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Simple Pointing to Objects may Facilitate Remembering

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Abstract

Two experiments demonstrate the impact of the self-performed actions during the encoding phase on the amount of the learned information. People memorized more items if they had touched the stimuli during learning. The experiments differ from many of the classical studies testing embodiment of human memory in two main respects:
First, the performed actions are completely unrelated to the essence of the learned stimuli, thus the results can not be explained by pure association-based facilitation. Second, the actions are performed during the encoding phase only, thus the results maybe directly linked to the nature of the encoded representations. The possible mechanisms that may underlie the observed influence are discussed shortly.

Keywords: embodiment; memory encoding; representations

Introduction – embodied cognition

The classical AI theory of manipulations of abstract symbols had been reconsidered during the last decades. Very influential in the field of the so-called embodied view of cognition are the books of Lakoff and Johnson (Lakoff & Johnson, 1980, 1999). They argue for a massive cross-domain interrelation of various structures that map each other. Furthermore, the authors claim that maybe the whole cognition is ground in the body. The growing theory of embodied cognition rejects in its extreme version even the very idea of representations: "What you get underlying our representations of the world - the kinds of things we formulate, for instance, in declarative sentences - is not further representations but rather a certain grasp of the world that we have as agents in it" (Taylor, 1987, p. 432).

The relation between the sensory-motor and the conceptual system was widely explored from different perspectives. O'Regan & Noë, (2001) focus on the dynamic interrelation of all cognitive systems – the perceptual one, the action one, and in turn the conceptual one. The fundamental base for the view that perceptual signals lie at the core of the conceptual representations is enriched by the works of Barsalou (1999) and Brooks (1987). According to the Barsalou's perceptual symbol system, the representations of all concepts, even the abstract ones, are based on associations with huge number of perceptual and motor neural signals. A wonderful theoretical analysis of the philosophical view of embodiment had been made by Anderson (2003), as well by Shepard (1984), Glenberg (1997), and Varela et al. (1991).

At the same time, many empirical studies gave additional support for the idea of embodiment. Sinai et al. (1998) and Proffitt et al. (2003) demonstrated how physical difficulties may change abstract judgments of people. For example, people judge a certain distance as longer if they stay with a heavy rucksack on their back. Myung et al. (2006) performed an experiment to show that recognition of the action, for example, typing on typewriter, is facilitated by the context of a piano just because of the common typical finger movements performed on both objects. In addition, not only the performed actions influence perceptions, but also the perceived objects influence directly some motor commands. Thus, in a series of experiments Tucker and Ellis (Tucker & Ellis, 1998; Ellis & Tucker, 2000), as well as Richardson et al. (2001) demonstrated this opposite effect – the perceived objects automatically and immediately activate certain action responses.

Evidence supporting the embodiment view on cognition can be found also in brain imaging researches (Hauk, Johnsrude & Pulvermüller, 2004, Damasio, 1999). Even the mirror neurons (Rizzolatti & Craighero, 2004) often are speculatively related to this view.

Together with the interdependency between perceptions and actions, the relationship between language and constraints of the body is explored widely by the scientists. For example, people prefer to say that a given umbrella is above the man's head if the umbrella protects the man from the rain even if the real position of the umbrella is at 45 degrees according to the head (Coventry et al., 2001). The claim that language is grounded in our bodies and actions is supported by a huge number of empirical evidences (Glenberg & Kaschak, 2002; Pecher et al., 2003; Solomon & Barsalou, 2001; Spivey et al., 2000; Stanfield& Zwaan, 2001; Zwaan et al.,2002). Catrambone et al. (2006) demonstrated that an irrelevant touch of the objects may facilitate relatively abstract analogy-making. Maybe babies first ground the meaning of verbs that are closely related to the body parts (Tardif & Wellman, 2000).

Actions – Massively associated with the representations or essence of the memorized knowledge

However, most of the empirical studies can not answer whether there are pure symbolic representations of objects in our mind that are massively associated with the action and perceptual representations or indeed the body actions and perceptions are the very essence of the memory traces. Many classic theories in the field of memory and learning assume that learning can be improved if the target

information is processed from different modalities. For example, The Levels of Processing Theory (Craik & Lockhart, 1972), which is deeply based on representational view of memory, is grounded exactly on the interaction between memory and vision (Craik & Lockhart, 1972), memory and hearing (Fletcher et al., 1998; Srinivas et al., 1997), memory and touching (Srinivas et al., 1997), and memory and smell (Schab, 1991). Dual-coding theory (Paivio, 1986) also assumes that the visual and auditory information are processed separately but nevertheless claims for a deep relation between them (Anderson & Bower, 1973). Thus, many empirical data that support embodied view on memory are actually arguments for the relationship between perceptions, actions, and conceptual system but do not contradict in any way to a possible existence of pure symbolic representations of the concepts.

