Abductive Cognitive Support for (Semantic) Dementia Persons

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Abstract. Previously, I introduced the concept of affordance to support dementia persons. Limited merits of affordance for supporting dementia persons are pointed out by Bozeat and Hodges. In addition, after the extension of Gibson's concept of affordance, it is mainly applied to the interface design. Based on the concept of affordance by Gibson, I proposed a dementia person support mechanism in which functions or meanings of things can be suggested. It is based on abduction framework and performed under the context of chance discovery to determine affordance. That is, the suggestion is not offered explicitly. I showed my assumption that complex situation can be transformed to a combination of simple situations and necessity of develop a mechanism to transform complex situation to a combination of simple situations. In addition I discussed it as curation in chance discovery. Thus the framework can be realized by the introduction of shikake's concept. A shikake is a trigger to start a certain action or to change person's mind and behaviour. As a result of the action, all or part of problem will be solved. It sometimes is not the person's will. In this paper, I will discuss the support of dementia persons as an installation of shikake in the environment. By the installation of shikake dementia persons can be implicitly guided to behave properly. It can be regarded as a proper selection of affordance by a proper curation. I will also discuss this type of issue from the viewpoint of the first-person research and information design.

1 Introduction

Recently according to the long life of us, it has been pointed out that one of the serious problem is dementia. Dementia is the progressive decline in cognitive function, such as memory, attention, language, and problem solving, due to damage or disease in the body beyond what might be expected from normal aging. For such dementia person it is difficult to understand several things. Accordingly it is necessary to support such person to understand things to have daily lives. Limited merits of affordance for supporting persons with dementia are pointed out by Bozeat and Hodges (Bozeat et al. 2002; Hodges et al. 2000).

Previously, I introduced the concept of affordance to support persons with dementia (Abe 2009, 2012b), in which functions of things can be suggested as

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a similar or related things. It is based on abductive framework and performed under the context of chance discovery to determine affordance. However it is rather difficult to determine affordance even for normal persons. I proposed the introduction of curation (Abe 2014) for affordance selection. In addition much more useful or better system can be considered for affordance selection. For that in this paper a concept of shikake can be introduced. A shikake is a trigger to start a certain action or to change person's mind and behaviour. As a result of the action, all or part of problem will be solved. In this paper, the support of persons with dementia as an installation of shikake in the environment will be discussed. By the installation of shikake, persons with dementia can be implicitly guided to behave properly. It can be regarded as a proper selection of affordance.

This paper mainly introduces the abduction and affordance paradigm to obtain the meaning of an object. The meaning of an object will be abduced with the guidance of affordance.

2 Affordance and Abduction

The followings are explained in several places and times. However, for the HCII conference I have not fully explained yet. I will give an introduction of abduction and related logics for the understanding the following discussions.

2.1 Affordance

Gibson ecologically introduced the concept of affordance for perceptional phenomena (Gibson 1977, 1979). It emphasizes the environmental information available in extended spatial and temporal pattern in optic arrays, for guiding the behaviours of animals, and for specifying ecological events. Thus Gibson defined the affordance of something as "a specific combination of the properties of its substance and its surfaces taken with reference to an animal." For instance, the affordance of climbing a stair step in a bipedal fashion has been described in terms of the height of a stair riser taken with reference to a person's leg length (Warren 1984). That is, if a stair riser is less than 88% of a person's leg length, then that means that the person can climb that stair. On the other hand, if a stair riser is greater than 88% of the person's leg length, then that means that the person cannot climb that stair, at least not in a bipedal fashion. For that Jones pointed out that "it should be noted also that this is true regardless of whether the person is aware of the relation between his or her leg length and the stair riser's height, which suggests further that the meaning is not internally constructed and stored but rather is inherent in the person's environment system" (Jones 2003).

Since Gibson's introduction, affordance has been widely discussed, and the other perspective and extensions have been added, for instance by Norman

(Norman 1988). Especially, it has been effectively introduced to interface designs after several extensions. However, this paper will not deal with this aspect of affordance.

