DIFFERENCES IN HUMAN AND AI MEMORY FOR MEMORIZATION, RECALL, AND SELECTIVE FORGETTING

Sachiko Yanagihara, Hiroshi Koga

University of Toyama (Japan), Kansai University (Japan)

sachiko@eco.u-toyama.ac.jp; koga@res.kutc.kansai-u.ac.jp

ABSTRACT

IT, including AI, has exceeded the humans ability in several areas, including memorization. Though many people aspire to be able to memorize everything recall it at will, humans have the advantage of intentionally forgetting things while learning new information. For people working in organizations, physical activity complemented by human intelligence is an advantage that humans have over AI. In this study, we examine the mechanisms of repeated memorization and selective forgetting of memory through the game of competitive karuta, which is a traditional Japanese card game. First, we outline the general differences between memories of humans and those of IT artifacts, including AI, confirming previous research of memorization and forgetting. Next, we outline competitive karuta and examine human memory in that context. Finally, we consider mechanical differences of memory between AI, which can remember everything, and human beings, who forget, in reference to the “intentional forgetting” of Golding and Macleod (1998). Moreover, we suggest that "the right to be forgotten" is a necessary perspective to consider regarding the use of AI for information, the substitution of people with androids, and the cyborgization of humans to provide the capabilities of AI.

KEYWORDS: intentional forgetting, memory, competitive karuta, artificial intelligence.

1. INTRODUCTION

Artificial intelligence (AI) mimics the learning behavior of humans; however, there are significant differences in the capabilities of AI and humans. Tasks exemplifying these differences are more appropriate for humans to perform. One of these significant differences is the capability of AI to store and use all information, in contrast to the imperfect memory of humans. Humans have struggled with the problem of forgetting, and most people want their memory to be reliable. Ricoeur (2000, p.197) commented on the consistency of this problem by stating that “In this regard memory defines itself, at least in the first instance, as a struggle against forgetting.” The pervasiveness of forgetting leads humans to fear their memory failing over time. Therefore, IT (including AI) is often relied upon for its superior capabilities of memorization. However, there is a concern that this increased reliance on AI will result in jobs currently performed by humans being lost to AI replacements.

This concerned is already reflected in board games. An AI specialized for Go (AlphaGo, produced by DeepMind) and an AI specialized for Chess (Deep Blue, produced by IBM) have both defeated human champions. Facial recognition systems using AI have become increasingly sophisticated,

and can find target faces among a crowd. AI systems never forget data and information after its initial memorization. While the persistent memory of AI can be considered valuable, it can also be considered to threaten “the right to be forgotten.” The imperfect memory of humans and their ability to forget has protected humans from the ethical threat of a perfect memory, considering the capacity of humans to be judgmental. Therefore, we consider a perfect memory to be inappropriate as an equivalent for human memory in a future society. Moreover, the complexity of a human's ability to intentionally memorize and forget has significant value in particular situations which AI cannot currently fulfill.

In this study, we examine the mechanisms of repeated memorization and selective forgetting through the game of competitive karuta, which is a traditional Japanese card game. First, we outline the general differences between human memory and memory of IT artifacts including AI, confirming previous research of memorization and forgetting. For the purposes of this paper, we refer to IT artifacts and AI simply as “IT,” when used collectively. Next, we outline competitive karuta and examine human memory in that context. Finally, we consider the mechanical differences of the perfect memory of AI, and that of human beings, in reference to the “intentional forgetting” of Golding & Macleod (1998).

2. MEMORIZING AND FORGETTING

2.1. Human forgetting

As stated by Gorry (2016), “Who would not appreciate an improved memory? Misremembering or forgetting frustrates all of us to one degree or another.” Completely accurate memorization was called “total recall” by Bell and Gemmell (2009), and total recall is generally viewed positively. However, the value of total recall in reality is contested. For example, Murata and Orito (2011) asked, “Is the society composed of people who have perfect (at least semantic and episodic) memory a good society?”

