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Enhancing Motivation in Disaster Prevention Learning with Perceptual and Semantic Gaming

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Abstract: Hazard maps provide knowledge about evacuation behavior, in addition to graphical indications of areas influenced by a disaster. However, without prerequisite knowledge or map reading literacy, it is not easy for citizens to fully understand hazard maps. Learning support systems for disaster education must thus to be effective in lightening the learning load and enhancing motivation for learning. If the content is not held in memory, learners would need to repeat the learning session, which would lessen their motivation for learning. Moreover, natural disasters do not happen often, and cannot always be predicted. Therefore, it is not easy to enhance citizens' motivation for disaster prevention learning. This can result in a vicious circle between degraded motivation and insufficient prerequisite knowledge. In this paper, we propose a learning support framework that helps gain learners' attention by gaming at two different processing levels and facilitates retention of disaster prevention knowledge on the basis of priming effect on implicit memory. The key idea behind this framework is to utilize two components: implicit learning by means of implicit memory and memory retention based on levels-of-processing effect, so that the vicious circle between degraded motivation and insufficient prerequisite knowledge can be disrupted.

Keywords: Disaster education, learning strategy, gaming, enhancing motivation

1. Introduction

In addition to graphical indication of areas affected by a disaster, hazard maps provide knowledge about evacuation behavior which enable decision making by concerned individuals. It is crucial for area residents to understand the significance and use of hazard maps distributed by local governments so that their self assistance ability can be improved. Without prerequisite knowledge or map reading literacy, however, it is not easy for many citizens to fully understand hazard maps. Therefore, the development of a learning support system which not only facilitates retention of the preliminary knowledge for hazard map comprehension but also enhances motivation for disaster prevention learning is essential.

Learning support systems for disaster education must be effective in lightening the learning load and enhancing motivation for learning. However, readiness for disaster prevention cannot be sustained unless previously learned content is firmly held in learners' memory, and the learners are motivated to repeat the learning process. If learned contents are not kept in memory, the learners have to review the learning sessions, which would reduce their intrinsic motivation for further learning. Moreover, as natural disasters do not happen often and cannot always be accurately predicted in advance, it is not easy to enhance residents' motivation for disaster prevention learning. This can result in a vicious circle between degraded motivation and insufficient prerequisite knowledge.

According to the ARCS model of motivation design (Keller, 1987), instructional environments need to be designed, so that learners' attention can be grabbed by stimulating their curiosity under unpredictable circumstances, and a sense of achievement can be formed by giving satisfaction. In this paper, we propose a learning support framework that attracts learner's attention by gaming and facilitates retention of disaster prevention knowledge by means of priming effect on implicit memory (Reber, 1989). This paper also reports the results of an empirical evaluation with a prototype system.

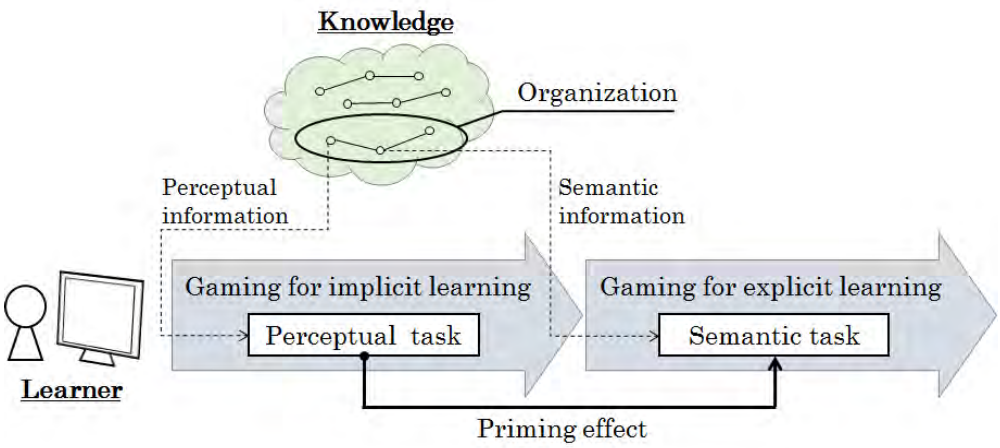


Figure 1. Overview of the proposed learning support framework.

