation and thinking, among them, thinking is the nuclear part, which makes the cognitive process becomes more rational. Based on cognitive neuroscience, this paper studies decision-making process of knowledge sharing among patients in an online health community that is an important place for patients to get emotional support and knowledge sharing (Jadad et al., 2006) and alleviates problems of information asymmetry and shortage of medical resources (Cotten et al., 2004). Raising the level of cognitive effects of knowledge sharing among patients has great significance to improve activity and sustainable development of online healthy communities (Kennedy et al., 2005), which is a key issue for many online health community service providers. As more and more patients collect information through online communities (Fox, 2009), the researches on the knowledge sharing behavior of virtual communities also more and more (Lau et al., 2007). Researches on virtual community knowledge sharing can be divided into three types: motivation theory, management technology and behavioral theory. Motivation theory studies the relationship between the motivation and goal of knowledge sharing, points out that the motivation of knowledge sharing is the "usefulness" (Krasnova et al., 2010), which aims to obtain information from the website better (Perse et al., 2000). Management technology aims to solve the obstacles of knowledge transfer through technical means. Behavioral theory mainly guides to build social networks and promotes participants' belonging, trust and emotional support. Fewer literature analyzed online health knowledge sharing mechanism from the perspective of cognitive neuroscience.

Unlike other virtual community users, the main users of online health community are patients. They suffer from physical or mental illness and are in need of support and help from other people. And medical information is highly

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sensitive, once was leaked or stolen, will cause serious consequences. So, in deciding whether or not to share information, patients will weigh the benefit and risks, constantly adjust their strategy to adapt to the environment (Nonaka et al., 2015), which is a process of cognitive evolution (Smith et al., 1973). Interaction and empathy (Preece et al., 2003) between patients form a complex network (Bouty et al., 2000). The network structure determines who the patient can reach (Kleijn et al., 2009) and how to share information. Combined with complex network and cognitive neuroscience, this paper builds a scale-free network (Barabasi et al., 1999), simulate cognitive evolution of patients in an online health community and discuss cognitive effects of knowledge sharing. The rest of this paper is organized as follows. Section 2 constructs online health community knowledge sharing cognitive evolution model. The result of simulation is revealed in Section 3. Section 4 summarizes the main conclusions and provides the policy implications.

Online health community knowledge sharing cognitive evolution model

Knowledge sharing network

In this paper, online health community patients and their connections are represented by the non-directional network graph $G (V, E)$, where vertexes represent patients in an online health community network, and edges indicate connections between patients. All edges in the network are non-directed and there is at most one edge between two vertexes. If there is a connection between two vertexes of $i$ and $j$ ($i, j \in V$), expressed as $e_{ij} = 1$; if there is no connection between $i$ and $j$, expressed as $e_{ij} = 0$. Two patients can learn and communicate with each other when there is an edge between them. $K_{(i)}$ is the degree of patient $i$, namely the number of patients who have an edge with patient $i$. $K_i = (k_{i1}, k_{i2}, \ldots, k_{in})$ represents the collection of all neighborhood vertexes of patient $i$. The average degree of an online health community network is defined as $k = \sum_{i=0}^{N} k(i) / N$, among them, $N$ is the total number of patients in the community. $p(i) = k_{ij} / \sum_{i=0}^{N} k(i)$ is the probability that newly added patients connect with other patients in the community.

Cognitive evolution model

The cognitive evolution consists of four parts: patients, evolution strategy, revenue function and strategy update rules. All patients in an online health community can participate in knowledge sharing. The online health community has the characteristics of "openness" and "autonomy", and autocracy hardly exists (Suler, 2010). People are free to decide whether to join an online health community and how to interact with other members in the community (Wasko et al., 2005). Medical knowledge sharing has potential risks (risk coefficient $c$ is used to express perceive potential risk of patients), so not every patient is willing to participate in knowledge sharing. Knowledge sharing strategy set is represented by $S = \{0, 1\}$, and 0 indicates non-cooperative strategy, i.e. not participating in knowledge sharing; 1 represents cooperation strategy, i.e. participating in knowledge sharing. Patients perceived benefits of knowledge sharing include the benefits of their own knowledge sharing (Jayanti et al., 2010) and the benefits of knowledge sharing from other patients. Through their knowledge sharing, patients gain satisfaction, accomplishment and self-image promotion, which is expressed by perceived benefit coefficient $r$. By information externalization and information combination that are two important parts of knowledge sharing (Nambisan et al., 2010), patients benefit from other patients' information sharing. Information transmission needs information carriers know how to encode information and how to convey tacit knowledge (Fuchs et al., 2001) to public knowledge and explicit knowledge (Steinmueller et al., 2000). If the information is highly encoded, that is, patient's ability to externalize information is relatively high, then knowledge sharing is easier to achieve (Ancor et al., 2002). Information receivers benefit by integrating information expressed by information carriers. Therefore, patient's benefit is determined by both himself and other patients, in this paper, information conversion coefficient $m$ and information absorption coefficient $n$ are used to show patient's information externalization ability and information combination ability respectively. Tab.1 shows patients' benefits of knowledge sharing in an online health community.