In humans, symptoms such as temporary amnesia are common regardless of age. People also often have experiences that they find difficult to remember even when they try, but that are then remembered later. This is similar to the case of IT when it is temporarily unable to access an index for information. However, human memory is not as simple as IT, and does not always remember by the same mechanism. Some things can be remembered by trying, and some memories are formed without trying. On the other hand, sometimes memories are formed and recalled even when you would rather not remember them. For example, a person who finds a memory to be unbearably painful can maintain his or her mental stability by partially or completely forgetting that memory. While such events could be considered unfortunate, and the person losing that memory may appear to be unhappy, it actually feels worse for that person to remember those memories. Still, we usually have negative feelings regarding memory loss. Ricoeur (2000) said “Forgetting is experienced as an attack on the reliability of memory.” Having a good working memory is valued in our society, and jobs generally require us to know many things. Humans express concern about forgetting as a potential sign of amnesia or dementia. However, forgetting need not be a negative phenomenon entirely. In this case, "forgetting" is not consciously performed as an intentional act, but is instead performed as a natural biological function.

Such forgetting mechanisms are generally considered important and necessary. The gradual dementia of the elderly is also considered in some ways to be an important mechanism for

reducing the mental burden of dying humans. This mechanism of memory and forgetting can be explained through neurological functions such as neuronal mechanisms (Yasuda et. al, 2018) and neurotransmitters (Inoue et al., 2013). However, studies on how humans subjectively perceive the mechanisms of memory have been limited to philosophical perspectives, such as those of Ricoeur and others, and there is no study that objectively demonstrates the actual state of memory and forgetting.

2.2. Differentiating the concepts of unlearning and forgetting

The concept of "unlearning" is similar to that of forgetting. Unlearning is mainly discussed from the perspective of organizational learning in the field of business organization. In business administration, it is often said that it is necessary to manage with consideration for past learning. However, in the case of "unlearning" in a new business, there are situations where past learning is rejected or ignored to allow for new learning.

Klammer and Gueldenberg (2019) reviewed 63 papers dealing with unlearning or/and forgetting, and they clearly distinguished unlearning and forgetting. They regard unlearning as "a purposefully initiated process of discarding knowledge" and forgetting as "involuntary knowledge loss." They also state that "especially in comparison to organizational learning, the concepts of unlearning and forgetting have received very little attention in scholarly research."

Though many papers focus on either unlearning or forgetting, from our research, only eight works emphasize both unlearning and forgetting. Among those that discuss both unlearning and forgetting, Wensley and Navarro (2015) provided one of the few papers focused on individuals, rather than on organizations. They defined forgetting as "intentional knowledge erasure or unintentional knowledge loss." In a review of several papers focusing on the similarities of unlearning, Klammer and Gueldenberg (2019) define the act of unlearning as "an organization actively (voluntarily) engages in giving up old knowledge". In other words, unlearning is "intentionally disregarding prior learning." Forgetting is not the same as unlearning. Forgetting is the temporary loss of multiple pieces of information from memory simultaneously, whereas unlearning is selective. Certainly, unlearning is very similar in concept to forgetting, but they differ significantly for individuals and organizations.

Rupčić (2019) focused on the relationship of the organization's learning dynamics, stated as follows: "when practitioners face challenges, they often find that certain knowledge must be abandoned or discarded, redefined and modified, or updated with new information. This process exists on the individual, team, and organizational level as every building block of a learning organization is continuously engaged in the learning-forgetting-unlearning-relearning dynamics." In other words, the "learning-forgetting-unlearning-relearning" exists not only in organizations but also individuals, and "unlearning" exists as a completely different process from "forgetting" in this mechanism. However, we think that memory and learning are different processes in human behavior, as memorization does not always lead to learning. In many cases of human behavior, long-term memory is required for learning better behavior, but memories being momentarily forgotten and then restored occurs frequently in humans. Moreover, players of some games are skilled in creating momentarily strong memories that are later forgotten. Learning may be performed based on long-term memory, but if the memory is intentionally forgotten, neither memory nor learning may be performed.

Learning is inherently different from memorization. While learning can be intentional or unintentional, learning manifests differently in behavior and conditioning. Though memorization can be achieved both actively and unconsciously, memory does not necessarily result in action. As a contrasting example, though we understand that studying consists largely of memorization, we also recognize the conceptual differences of unlearning and forgetting. We agree with the definition of “unlearning as a purposefully initiated process of discarding knowledge and forgetting as involuntary knowledge loss” (Klammer and Gueldenberg, 2019). Therefore, we consider unlearning to be sufficiently differentiated from memory and out of scope for this paper, and we will focus only on “forgetting.”