In most of the experiments that test embodied effects on human behavior, the performed actions are closely associated to the respective test items. For example, recognition of a typewriter is faster in the context of a piano (Myung et al., 2006). However, this does not mean that the concrete movements of fingers are inseparable part of the representation of the typewriter. Instead, maybe there are huge number of associative links between the symbolic representation of the concept 'typewriter' and many concrete situations in which a typewriter has been used. Furthermore, maybe the representation of these concrete situations is linked (again associatively) to the representation of the concrete finger movements.

Thus, we decided to conduct an experiment in which the manipulated action is not associatively linked to the essence of the tested items in any way. More concretely, we decided to test whether simple pointing to a colour sample may improve actor's memory of this sample.

In addition, we wanted to ensure that the effect of action should not be manifested during the test phase. With other words, we attempted to avoid the possible explanations that actions and movements may influence the process of retrieval. Thus, we ask participants to perform or not certain actions during the phase of memorizing only. Then people from both acting and not-acting groups were tested in the same way – by asking them to write on a sheet of paper what do they remember.

Experiment 1: The role of the own action

Method

Design

One-factorial between-subject design was used. People from both the control and the experimental group were asked to memorize the colours of twelve small rectangles, placed at different positions on the screen. People from the experimental group were asked to open the rectangles themselves by touching different parts of the touch-screen. When any of the rectangles on the screen was touched a colour appears on its place. Participants from the control

group observed the same procedure of opening the colours without touching the screen. The dependent variable was the number of correctly recognized colours on the respective positions.

Stimuli

Six different colours, each of them used twice, were randomly placed on a 4x3 table. The exact positions of each colour, as well the predefined order for their exposure, are shown on table 1. Initially all colours are "closed", i.e. the rectangles were gray.

Table 1: The order of opening and the colour of each rectangle.

6. red	3. blue	8. green	11. orange
10. yellow	12. black	1. red	7. blue
9. green	4. orange	5. yellow	2. black

Procedure

A 4x3 table with 12 gray rectangles was placed at the middle of a touch-screen monitor. When a fixation cross appeared within a certain rectangle, participants from the experimental group touched it and the rectangle changed its colour from gray to one of the six target colours (i.e. red, green. yellow, orange, black and blue). The duration time for the colour presentation was fixed to 1500ms than the rectangle became gray again. One second later the fixation cross appeared on a different location and the procedure was repeated until all twelve rectangles were seen.

Participants from the control group did not touch the screen. Two seconds after the fixation cross the rectangle changed its colour alone for 1500ms and then turned into gray again. Thus, the control participants were only permitted to observe the same procedure as participants in the experimental group but were not actively involved in it.

The order of presentation of the rectangles, as well the position of the colours, was randomly assigned at the beginning of the experiment and was the same for all participants.

The memory test for both groups was performed five minutes later, at which time the participants looked a short movie. Each participant received a sheet of paper with a 4x3 empty table graphed on it. Then he/she was asked to fill the table with the colour labels that he/she can memorized. For each participant the number of positions filled with correct colour labels was counted.

Participants

53 students from New Bulgarian University (26 in the experimental and 25 in the control group) took part as volunteers in the experiment. The range of their age was from 19 to 32 years; 24 of them were males and 29 were females, randomly assigned to both groups.

Results

Nobody had memorized correctly eleven or twelve colours; everybody had memorized at least one; one person had memorized correctly only one colour.

The mean number of correctly recognized colours for the control group was 4.33, st. dev. 1.94. People from the experimental group had recognized correctly mean 5.96, st. dev. 2.60 (see figure 1). The difference was significant: $t(51) = -2.59$, $p = 0.012$; the size effect (Cohen's d) was 0.725.