2.2 Abduction and Chance Discovery

Abduction. In this section, as an incomplete knowledge reasoning (reasoning dealing with incomplete knowledge), In the following, I briefly explain incomplete logical reasoning systems—induction, and abduction.

Peirce characterized abduction and induction as follows (Peirce 1955):

- Abduction is an operation for adopting an explanatory hypothesis, which is subject to certain conditions, and that in pure abduction, there can never be justification for accepting the hypothesis other than through interrogation.
  Inference for (novel) discovery
- Induction is an operation for testing a hypothesis by experiment, and if it is true, an observation made under certain conditions ought to have certain results.
  Inference for classification and learning, which are (generalized) discovery

Thus although abduction and induction are categorized into an incomplete knowledge reasoning and can discover something "new." In fact, something abduction discovers are rather different from those which induction discovers. If we need to discover general tendencies or classification induction will be better. On the other hand, if we need to discover something rare or novel, abduction will be better. In the following a computational abduction, which is hypothetical reasoning will be illustrated.

Hypothetical Reasoning. Abduction is usually used to find the reason or explanation (set of hypotheses) in a logical way to explain an observation. For instance, the inference mechanism of Theorist (Poole et al. 1987) that explains an observation (O) by a consistent and minimal hypotheses set (h) selected from a set of hypotheses (H) is shown as followings.

$$F \nvdash O. \qquad (O \text{ can not be explained by only } F.) \tag{1}$$

$$F \cup h \vdash O. \quad (O \text{ can be explained by } F \text{and } h.) \tag{2}$$

$$F \cup h \nvdash \square. \quad (F \text{and } h \text{ is consistent.}) \tag{3}$$

Where F is a fact (background knowledge) and $\square$ is an empty clause. A hypothesis set (h) is selected from a hypothesis base ($h \in H$).

Chance Discovery. It is important to deal with rare or novel phenomena which might lead us to risk or beneficial opportunity in the future. This type of activity is called as chance discovery. A chance is defined as "*a novel or rare event/situation that can be conceived either as an opportunity or a risk in the future*" (Ohsawa and McBurney 2003). It is rather difficult to discover a chance by usual statistical strategies. Abduction and analogy (Abductive Analogical

Reasoning (Abe 2000) which can be regarded as an extension of CMS (Reiter and de Kleer 1987) was adopted to perform chance discovery (Abe 2003a,b). Where chance discovery is regarded as and characterized as an explanatory reasoning for the unknown or unfamiliar observations. A chance is therefore defined as followings:

1. **Chance** is a set of unknown hypotheses. Therefore, explanation of an observation is not influenced by it. Accordingly, a possible observation that should be explained cannot be explained. In this case, a hypotheses base or a knowledge base lacks necessary hypotheses. Therefore, it is necessary to generate missing hypotheses. Missing hypotheses are characterized as chance.
2. **Chance** itself is a set of known facts, but it is unknown how to use them to explain an observation. That is, a certain set of rules is missing. Accordingly, an observation cannot be explained by the facts. Since rules are usually generated by inductive ways, rules that are different from the trend cannot be generated. In this case, rules are generated by abductive methods, so trends are not considered. Abductively generated rules are characterized as chance.

3 Dementia and Its Care

3.1 Dementia

Dementia is the progressive decline in cognitive function, such as memory, attention, language, and problem solving, due to damage or disease in the body or brain beyond what might be expected from normal aging. In the later stages, persons with dementia will not be able to recognize time (day of the week, day of the month, and year etc.), place, and person. Phenomena due to aging and dementia are quite different. For instance, for memory, aged person does not forget all of his/her experiences, on the other hand, persons with dementia forgets whole of his/her experiences. Dementia is roughly categorized to cortical and subcortical. For instance, several types of cortical dementia are reported such as Alzheimer's disease. Except for the treatable types, there is no cure to dementia, although scientists are progressing in making a type of medication that will slow down the process of dementia. For instance, for the medication of Alzheimer, actions such as cheerful communication and proper stimulation are recommend for slowing down (Kasama 1997). In addition, some studies have found that music therapy which stimulates emotion as well as brain may be useful in helping patients with dementia (Aldridge 2000). Alternative therapies are also discussed for the care of Alzheimer's disease and dementia (Cafalu 2005a,b).