2.3. Differences between humans and IT in memories and forgetting

Tulving (1974) defines human "forgetting" as "the inability to recall something now that could be recalled on an earlier occasion.” One theory of forgetting is co-dependent forgetting, known in psychology as context-dependent forgetting, and defined by Tulving as “reflecting the failure of retrieval of perfectly intact trace information.” This theory is famous for describing episodic memory. Episodic memory is subjective and autobiographical, and it is characteristic of the mechanisms of memory for sentient beings. Except AI, IT artifacts cannot memorize episodically, and instead memorize all information through concrete commands given by a human. Therefore, they forget memorized information only in particular situations. Moreover, they can recall all memories as needed in ordinary situations, having total recall as previously explained.

Hardware defines the only storage limitation of IT. Though forgetting is an everyday occurrence for humans, it is special situation for IT because they cannot intentionally forget. Previous studies have shown that human memory requires the ability to intentionally forget (Macleod & Golding, 1998). “Strategic forgetting” (Kearns et.al, 2010) and “organizational forgetting as strategy” (de Holan & Phillips, 2004) are concepts similar to “intentional forgetting.” The former is used in the context of reclaiming value through transition by confidently forgetting stigmatized memories of cultural history. The latter, on the other hand, is used in the context of managing organizations and human resources efficiently and effectively. The latter also emphasized the context of organizational behavior, though the behaviors of an organization are created by a set of individual actions and behaviors. Hence, these particular types of intentional forgetting do not differ between individuals and organizations. These concepts and intentional forgetting can also be used for IT because they coexist with humans in "the constitutive entanglement of the social and the material in everyday organizational life” (Orlikowski, 2007).

In addition, Ricoeur (2000) says “Forgetting is bound up with memory,” and “Forgetting can be considered one of the conditions for it.” Though IT artifacts do not intentionally forget, they share this relationship between memory and forgetting. Kluge and Gronau (2018) have defined “intentional forgetting” as “the motivated attempt to limit the future recall of a defined memory element.” Timm et al. (2018) explained further that “intentional forgetting” is a significant mechanism in an AI system. For example, Nuxoll et al. conducted a study for an algorithm of forgetting to artificially perform episodic memory (2010). The importance of this is demonstrated by technical methods for forgetting being studied considering the "Right to Be Forgotten" (Villaronga, Kieseberg, Li, 2018). To develop this idea further, we consider the processes of memory and forgetting used in competitive karuta as a way to observe the “intentional forgetting” that AI cannot do, but which humans can, through the repetition of memorization and forgetting.

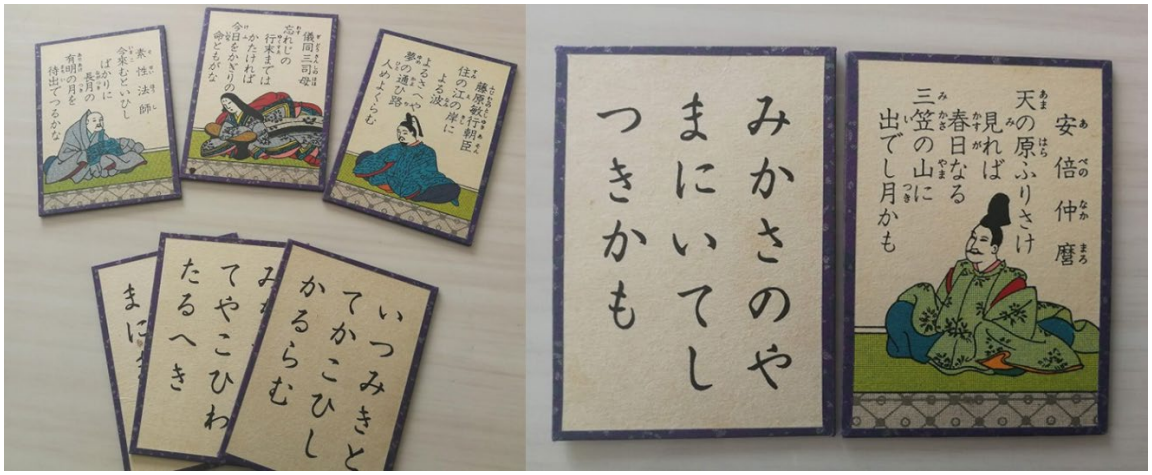
3. MEMORY AND FORGETTING MECHANISMS THAT CAN BE SEEN IN "COMPETITIVE KARUTA"

