

# Analogical Episodes are More Likely to be Blended than Superficially Similar Ones

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## Abstract

The paper contrasts two cases of blending between episodes: blending of episodes that share a lot of elements and their properties (superficially similar episodes) and blending of episodes that are dissimilar at the surface level but share the same structure of relations. Classic theories and models of blending would predict that superficially similar episodes are more likely to be blended since there is a bigger overlap between the feature vectors representing them. In contrast, the AMBR model of analogy-making and memory predicts that analogical episodes are more likely to be blended. The data from the psychological experiment are in favor of the AMBR model: people blend structurally similar episodes much more often than superficially similar ones.

**Keywords:** memory, analogy; memory distortions (blending), psychological experimentation.

## Memory Distortions and the Possible Mechanisms of Memory Construction

If we vividly recall an episode of a romantic night in the mountains walking hand in hand in the snow and looking at the dazzling stars on the dark sky and talking about poetry and love we can ask ourselves “was this real?” or was I dreaming. If we want to spoil the illusion we can explore it carefully by asking our partner a variety of questions and comparing our memories for the event. Most probably, it will turn out that some of the details that we vividly remember are in fact not true, that we are blending various episodes and some of these details come from another occasion, e.g. another romantic night with the same partner walking on the beach rather than in the mountains. The detail itself is real and that is why it is so vivid, simply it is not from the same episode. The vividness of this recollection, however, makes us strong believers in this illusory memory. It is hard to accept that it was not true.

Much evidence has been collected that people do distort the real episodes and strongly believe in false memories. Sir Frederic Bartlett was the first one to demonstrate memory distortions (Bartlett, 1932) as result of using generalized schematic knowledge and using it for the reconstruction of the event. Loftus & Palmer (1974) provided additional evidence for the role of generalized schematic knowledge in constructing memories – they demonstrated that depending on the schema activated the events are reconstructed in different ways. Further on, Loftus and her colleagues (Loftus, 1977, 1979, 2003) have shown that people blend several events (like a slide show and a story) together, a real

episode and an imagined one, a personal experience and an advertisement, etc. In all these cases the participants in the experiments proved to be very unreliable eyewitnesses – they were picking elements from one episode and implanting it into another still believing they have perfect memory of the event. Neisser (1981) offered the case study of John Dean’s memory demonstrating a lot of inaccuracies. Later on Neisser and Harsh (1992) studied the so called “flashbulb memory” about a highly emotional event, in this case the incident with Challenger, and have shown that people wrongly recollected the events several years later (compared to their immediate memory which was collected at the time of the incident) and still believed they had vivid and accurate memories of the event and they were telling a lot of false details most probably taken from another event. Nystrom and McClelland (1992) managed to produce similar effects in the lab by causing people to blend sentences they have studied earlier. Deese (1959) and Roediger & McDermott (1995) demonstrated that people can wrongly recollect a word being in the list of studied words if it is strongly associated with many words in the list.

There is vast literature nowadays that supports and extends these findings with data from psychological experiments, brain imaging and brain lesion explorations, ecological autobiographical studies, etc. (Schacter, 1995, 1999; Moscovitch, 1995; Kokinov & Hirst, 2003).

There is, however, a problem. Since the time Neisser (1967) announced and formulated the constructive approach to human memory suggesting that memory is a constructive process rather than a storehouse, there are very few proposals how this construction can possibly happen. This lack of theoretical grounding of the experimentation makes the field moving forth and back in various directions without clear predictions and explanations.

Among the few existing memory models that can possibly explain and reproduce episode blending there are the CHARM model, proposed by Metcalfe (1990) with the explicit goal to explain Loftus’ data; the TODAM model, proposed by Murdock (1982, 1993, 1995), and the Complementary Learning and the Trace synthesis models, proposed by McClelland and his colleagues (McClelland, McNaughton, & O’Reilly, 1995, Nystrom & McClelland, 1992). Although quite different from each other in many respects, they share a common idea – the episodes are represented by feature vectors and if two vectors are very similar to each other an error can easily occur in recalling it. In TODAM and CHARM the errors are caused by the fact

that all memory traces are added up to a single memory trace and therefore if two traces are overlapping quite a bit then they interfere with each other and are distorted during the encoding process. The Trace synthesis model, and its cousin the Complementary Learning Model, on the contrary, explain the memory errors by a wrong activation pattern during recall. One potential problem is that all these models represent episodes as a list of features without internal structure, without relations among their elements. It may turn out that this is not a problem at all if the structure does not play any role in the memory distortion process.