3.2 Dementia Care

Bozeat and Hodges analyzed the feature of mapping between objects and their meaning for a person with semantic dementia from four factors—affordance, presence of recipient, familiarity, and problem solving (Bozeat et al. 2002; Hodges et al. 2000). They showed very important and interesting results. For instance,

they pointed out that "as a group, the patients did not achieve better performance on a subset of affordable objects when use of these was compared with a familiarity-matched subset of objects lacking such affordances. This absence of a general group benefit applied both to overall use and to the specific component of use afforded by the object's structure.[...] it became clear that there was a reliable benefit of affordance on the specific components of use, but only for the most impaired patients." They also pointed out that "[t]he impact of recipient, like affordance, was found to be modulated by the degree of semantic impairment. The patients with a moderate level of conceptual impairment demonstrated significantly better use with the recipient present, whereas the patients with mild and severe impairment showed no effect. [...] It was not surprising, therefore, to find that familiarity also influenced performance on object use assessments."

These observations and analyses show that proper affordance might give a certain support to persons with dementia for understanding (meanings of) objects. In the following section, their observations are considered to develop the dementia person support system.

4 Dementia Care Inspired by Affordance

In this section I discuss how to present or suggest hidden information in dementia care situation. Such hidden information can be presented as certain stimuli in several situations, for instance a group house for dementia persons. Perhaps it will be rather difficult to prepare such stimuli in a general situations. Because it will be difficult to prepare a special function in such a general situations. Anyway, as shown in the previous section, even for a person with dementia, if he/she receives certain stimuli, he/she sometimes achieve the better performance. The problem is that what type of stimulus will be better to present and how to make it recognize. Actually such stimulus should be "afforded (selected from an environment)" by the user. That is, it can be regarded as an "affordance" in an environment. Accordingly I will introduce the concept of affordance to a dementia care system. Proper affordance might give a certain support to persons with dementia in understanding (the meanings of) objects.

For affordance, according to the Gibson's definition, an *Object* is observed and affordance is selected in the environment to understand its meaning. In addition, we can give a certain meaning to the *Object* explicitly or implicitly. Though meaning actually should exist inside of the *Object*, in this framework meaning is explicitly described for the logical formalization[1]. That is, the meaning should be observed and the affordance functions as a type of link to *Objects*. When the meaning is fixed, the affordance determination situation will be logically described as follows:

$$F \cup Object \cup affordance \models meaning \tag{4}$$

$$F \cup Object \cup affordance \not\models \square \tag{5}$$

[1] This logical formation was defined by the author (Abe 2009, 2012b).

The above formalization is described based on the formalization of Theorist (Poole et al. 1987) which is a hypothetical reasoning (abduction). F is so called facts which involves fundamental knowledge in the world. The generated (selected) affordance is consistent with F and $Object$ (Eq. (5)). Then $Object$ is given meaning (the $Object$'s meaning can be understood) as an explanation by affordance and abduction.

Thus in this framework affordance can be regarded as a hypothesis set. Consistent affordance (Eq. (5)) can be selected in the environment (hypothesis base) to explain meaning. In addition, for understanding subset of or similar afforded objects ($Object'$), the affordance determination situation will be logically described as follows:

$$F \cup Object \cup Object' \cup M \cup affordance \models meaning \tag{6}$$

The above logical descriptions can be illustrated in Fig. 1. In fact, the above description is based on Goebel's formalization of analogy (Goebel 1989). M is a mapping function from $Object$ to $Object'$. That is, to understand the same meaning of the subset of or similar afforded objects, an additional mapping function M is required. Thus if M can be determined and the usage of $Object$ is known, $Object'$ can also be understood. For normal persons, M is easy to understand. However, for persons with dementia, it is pointed out that it is rather difficult to understand and determine M. Then the issue becomes how to suggest a mapping function M as an additional hypothesis.