3.1. History of competitive karuta as Japanese traditional game from karuta as literature

There are many traditional indoor Japanese games. For example, the famous Japanese board game "Shogi (将棋)," which is similar to "Go (碁)," is known to have been played as early as the 16th century. Many Shogi games have been developed as software for PC, and AI has recently been used against professional Shogi players. Traditional Japanese games such as Shogi often challenge players to memorize and recall the state of a game. This is especially true of competitive karuta, which is sometimes referred to as "*Kyōgi karuta* (競技かるた)". Competitive karuta was established based on a 13th century literary work called *Ogura Hyakunin Isshu* (小倉百人一首), or *Hyakunin Isshu* (百人一首) when abbreviated, which translates to "One Hundred Poets, One Poem Each" in English. In competitive karuta, poems from Hyakunin Isshu, each comprising 31 syllables, are written on cards called "*karuta*." Of these, "*yomifuda* (読み札)" cards contain an entire poem, whereas "*torifuda* (取り札)" cards contain only the second half of the poem (See Figure 1). As competitive karuta is originally based on a literary work, it is not widely known as a game abroad. Moreover, the style of Japanese text used in Karuta is traditional rather than modern, so it can be very difficult for people who are not native Japanese readers. However, as both a work of Japanese literature and as the game of competitive karuta, the familiarity of Hyakunin Isshu is gradually growing worldwide.

Figure 1. Cards of Ogura Hyakunin Isshu.

Left: Three sets of yomifuda (top) and torifuda (bottom) cards. Yomifuda cards are for reciting, and include an illustration of the author and a poem written in full. Torifuda cards are to be taken by players, and include only the ending of the corresponding poem. Right: One set of corresponding yomifuda and torifuda cards for the same poem.



Source: Photos taken by the author

Despite its difficulty, competitive karuta is played in several international communities. Clubs belonging to All Japan Karuta Association exist in the USA, Thailand, Singapore, China, Brazil, France, and Germany. Furthermore, the International Festival for Competitive Karuta ("International Ogura Hyakunin-ishhu Karuta Festival 2020") will be held preceding the 2020 Olympic and Paralympic Games in Tokyo (All Japan Karuta Association, 2019). The website for this festival is available in both Japanese and English. Moreover, there is a website available for

players who speak a foreign language (Stone, 2018). This is one of the positive characteristics of competitive karuta combining both sports and culture (Bull, 1996). Though rules can be very difficult, it is played by people of many cultures, and its significance in Japanese culture differentiates it from other board games or card games.

As a collection of poetry, the contents of Hyakunin Isshu are important for most Japanese readers. Currently, most Japanese high school students learn the unique sound of Japanese poetry from Hyakunin Isshu, and it is used in the curriculum of Japanese language classes for interpreting the cultural background of its time. Therefore, Hyakunin Isshu Karuta is popular among Japanese people as part of a common culture. It is also popular as a card game to be played during the New Year, and there are many schools that hold championship events in January. Karuta games played in such tournaments are simpler than competitive karuta games, but competitive karuta is also well known. Championship games are televised through programming on NHK, the Japanese state channel, and the results of championship games are broadcast on the NHK news program. In recent years, manga (Japanese graphic novels) depicting competitive karuta have become popular, one of which has been developed into a movie, further increasing its recognition. As a sport, the population of players is relatively small and the detailed rules of Competitive Karuta are generally not understood in depth, but it may be considered a minor sport in the sense that most Japanese people have at least a casual understanding, and a win or loss during a match can be understood as it is observed.