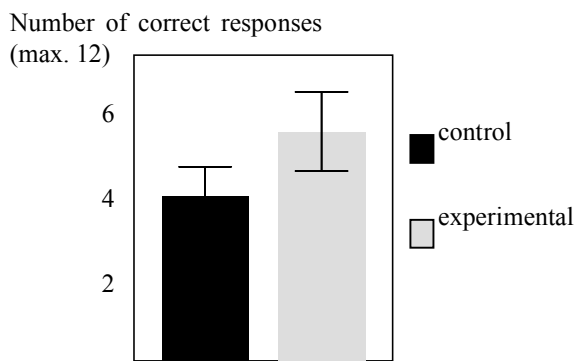Number of correct responses
(max. 12)

Figure 1. The results from the first experiment - mean number of positions, filled with correct colours during the memory test for both groups. The error bars show 95% CI for the means.

Discussion

The results from the experiment demonstrated that people memorize better when they use their own hand for touching the stimuli during learning. These results differ from most of the empirical data supporting the idea for embodiment of our memory traces because the memorized items were completely unrelated to the specific hand action and because the action was performed during the encoding phase only, but not during the test phase. Thus, the results are in favor of the hypothesis that concrete situated actions, performed by people, are important part and key factor of the representation of relatively abstract and in some sense purely symbolic items.

However, two alternative explanations of the experimental results may arise: First, maybe memories of people from the experimental group are richer because a representation of a movement is added to the representation of each colour position. Thus, because the overall amount of information for the experimental group is larger, maybe the respective memory traces are more accessible. Second, it could be that participants from the control group were less motivated and less involved in the task.

Thus, a second experiment had been performed. The amount of the information that maybe encoded was controlled. In addition, the experiment was performed in an ecological environment by a trained experimenter who tried to keep the attention of people from both groups.

Experiment 2: Control of the amount of information

This experiment differs from the first one in three aspects:

First, a manually made cardboard was used instead of a computer touch-screen. Second, the experimenter opened and closed the covers of the coloured rectangles for the control group. This ensured that for both groups somebody's movements can be encoded. Third, the experimenter was trained on several things: to keep the motivation and attention of the participants; to know the exact order of opening the covers; and to keep the time for exposition of the colours as equal as possible.

Method

Design and stimuli

The design of the second experiment followed exactly the respective one from the first experiment. However, the stimuli used differed significantly. A 4x3 cardboard was manually modeled and each of the twelve rectangles was differently coloured. The pattern of the colours followed exactly the respective pattern from the first experiment (see table 1). Twelve gray covers that could be opened were stuck in one side of the rectangles.

Procedure

The experimenter touched one of the covers till the respective participant attended it. Then in the control group she opened the cover for about one and a half second and then closed it. Participants from the experimental group were instructed to open the cover that was pointed from the experimenter themselves and after one and a half second they closed the cover. The order of presentation of the stimuli was the same as in the first experiment (see table 1).

After the presentation of the twelve stimuli, all participants watched a five minutes movie on a portable computer screen. After that all of them received a graphed sheet of paper and were asked to fill the positions with the colours they remember. Thus, the overall procedure was the same as in the first experiment.

Participants

40 persons (20 women and 20 men) took part as volunteers in the experiment. The range of their age was from 18 to 35 years. All they were randomly assigned to one of the two groups.

Results

Everybody had memorized at least one colour position; two persons had memorized correctly just one; one of the participants had filled correctly all twelve colours.

The mean number of correctly recognized colours for the control group was 4.50, st. dev. 2.37. People from the

experimental group had recognized correctly mean 6.45, st. dev. 2.69 (see figure 2). The difference was significant: $t(38) = -2.43$, $p = 0.020$; the size effect (Cohen's d) was 0.77.
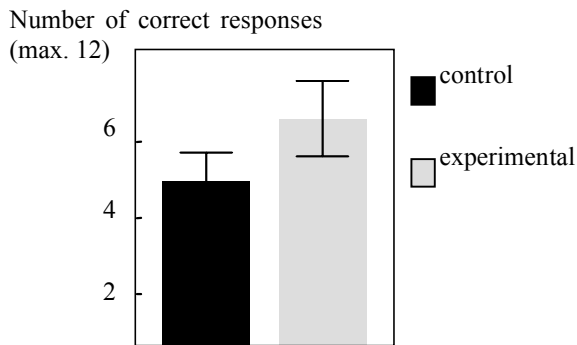
Number of correct responses (max. 12)

Figure 2. The results from the second experiment - mean number of positions, filled with correct colours during the memory test for both groups. The error bars show 95% CI for the means.