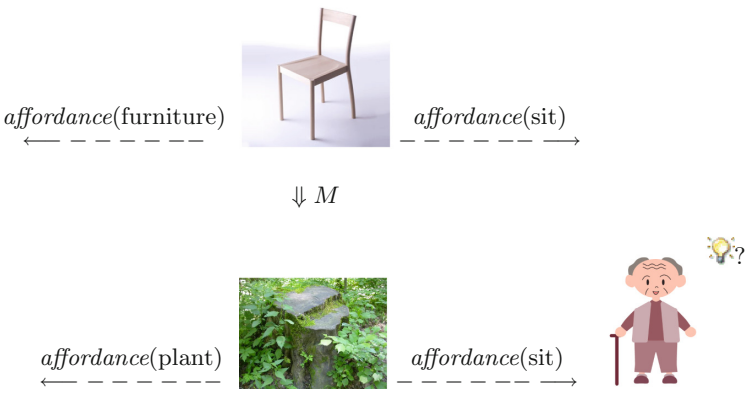

Fig. 1. Affordance: communication between human and environment

In the following sections, I will discuss the above problem.

5 Shikake

5.1 What is a Shikake?

According to Matsumura's definition (Matsumura 2013), a shikake is an embodied trigger for behaviour change to solve social or personal issues. As a result of the action, all or part of problem will be solved. It may not sometimes be the person's will. Matsumura continues that the shikake should be properly designed. That is, the relationship between a problem to solve and a trigger to action should be properly designed.

In addition, Matsumura uses a keyword "affordance" to explain such a trigger. His affordance is based on Norman's one (Norman 1988), accordingly it may be different from Gibson's one. However, in the followings, discussion will be conducted based on Gibson's one. Because our affordance is based on Gibson's affordance.

5.2 Shikakeology

Shikake. Key concepts shown in chance discovery are very similar to those in shikakeology. In fact, a chance is a rare and novel event. In addition, hidden or potential events are mainly dealt with in chance discovery. A chance itself is not easy to discover, because it is usually hidden or out of our scope. A shikake should sometimes easy to discover, because it functions as a trigger. Without being found out, any shikake cannot function. However, the shikake itself may not easy to be understood.

An example of a (n implicit) shikake is, for instance, hidden Mickey (Fig. 2) in the Disney Land. In order to discover the hidden Mickey, people run around the Disney Land. During searching, they may discover other interesting things. Of course, when they can find the hidden Mickey, they will be happy. Thus hidden character functions as a trigger to such activities (search and run). By this trigger (shikake), they can enjoy the Disney Land more than a simple tour in the Disney Land. Even if they cannot find it, they will come back to the Disney Land again to find it. A shikake also has such an effect, but in this paper such an effect will not be considered.

In the followings I will explain the relationships between shikake and curation, affordance, and chance which I use in the framework of the support system for dementia person.

Shikake and Curation. Curation in chance discovery (Abe 2010, 2012a) can be regarded as a strategy of the information display[2]. A shikake can also be regarded as a strategy to lead us information. In the usual curation, information display is designed for audience to understand information easily. Then the curator's

[2] Of course there are a "general" curation in museums and e-Science Data Curation (Lord and MacDonald 2003). However, in this paper, only curation in chance discovery will be considered.

Fig. 2. Hidden Mickey

knowledge can be transferred to audience by his/her curation. By a shikake, the staff will not directly transfer his/her knowledge to the audience, but by a trigger of shikake, their knowledge will be transferred to the audience. Thus a shikake will be provided in some case in curation.