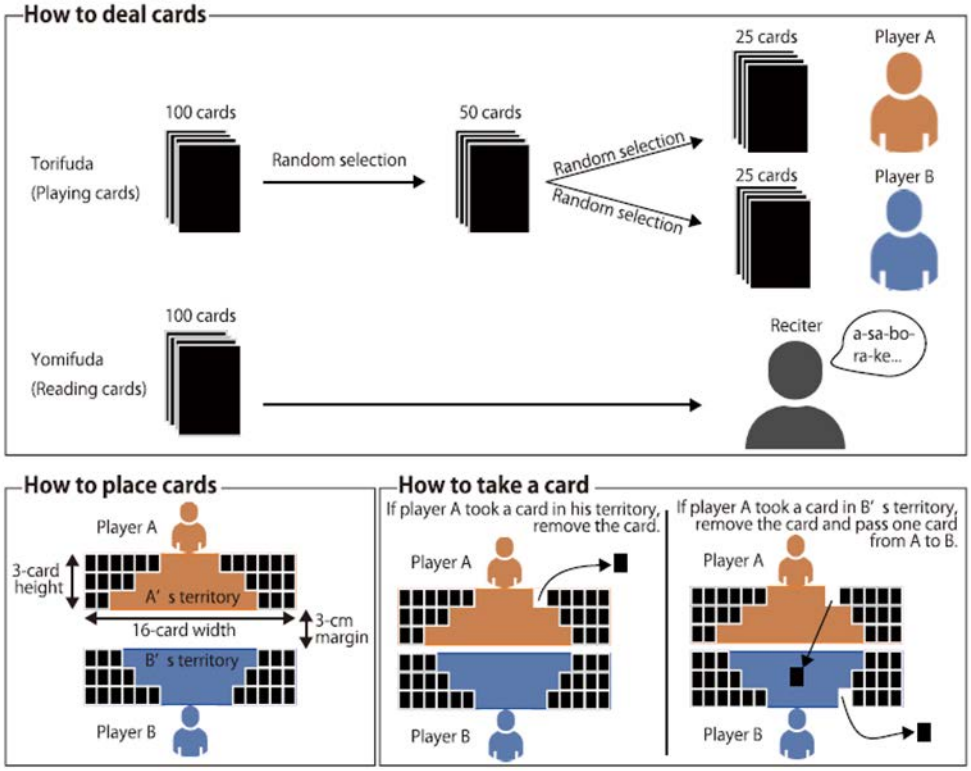
3.2. Outline of competitive karuta

The basic rules of the game are simple, and the playing area is as shown in Figure 2. After a yomifuda card is selected, a reciter reads the first half of the poem given on the card, and the players must select the corresponding torifuda card that contains the second half of the poem. The objective of the game is to reduce the number of cards in own territory from 25 to 0, and this is done by correctly remembering and identifying torifuda, which match the recited yomifuda (See Figures 2–3). When the correct torifuda is selected, the player who identified the correct torifuda either removes a card from their territory or adds a card their opponent's territory. If a player selects a torifuda incorrectly, this is known as an "*otetsuki* (お手つき)," or "foul" in English, and results in a card being taken from the opponent's territory, increasing the mistaken player's number of owned cards. Before the start of the game, the positions of the cards in the field are memorized in advance, and players attempt to memorize the cards by "*kimariji* (決まり字)," which is the first syllable of a card by which a correct torifuda can be identified. However, because the placement and kimariji of the cards change as the competition progresses, it is necessary to re-memorize the placement and kimariji of the cards quickly. Because this process is easy for IT, game apps for competitive karuta have already been launched.

Players must make decisions and move quickly to identify and select cards according to the progress of the game. This decision-making and action based on the game information has a direct impact on the outcome of the game. Though the physical aspect of the game can be performed reliably by a robot arm following the derivation of an optimal solution using an AI, the most important aspects of the game are memorizing the initial position and kimariji of the cards and then re-memorizing them as the game state changes over time. For this task, past memories are forgotten, and new information is repeatedly stored. No matter how fast the robot moves, it cannot win if its memory is weak. Even if an application is developed with total

recall and accurate operation, a first-class player is difficult to surpass unless the application has the ability to hear slight differences in the voice of the reciter.

Figure 2. Rules of competitive karuta.



Source: Yamada, Murao, Terada, and Tsukamoto (2018)

Figure 3. Preparation for beginning a match.

Left: Each player takes 25 cards face-down from 100 cards available. Right: The official reciter reading a yomifuda card for competitive karuta.

Source: Photos taken by the author from a match on January 3rd 2013

3.3. Mechanism of memory and forgetting of competitive karuta

In a competitive karuta game, memorization and forgetting are repeated frequently after every reading of a yomifuda card. A player wins by being ahead by reducing own all cards, so in the case of a close match, as many as 100 yomifuda cards are read. In addition, as many as 5 or 6 the games can be played in a day leading to the final stage of tournament matches, so the winner and runner up will memorize and forget up to 500 times before the tournament is finished. Because the 50 cards used for each match are drawn from the same collection of 100 cards, cards will be seen multiple times, and if the states of previous matches are not forgotten, confusion will result from inconsistencies in a player's memory during a match.