Discussion

During the second experiment the time of colour exposition was not controlled but the amount of the exposed information was equalized for the two groups, i.e. someone's hand opened and closed the covers. At the same time, in the first experiment, any possible influences from the exposure time or from the behavior of the experimenter were eliminated. Nevertheless, similar pattern of results was observed in both experiments. Moreover, although during the ecological experiment people memorized a bit more in both groups, the size effect was almost the same in the two experiments. Thus, the effect of the authentic actions on the amount of the memorized information seems to be stable enough.

Models that can account to the experimental results

Often the phenomena of the embodiment cognition are related to the constructive processes of cognition. Thus, the models of constructive memory like the CHARM model (Metcalfe, 1990), the TODAM2 model (Murdock, 1995), the Trace synthesis model (Nystrom, McClelland, 1992) and the Complementary Learning Systems (CLS) model (McClelland, McNaughton, & O'Reilly, 1995) can account to many of the empirical data that support the embodied view. All these models are based on massively interconnected associative networks. Thus, they can explain the influence of the performed actions to the perceptions (for example, the contest of a piano may facilitate the recognition of a typewriter). They can explain as well the opposite relationship – the perceived objects may automatically activate motor commands.

However, the results from the two experiments can not be explained satisfactory from this type of models. The main reason is that the associative links can be excluded as a possible reason for the effect, because people did not make any movements during the recognition phase.

A second possible explanation of the experimental results can arise from the encoding of the information that comes from proprioception. As it was mention during the discussion of the first experiment, maybe people from the experimental group have richer representations, because their own pointing is an additional portion of information. This was one of the reasons for conducting the second experiment, in which somebody's hand movement can be encoded in both groups. However, the information that comes from the proprioception still is available for the people from the first group only. Unfortunately, there are not any memory models that take into account this type of information.

Ballard and colleagues (Rao, Ballard, 1995, Ballard et al., 1997) propose their model, based on the idea for deictic pointers. According to the authors, eye-fixations and the attention serve for creation and manipulation of pointers to the objects in the environment. The pointers, instead of the representation of the objects can be encoded in the memory. If necessary, it is easy to use these pointers for finding the objects and to encode from them the necessary information. From one hand, the deictic codes model proposes a way for a drastic decreasing of the necessary calculations for performing tasks in a 3-D environment. From other hand, they answer to the question why people are limited for the amount of information that can process simultaneously.

The paradigm of the proposed experiments seems very close to the deictic codes view. Maybe pointing to the objects with a hand is an additional source for creating such deictic pointers. Thus, it seems natural why people from the experimental group have better memories – they can just use more deictic pointers.

Unfortunately, the model that Ballard and colleagues propose is still not enriched with mechanisms for creation, manipulation, and retrieval of memory traces from the long term memory. Thus, the relation between the deictic codes view of the embodiment and the results from the two experiments seems promising but still speculative.

Finally, maybe pointing to the objects has additional social value that in turn can influence memory. (Nathan, in press) proposes various examples how gestures may enrich the listener' understanding as well as the speaker's one during a conversation. Thus, people from the experimental group point to the colour samples and they point not only for themselves but to the experimenter too. Maybe this is the reason for their better memory.

Conclusion

The theory of embodiment of memory and cognition opposes in its extreme versions the classical representational based view. Many empirical data support the close relationships and interdependencies between our conceptual system and the sensory-motor inputs and outputs. However, it is still an open question whether actions and perceptual signals lie at the very core of the memory traces or it is just a massive associative interconnection between the separate conceptual and sensory-motor systems.

The two related experiments, presented here, tried to highlight more this question. People memorized better colour samples if they touched them instead of just observed them. The same effect of the action of touching has been observed both during the controlled laboratory experiment and during the more ecological second experiment.

It is demonstrated that the simple touching influences what people had learned even if the respective touching is not related in any way to the essence of the information, required to be learned. Thus, the results are in support of the hypothesis that the movements that we perform maybe are a substantial part of the representation of the things we learn during these movements. This hypothesis is supported additionally by the fact that the observed effect is caused by what is actually encoded, not by any influences of the actions during the recall phase.

The experiments, however, do not highlight any possible mechanisms that may underlie the observed effect. It is not clear whether the concrete touching influences the attention, the way of encoding, both, or something else.

Nevertheless, the observation that simple touching can influence the rate of memorizing of relatively abstract items seems promising for further investigations.

Acknowledgments

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