Shikake and Affordance. From the viewpoint of the concept of affordance, a shikake is in an environment and offers a certain guidance for affordance selection. When we can collect the affordance properly, the shikake functions properly and we can proceed to the next stage. A shikake is a type of controller for the affordance selection. By being aware of a shikake, we can be lead to proper affordance source to collect it. For instance, if people are aware of any affordance from a hidden Mickey which is a shikake, we can collect proper affordance which shows that a hidden Mickey is, for instance, very interesting and enjoyable. That is, they can select a proper affordance according to their better benefit. Thus shikake can be explained by the concept of affordance.

Shikake and Chance. A shikake exists in an environment, and if it is applied to us we can change or proceed our activity directions for the better future. A chance will be exist in an environment, and by discovering it we can proceed to the better future. Thus the curated environment can be regarded as an environment equipped with a shikake. According to the policy of chance discovery, curation will be performed implicitly. A shikake can be either explicitly or implicitly placed. For an implicit placement, a chance and a shikake have a certain relationship. Because the above type of strategy is explained by affordance selection. That is, in the environment, a shikake exists and the shikake is a certain pointer for the proper selection of affordance. A shikake does not coincide with a chance but it can help in chance discovery. Of course, in chance discovery, any shikake cannot be explicit.

In the next section, a support system for dementia person will be discussed from the aspect of a shikake.

6 Introduction of a Shikake to Dementia Support System

In the previous section, I discussed the support system for dementia person in which affordance is selected to obtain meaning or function of things. I discussed the difficulty of the affordance selection even for normal persons, and pointed out that the issue becomes how to suggest a mapping function M as an additional hypothesis. M is an additional mapping function. As Bozeat and Hodges suggested, feature of mapping between objects and their meaning for a person with semantic dementia are affordance, presence of recipient, familiarity, and problem solving Thus a mapping system is very important to extend or change existing information to information on unknown world based on familiarity of more than two things. If a mapping function from the familiar world to unknown world is properly provided, it is rather easy to guess the meaning in the unknown world. In order to recognize the mapping function, it is necessary to introduce a certain system such as curation or a shikake to guess such a function. In this section, one of the solutions will be shown as an introduction of a shikake.

As explained in the above, a shikake is defined as an embodied trigger for behaviour change to solve social or personal issues. In addition, as discussed in the previous section, a shikake should sometimes easy to discover, because it functions as a trigger, but the shikake itself may not easy to understand. In addition, by a shikake, the staff will not directly transfer his/her knowledge to the audience, but by a trigger of shikake, their knowledge will be transferred to the audience. Thus the feature of a shikake is suitable for suggestion of a mapping function M.

Then a shikake can be included in the formulae shown in the previous section.

$$F \cup Object \cup Object' \cup M \cup affordance \models meaning \tag{7}$$

can be transformed as follows:

$$F \cup Object \cup Object' \cup shikake \cup affordance \models meaning \tag{8}$$

$$F \cup Object \cup affordance \not\models \square \tag{9}$$

Accordingly a shikake can function as a the other object with mapping function. $Object' \cup shikake$ means that $Object'$ is a shikake to select a proper affordance for guessing the meaning or function of $Object$. For instance, if somebody does not understand the meaning or usage of a folding bed, a folding wallet can be placed near the folding bed or shown to the user. Perhaps it will be better to show the wallet in an unfolding style. If he/she close and open a folding wallet, he/she can understand how to use the folding bed. That is, they can select an affordance as folding from the bed. In this case, showing a folding wallet can be a shikake to understand (select an affordance) the function of a folding bed. If

the user is aware of the similarity between a folding bed and a folding wallet, he/she can understand the function of a folding bed. In this case, a folding wallet can be shown implicitly, for instance it is placed on a floor as if it were dropped by somebody. This shikake mechanism is described in Fig. 3.