The task of playing competitive karuta is complex and requires using information and understanding while completely forgetting past game information. Moreover, the amount of information to memorize when taking cards is high, and includes the placement of torifuda in the bases of both players, the kimariji of each torifuda while considering the situation leading to the current game state, which poems have already been read, and the current kimariji of torifuda that have not yet been read. Because these items change each time a card is read, it is necessary for players to overwrite their current memory and forget older memories in a short time before the next card is read.

For example, there are only two poems that begin with the syllable "U": "U-ka-ri-ke-ru" and "U-ra-mi-wa-bi". At the beginning of a match, players can identify the appropriate card to select by recognizing the second syllable of a poem if it begins with "U", depending on if it the poem begins with "U-ka" or "U-ra". However, after one of those poems has been recited and the corresponding card has been removed from the field, players can get identify the correct card after only hearing "U", as the first syllable, so they adjust their memory of the kimariji. Furthermore, if both the "U-ka" and "U-ra" cards are held by the opposing players, they must listen for the second syllable to avoid choosing the wrong card.

Though only two poems begin with the syllable "U", eight poems begin with "Na", and 16 poems begin with "A". Players memorize the positions of each card their fixed letter (kimariji) for 15 minutes before the game begins, but as the fixed letters change over the course of the game, it is necessary for the players to rewrite their memory as each poem is recited. In addition, players change the locations of the cards during the match as poems are recited and cards are selected. Yomifuda cards are read frequently, and players must memorize the new card positions in a very short amount of time between each reading of a yomifuda card.

Competitive karuta uses a mechanism of memory that is similar to that used for the called game called "Concentration". Players use only the essential information of past memories. However, previously memorized information is not used directly because using it becomes an obstacle to accessing current information and ensuring the accuracy of that information. This is not the case for IT artifacts, which have the capability of total memorization and recall. To accurately model human memory, though it is important to store information in an extended area that can be separated and forgotten, searched when necessary, and accessed, it is also important to block the access of some information to improve accessibility to prioritized information. In "Concentration", it is difficult for players to win against IT, which can memorize everything completely. The difference between competitive karuta and Concentration is that there are psychological tactics used between humans, and the content of those psychological tactics includes the frequency of repetitive memorization and intentional forgetting. The psychological

tactics used also depend on the opponent. This phenomenon is difficult to observe against IT because of the advantage of total recall.

Of course, even in competitive karuta, if a human lets an AI learn how to play matches using a game app, it will learn various battle patterns. An AI for Shogi can play more matches in a short period of time than humans can, and its learning makes it stronger than humans. However, they cannot learn differences in the speed card selection due to players having more familiarity with certain cards. Because an AI with perfect memory does not have preferences or familiarity, it will always respond the same to all cards. By contrast, human players can deduce or intuit their opponent's favorite cards and strategically arrange the cards for an advantage.

The reason why you can compare your opponent's small actions with the memory you have in an instant and make use of it in a match is that you can use your past knowledge instantaneously while performing intentional forgetting. If you use prior information at the same time, it will fail. It is therefore necessary to forget past information and data intentionally, using only knowledge.

This mechanism of intentional forgetting through omission can be observed in humans, and it improves memory reliability. We know that repeated learning prevents forgetting and improves long-term memory. However, it is important for humans to intentionally forget while repeatedly memorizing information, which differs from the behavior of AI. Modern IT is capable of total recall, and we recognize this capability as useful. Though humans would like the ability to memorize and recall at will, memory may be strengthened through intentionally forgetting.

Players must remember certain information in the long term while forgetting specific details of previous memories. The requirements of a player's memory can be summarized as follows:

- Strong memory at the start of the game
- Forgetting new and old memories as the game progresses
  - Players must repeatedly rewrite a strongly established memory roughly every 30–120 seconds over the 15-minute length of each game while forgetting their memory of previous game
- Creating new memories by organizing forgotten memories
  - If players forget previous events in the course of a game, they cannot confirm the current kimariji
  - It is necessary to memorize which poems do not exist in the current game
  - The memories used for learning, organized for each moment, must be forgotten
- Forgetting previous game information when remembering the next game
  - Accounting for the uniqueness of changing conditions even though the physical appearance of the placed cards is the same
  - The use of memorization is similar to that used in the card game called "Concentration," but the selection of cards based on fixed characters may not always be shortened, and may be longer depending on the player's strategy