2. Learning Support Framework

2.1 Cognitive Psychological Findings Applied for the Learning Support Framework

Memory without explicit consciousness of recall (implicit memory) is distinct from memory with consciousness of recall (explicit memory). A learning process that produces an effect on implicit memory is called implicit learning (Reber, 1989), and the effect brought about by implicit memory is known as *priming effect*. The priming effect is a kind of learning effect because memory tasks without conscious recall result in a positive effect on subsequent memory tasks (Terasawa, 1998). The positive effect can last for an extended period of time; for example, Komatsu (1984) demonstrated the priming effect was observed 5 weeks later when presented with a short stimulus of 3.5 second duration.

In human information processing, the depth of mental processing ranges from shallow to deep (e.g., structural, phonemic, and semantic). Deeper levels of processing achieve higher memory retention, which is called the levels-of-processing effect (Craik & Lockhart, 1972). Since more processing resources are required to accommodate the increase in process level or mental load, deeper level processing takes longer to complete (Craik & Tulving, 1975). The load at the semantic level is thus higher than that at the perceptual level. On the other hand, the cognitive load is quite small for shallow processes. However, repeating shallow processes can not lead to an improvement in memory retention even if the entire learning load is small throughout the course of the repetition (Craik & Lockhart, 1972). Memory retention based on the levels-of-processing effect and implicit learning have been adopted individually for previous learning strategies. In this study, we propose a learning support framework that utilizes these two components to break the above-mentioned vicious circle between degraded motivation and insufficient prerequisite knowledge.

2.2 Approach to Motivational Enhancement

Here we use the term “gaming” in the sense of simulation (Duke, 1974), which involves a representation or a model of reality in software. Players take the central role while in use, and that motivates players to learn readily from a particular scenario. In the area of disaster prevention learning, a card game called "Cross Road" (Yamori, 2012) was devised to attract learners’ interest and improve disaster imagination by challenging players’ judgment under time-varying uncertain situations. Most learning support systems make the learners aware of learning content in the original context of the simulation, and the learning contents are stored in the learner’s explicit memory. In our learning support framework, on the other hand, learning content is associated with constituents in a gaming context that is easier for learners to comprehend than in the context of the target field that is unfamiliar due to their lack of preliminary knowledge.

In our framework the learning process starts with gaming for implicit learning, where learning content is exposed merely as objects in the gaming scene without regard to the meaning of the context

(a) Perceptual game for shooting graphic symbols by touching the screen

(b) Semantic game for underpass as a role-playing game

Figure 2. Examples of perceptual and semantic gaming.

of disaster prevention knowledge; in the next stage, those objects are presented for explicit learning where all content is presented explicitly in the sense of a particular target field (Figure 1). According to this distinction of the presentation context, this framework facilitates retention of knowledge by associating preliminary knowledge or graphic symbols recognized during the perceptual task (e.g., bridge, underpass, and evacuation shelter in Figure 2(a)) with an entity in a target field appearing in the subsequent semantic task (e.g., underpass in Figure 2(b)).

3. A Prototype System for Flood Disaster Prevention Learning

Figure 3 shows a learning process based on our framework mentioned above, which includes a perceptual game for implicit learning and a semantic gaming for explicit learning. Each game is followed by a session for giving background knowledge. In the remainder of this section, the perceptual and semantic games are further explained.

3.1 Perceptual Game for Implicit Learning

In the prototype system, a shooting game targeting graphical symbols of map legends (Figure 2(a)) was used as a game for implicit learning with a perceptual task (hereinafter referred to as a perceptual game). In the perceptual game, five graphical symbols given in Table 1 (evacuation shelter, welfare evacuation shelter, gauging station, underpass, and bridge) were used as shooting targets. These targets are square, and their side length is one fourth of the screen height. These targets appear randomly from the left side and move linearly toward the right, and the moving time of a target from one side to another is about 2 seconds. With a maximum 12 targets appear on the screen at one time, and totally 32 targets appear during a gaming session in the prototype system.

The perceptual game, which consists of two sessions, is presented first to the learners (Figure 3(1)). The first session of the perceptual game exposes moving map legend symbols, and requests learners to touch as many of the symbols as possible. The number of touched symbols are counted and recorded as game's score. In the second session, additional rules are explained to the learners, namely, when symbols which stand for dangerous places (e.g., bridge and underpass) are touched, the number of such touched symbols is subtracted from the total score, while the number is added when symbols for safe places such as an evacuation shelter are touched. These additional constraints for gaming intend to encourage implicit understanding of the distinction between dangerous and safe places in the map legend. Note that the learning here is conducted implicitly because at this moment game users do not know that the map legend symbols are part of disaster evacuation knowledge. Since the perceptual game is a very simple shooting game, it allows the learner to concentrate more on touching graphical symbols. The key point here is that implicit learning during the perceptual game facilitates explicit learning by producing a priming effect later in the semantic gaming.