The shape of the folding wallet can become a trigger to understand the usage of a folding bed. It may be rather different from the hidden Mickey. However, both can be a trigger to the next action. For the hidden Mickey, it functions as a search object to be found. For the folding wallet, it functions as a reference object to understand the similar thing. For an example, the similar relationship is shown. However, other relationships or functions can be considered to prepare a shikake.

Fig. 3. Shikake: a key to the better affordance selection

Thus if we consider the existence of a shikake, affordance will be selected more easily and properly. Because a shikake functions as a hint to select the better affordance.

In the above, a shikake as an object is shown. However, the other type of shikake can be considered. For instance there are lot of sentences in the world for the proper guidance of human's activities. For instance, instead of "caution!!" in a certain place such a phrase as "Watch your right side to check the existence running cars." is frequently placed near a crosswalk (without a signal). This type of phrase will be effective for the person in hurry. In fact this type of a shikake will not understood by a semantic dementia person. However, a certain phrase can be function as a shikake even for the person with dementia. For instance in the above case, if you say "after reading book, please close the book" to the person with dementia, they can understand how to fold the bed.

Tadaki studied curation system which tries to control visiters focus to art works (Tadaki and Abe 2017). She conducted several shikake instrations to determine which type of shikake will function better. The result can be extended to use in the support system for the persons with dementia. The showing strategy

of labels (a shikake introducing to the meaning of the object) will be considered as a good curation.

In several places (shops), music is very effectively used for avoiding shoplifting (Beckerman 2015). In fact, this type of shikake is frequently used, but for the our case, can it be used as a shikake? If it is possible, it will be very useful. But I do not think it can be used for our purpose. Because the sound is an invisible object. Therefore it is rather difficult to place a certain sound as a shikake. Perhaps a special sound may stimulate the brain to fire a certain place for reminding meanings. For this case, though this idea is very interesting, but since I'm not a brain scientist, I will not deal with this solution. In fact as shown above, music therapy will stimulates emotion as well as brain (Aldridge 2000). This type of sound effect will be used in several situations.

The concept of information design is very important in the presentation. In fact, it can be regarded as a special case of curation. Thus it can be discussed in the context of shikake. In the book edited by Robert Jacobson (Jacobson 1999), Roger Whitehouse discussed the uniqueness of individual perception. He tested several designs in several situations. He pointed out that "[m]ost importantly, we began to understand how easy it is to disenfranchise individuals simply by not perceiving and correctly interpreting the most basic facts about their needs." Then he pointed out that "[a]s designer, we need to be conscious of, accept, and embrace the notion of unique perceptual abilities and respond generously to the needs it implies." It can also be discussed in the context of the first-person research (Suwa and Hori 2015). In the first-person research, all matters (objects, behaviour etc.) are subjectively observed and analysed. Thus we cannot generalize all matters.

For the first-person, Jocene Vallack pointed out (Vallack 2010) that "the first-person experiences undergo a metamorphosis and become universal insights. The process occurs though one's solo journey into the epoche[3], beyond which lie the eternal forms of existence." That is, the status of research will change from subjective to intersubjective and therefore universal. Thus according to his thought. if we continue the first-person research, it will become a universai research. However, it will not so easy for our aim. Because our target is person with dementia. It will be more difficult. We should stay in the first-person research to conduct the tailor-made support.

Thus there are lot of matters to consider when we design a support system for persons with dementia.

7 Conclusions

In this paper, a series of the support systems for persons with dementia inspired by affordance are reviewed. In addition, a shikake is introduced to supplement the affordance selection in a dementia support system. A shikake is a trigger to start a certain action or to change person's mind and behaviour. In this paper,

[3] Jocene Vallack defined epoche as "incubation period.".

a shikake is used as a part (hint) of a mapping function between an unfamiliar thing and a familiar thing. A familiar thing is offered as a shikake to select proper affordance.

In this paper only a theory and a simple example are shown. In the next paper, experiments with the support system for persons with dementia inspired by affordance and shikake installed system will be reported.

In addition, I discussed several aspects of shikake in this paper. These aspects should be considered in the next support system.

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