Patients' information absorption coefficient and information conversion coefficient is independent of each other, obeys uniform distribution of $(0, \beta)$ and $(0, \alpha)$ respectively. Among them, $\beta$ represents the upper limit of information absorption coefficient and $\alpha$ indicates the upper limit of information conversion coefficient.
Table 1. Patients' benefits of knowledge sharing in an online health community

<table>
<thead>
<tr>
<th></th>
<th>Patient B</th>
<th>Not for Information sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient A</td>
<td>Share Information</td>
<td>v_a r_a + v_b r_b = v_a c_a</td>
</tr>
<tr>
<td></td>
<td>Not for Information sharing</td>
<td>v_a m_a + v_b m_b = v_a c_a</td>
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Strategy update rules
Based on information sharing cognition, patients choose different strategies. According to the change of cognitive, patients adjust their strategies and get the benefits. Based on cognitive neuroscience, patients with strategy adjustment in order to get the most benefits. The strategy update rules include choosing the highest revenue strategy (Nowak et al., 1992), choosing better revenue strategy with a certain probability, choosing strategy rely on benefit differences (Gyö et al., 1998) and other strategy learning rules. Based on the characteristics of online health community knowledge sharing and cognitive neuroscience, the updated rules based on Memory are used in this paper (Wang et al., 2006).

After each game, each patient is introspective according to the neighborhood strategy, take a virtual game with own counter-strategy, virtual benefit is obtained, then the real earnings compared with virtual benefit, get the corresponding optimal strategies, and record it into the patient’s memory. In a later game, the patient decides which strategy to take based on the memories stored in the previous rounds. Finally, dynamic equilibrium state of the community is achieved, that is, the proportion of patient choosing knowledge sharing remains unchanged. The influence of different parameters on patient knowledge sharing level is measured by the proportion at this time.

Online health community knowledge sharing simulation process and results
Knowledge sharing behavior
According to the knowledge sharing cognitive evolution mechanism and initial value, the model is simulated by computer programming language.

Step 1: Generate a scale-free network of N=1000.

Step 2: Judge whether there is a connection between the two patients. If there is a connection, the game will be played according to the game benefit matrix of Tab.1.

Step 3: Calculate the benefits of each patient in the community and the proportion of information share in this round game.

Step 4: After each game, each patient updates the strategy according to the strategy update rules.

Step 5: Determine whether the system is stable (i.e., the proportion of patients who choose to share information in the system remains unchanged). When the system is stable, the proportion of patients who choose to share information at this time is calculated, and the simulation results are output. Otherwise, we repeat the step 2.

Step 6: Adjust input and compare the evolution of community knowledge sharing under different values.

Figure 1. Influence of benefits coefficient on the level of knowledge sharing

Analysis
(1) The higher perceived benefit coefficient r, the higher level of knowledge sharing. When other parameters remain the same, improve perceived benefit coefficient of patients in an online health community, statistics the proportion of patients who share information when the system is stable, get the trend diagram is shown in Fig.1. The horizontal coordinate represents the upper limit of perceived benefit coefficient of community patients, and the vertical coordinate represents the proportion of patients who share information when the system is stable in different situations. As shown in Fig. 1, with the increase of perceived benefits coefficient of knowledge sharing, the proportion of patient's knowledge sharing is increasing, namely the perceived benefits coefficient of knowledge sharing is positively correlated with the level of knowledge sharing.
(2) The higher perceived risk coefficient, the lower level of knowledge sharing. When other parameters remain the same, with the increase of perceived risk coefficient, knowledge sharing level is decreasing, namely the perceived risk coefficient is inversely related to the level of knowledge sharing, as shown in Fig. 2. The horizontal coordinate represents the upper limit of perceived risk coefficient, and the vertical coordinate represents the proportion of patients who share information when the system is stable.

Figure 2. Influence of risk coefficient on the level of knowledge sharing

(3) Information absorption coefficient and information conversion coefficient have no direct influence on the proportion of knowledge sharing in an online health community. When other parameters remain unchanged, the influence of information absorption coefficient on the level of knowledge sharing is shown in Fig. 3. The horizontal coordinate represents the upper limit of information absorption coefficient, and the vertical coordinate represents the proportion of patients who share information when the system is stable in different situations. When the information conversion coefficient is 0.99, 0.51 and 0.2 respectively, the proportion of knowledge sharing is not present certain regularity, namely with the increase of information conversion coefficient, the level of knowledge sharing is likely to increase or decrease.

Figure 3. Influence of information absorption coefficient on the level of knowledge sharing

(4) When other parameters remain the same, information transformation coefficient has no directional influence on the level of knowledge sharing, as shown in Fig. 4. The horizontal coordinate represents the upper limit of information conversion coefficient. The vertical coordinate represents the proportion of patients who share information when the system is stable in different situations. When the information absorption coefficient is 0.99, 0.51 and 0.2 respectively, the proportion of knowledge sharing is not present certain regularity, namely with the increase of information conversion coefficient, the level of knowledge sharing is likely to increase or decrease.

Figure 4. Influence of information conversion coefficient on the level of knowledge sharing

Conclusions
Based on cognitive laws, this paper analyzes the influence factors of patients’ knowledge sharing. The results show that perceived benefits coefficient is positively correlated with the level of knowledge sharing, and perceived risk coefficient is inversely related to the level of knowledge sharing, but information absorption coefficient and information conversion coefficient have no direct influence on the level of knowledge sharing. This has an important guiding role for raising the level of knowledge sharing and emotional support of patients in an online health community.

Perceived benefits coefficient will directly contribute to information sharing. It shows that patients in the online health community to share information, in addition to expect to obtain...
information from other patients, more important is to obtain spiritual enjoyment, satisfaction and respect from others. The risks of privacy, time, energy and money will directly lower the level of patient's knowledge sharing. Therefore, safe and friendly interaction environment, convenient and fast technology and effective incentive mechanism are crucial to improve the knowledge sharing level of online health community.

References
Cotten SR, Gupta SS. Characteristics of online and offline health information seekers and factors that discriminate between them. Social Science & Medicine 2004; 59(9): 1795-806.
Kennedy D, Norman C. What don’t we know? Science 2005; 309 (5731): 75.