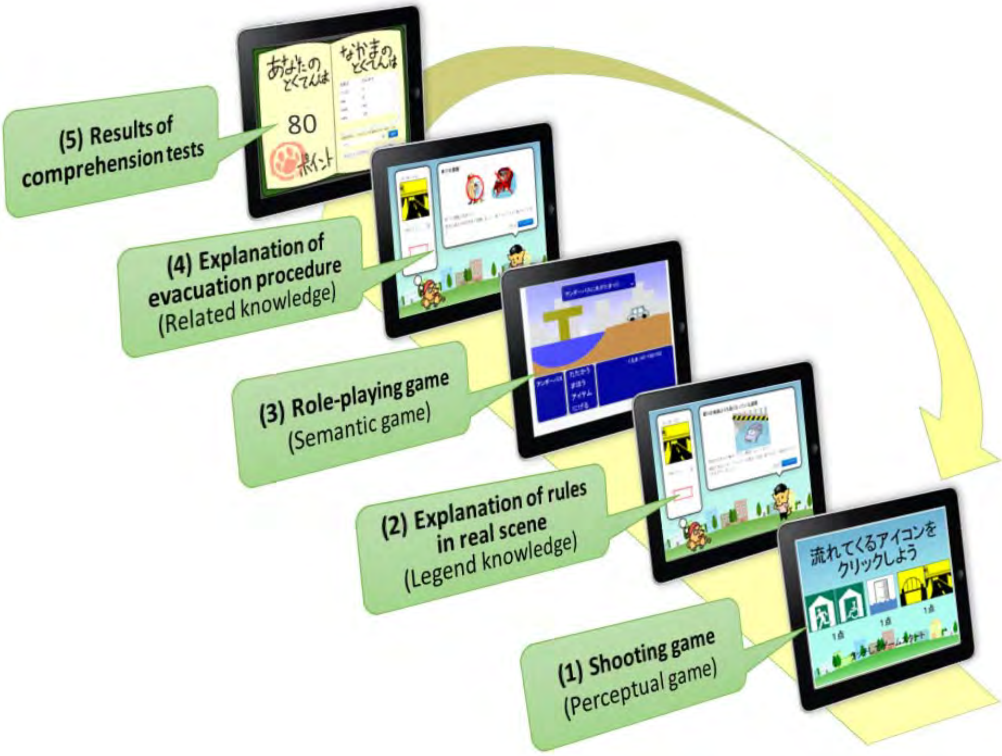


Figure 3. Learning process in the prototype system based on the proposed framework.

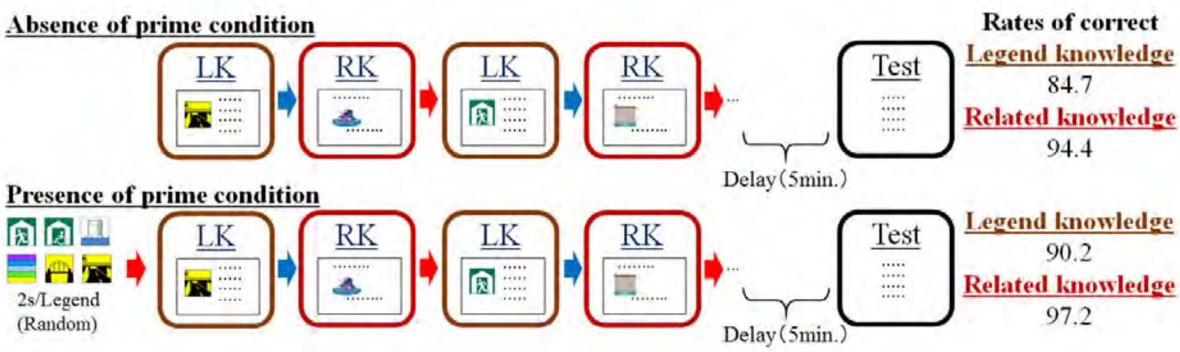


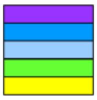
Figure 4. Results of the second experiment.