4. DIFFERENCES IN MECHANISMS OF INTENTIONAL FORGETTING AND MEMORY BETWEEN HUMANS AND AI

The case of competitive karuta suggests that we can observe the human mechanism of memory and forgetting referred to as “intentional forgetting” by Golding & Macleod (1998). “Intentional forgetting” is an old concept and is also known as “motivated forgetting” (Weiner, 1968). However, the recent development of IT can retain all information, which is seen by many as desirable. Moreover, while most people agree that human beings can never surpass IT in terms of memory, IT can never consciously forget because IT do not have consciousness. As IT cannot forget consciously and intentionally, this demonstrates a problem of “the right to be forgotten.”

Though these aspects of memory and forgetting are difficult to directly observe in the game of competitive karuta, they can be observed objectively to some extent. Memory is instantaneously renewed during the game, and previous memories are forgotten. However, these forgotten memories are not something to be permanently deleted when the scene is finished, and they are revived as material for future decision-making. Some memories should be established as knowledge later, if necessary. When a person intentionally hides important information in a strategic situation called a "match," which consists of the accumulation of momentary memorization and forgetting, it can be called "strategic oblivion."

In other words, in the game of competitive karuta, only an essential understanding is extracted from past memory and used as knowledge, but the details of information in the memory are not used in order to prevent them from becoming an obstacle in accurately recalling information of the current memory. In IT, information becoming a barrier to accessing other information generally does not occur, excepting events such as data collision or programing mistakes. By following instructions, the necessary information can be accessed. However, that information is a set of momentary fragments of memory, and even if an AI learns the flow of the game, it is difficult to learn things such as the opponent's otetsuki due to a memory error, the unique exchange of cards performed by their opponent, and card familiarity.

This is different from today's world of IT where everything is always stored in a searchable form. It is a game which cannot be solved when all things are considered retrieval candidates, even things that we would prefer to forget. A world including the "right to be forgotten" is incompatible with requiring total recall. Replicating human memory with IT is not an issue of simply having a larger memory capacity. Human memory is more similar to the use of bank switching and Expanded Memory Specification, which was used in the early 1990s to exceed the limitations of computer processors, allowing them to directly address different configurations of memory depending on the situation. Rather than constantly improving capacity, a more accurate replication of the reliability of human memory will store information in an extended area that can be separated, ignored, and made accessible when necessary so that the information can be intentionally blocked. Because the current state of AI is capable of total recall, it does not support the right to be forgotten, which presents an ethical problem when considering the introduction of AI into human society. An additional ethical problem is presented when considering the use of AI as an extension of the human brain through cyborgization. The ability of humans may be limited, but the limitations of humans are very significant in defining humanity; thus, exceeding the limitations of humanity could potentially be considered as a loss. This study suggests that because modern AI does not include "intentional forgetting", an ethical coexistence between humans and AI in society will remain limited.

5. CONCLUSION

In summary, we suggest that modern AI cannot currently replicate the memory of human beings, and does not have an equivalent relationship between memory and forgetting. However, an equivalent relationship may eventually be a possibility. When considering people working in organizations, humans are superior in activities that require collaboration to perform physical activities. This is a necessary consideration in the relationship between AI and humans. Though IT artifacts have a capacity for memory that surpasses human memory, the difference between AI and humans is significant in modeling human intelligence accurately. To accurately model human intelligence, AI must make human-like decisions about whether to forget a given piece of learned information. Until AI has the ability to intentionally forget, AI intelligence cannot be considered analogous to that of human beings.

Lastly, we consider the limitations of this study. Competitive karuta is a very particular case, and is not being widely played throughout the world. It also has a special background of Japanese culture. It is possible that this idea is only appropriate to this particular case. However, the most important point to be made in this paper is that this case shows that the ability of IT in terms of memory is currently not appropriate for replicating the human mechanism of memory and forgetting. On that point, this research is just one case of observing the unique mechanisms of human memorization and forgetting. In the future, further studies are needed to determine the relationship between memory and forgetting for communication between human beings and AI, and for examining this mechanism when considering the further limitations of AI and human potential. Thus, although there are limitations, this study suggests the importance of forgetting as a mechanism in future AI development.

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