The learning effect of the proposed framework was tested in two web-based experiments with a total of 144 participants. In the first experiment (Hirai, Tanaka and Hori, 2013a), the rate of correct answers for the test of related knowledge differed significantly among presence (97.2) and absence (85.4) of prime conditions, $p < .05$, and the correct answer rate was higher in presence of prime condition. In the second experiment (Hirai, Tanaka and Hori, 2013b) depicted in Figure 4, the rates of correct answers for the tests of legend and related knowledge differed with marginal significance under presence or absence of prime conditions, $.05 < p < .10$. These results indicate that the rate of correct answers was higher in presence of prime conditions in both cases. The results of these experimental studies demonstrated the effect of memory retention of map legends and their related knowledge when perceptual-level information was presented before exposure to semantic information.

3.2 Semantic Game for Explicit Learning

As gaming for explicit learning in the semantic task phase (hereinafter referred to as semantic game), simulation games that mimics disaster situations were used. The semantic games required that the

Table 1. Map legend and its graphical symbol used in the perceptual game, and task descriptions of each semantic game that corresponds to a map legend.

Map legend and symbol used in the perceptual game	Task descriptions of each semantic game
Flood water depth 	Choose a building in which to shelter outside an area being flooded, before the time nearby rivers are flooded.
Gauging station 	Quickly choose a correct action based on emergency information presented at random.
Evacuation shelter 	Manipulate a graphic symbol of an evacuee and, by way of save road, navigate it to an evacuation shelter within the set time.
Welfare evacuation shelter 	Connect explanatory text to the illustration that most appropriately describes the scene of assisting vulnerable people.
Underpass 	Operate a graphic symbol of a car, and choose a command of battle action to fight with an anthropomorphic, flooded underpass (Figure 2(b)).
Bridge 	Operate a character of a little bonze, and choose a direction of movement to buy dumplings on a rainy day.

activity in the game correspond to the rules of the real disaster situation. The current prototype system provides with six semantic games featuring each of the six map legends in Table 1. When played with these semantic games, learners cannot make a higher score unless they understand the meaning of the map legends and their implications in disaster situation.

3.3 Gaming Simulation for Setting off Unsafe Behavior

It is not difficult for learners, for the most cases, to understand appropriate evacuation behavior as knowledge of disaster prevention. For example, it is straightforward to know why flooded underpasses should not be went through by cars. It is just because cars would be submerged and got stuck on the way. However, people sometimes fails to apply such knowledge to take an appropriate action, due to the so-called knowledge-to-action gap. Even if a learning support system simply presents a dangerous situation to learners, it does not necessarily mean the learners take unsafe actions spontaneously. For a better understanding of unsafe behavior in disaster prevention learning, simulation is useful since learners' behavior can be contextualized in a dangerous situation. Thus it is a crucial requirement for a learning support system to lead learners to take unsafe actions spontaneously.

In our learning support system, semantic games allow learners to take unsafe actions under the simulated or explicit context of semantic tasks. For example, a semantic game for underpass is realized as a role-playing game (Figure 2(b)). In essence, a semantic game can be regarded as a multiple choice test because the players finally select one of the actions available in the gaming contexts,. In the field of cognitive psychology, a phenomenon called the testing effect is known, which means that taking a memory test repeatedly produces substantially better retention than studying learning materials (Roediger & Karpicke, 2006). Taking account of the effect of this finding, semantic gaming is expected to contribute to enhancing memory retention because gaming facilitate for the learners to take tests or semantic games repeatedly.

4. Concluding Remarks

We set up a resident experience booth during an evacuation drill held in an area of Takatsuki City in Osaka Prefecture, Japan, on Nov. 9, 2013. About 100 local residents from children to the elderly participated in this drill. We provided a tablet terminal to participants at the venue so they could experience the prototype system. We then conducted an interview survey and a questionnaire survey. The proposed system gave local residents the opportunity to think about their behavior in disaster by directing their attention to the importance of flood hazard maps. It was confirmed from the experience that the disaster prevention information presented by the prototype system was understandable, and that residents were very interested in playing the prototype games. At the closing session of the disaster prevention drill, our activities were appreciated by the head of Takatsuki City Crisis Management Office as substantially contributing to increasing the awareness of disaster prevention for local residents. We are going to put this research to practical use and continue to develop application systems for disaster prevention education to be tested in schools and communities.

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