However, some experimental data suggest that structure does play a role in the reconstruction process. Thus Kokinov and Zareva (2001) and Zareva and Kokinov (2003) demonstrated that blending can occur even between dissimilar episodes. This kind of very complicated blending is not explainable within the above models since the features representing the two episodes are very different and therefore the two memory traces will hardly overlap. These studies were provoked by a strange prediction of the AMBR model of analogy-making and memory (Kokinov, 1998; Kokinov & Petrov, 2001; Grinberg & Kokinov, 2003) that if two dissimilar episodes are connected to each other by a double analogy with a third one, these two episodes may become blended. The experimental studies cited above confirmed the prediction of the model.

Even though AMBR made a prediction that was experimentally confirmed and that is not easily reproducible in other models, AMBR still needs further experimental exploration. The double analogy blending is a very specific and complicated case that is not so easily observed in everyday life (although it should often happen since we often make analogies between remote domains and many of them with the same target, it would be difficult to dig it out and describe it).

Thus in the current study we are using much simpler material, which is much closer to our everyday life and would be easier to be traced. The idea is simple. Everyday we are learning hundreds of stories and we are experiencing thousands of events, some of these stories and experiences are highly similar on the surface (the same persons take place, the same objects are around us, the same properties of the objects are present, etc.) and therefore could be expected to correspond to highly similar feature vectors and thus the CHARM, TODAM, and CLS models will potentially predict that they are easily distorted by being blended with each other. On the other hand, AMBR would predict that those episodes that are structurally similar, even though they might be superficially dissimilar, will be more easily blended. In other words, if we see a remote analogy between two episodes that would be a greater force to blend them in memory rather than if they are merely the same but structurally different.

The main idea of the current experiment is to ask participants to study several stories, some of which are superficially similar but structurally different, and others are superficially dissimilar, but structurally similar, and then several days later to ask them to retell the stories and to see which of the stories will become more distorted, i.e. which pairs of stories will be more often blended.

## Experiment

The goal of this experiment is to explore and contrast various possible sources of intrusion in our memories for an event and more specifically whether analogical episodes play a special role in that. We would like to contrast superficially remote but structurally similar analogs to superficially similar but structurally dissimilar cases as possible sources of implanted memories.

### Hypothesis

Our hypothesis is that analogical episodes will be more probable sources of intrusions than superficially similar and than dissimilar ones.

### Design

The experiment has a within group design and the manipulated variable is the type of similarity between the target episode and the potential source of intruders:

- **Analogous episode:** an episode that is structurally isomorphic to the target but does not share elements with it.
- **Similar episode:** an episode that shares a number of elements with the target and, thus, is superficially similar to it, but which does not share the same structure, i.e. the relations between the elements are different.
- **Dissimilar episode:** an episode that shares neither elements, not relations with the target.

The dependent variable is the proportion of intruded elements when reconstructing the original target story.

### Procedure

Each participant read four stories and had to answer some general questions about their style and how intriguing they were. Three days later the participants were asked to retell the four stories in as much detail as they can. This was surprising to the subjects since they were not instructed to remember the stories. The participants were instructed that they would be paid proportionally to the amount of correct details they could recall from each story.

### Stimuli

The four stories (A, B, C, and D) were carefully designed in such a way that two pairs of them were structurally analogous to each other ( $A \sim B$  and  $C \sim D$ ), two other pairs were superficially similar, but did not share the same relational structure ( $A \approx C$  and  $B \approx D$ ), and finally the last two pairs were dissimilar both in terms of structure and surface ( $A \neq D$  and  $B \neq C$ ).

The superficial similarity was achieved by sharing some elements like the main characters (people vs animals), objects (bumbles, robins, falcons, etc), locations (old bridges), states (frightening), etc. These elements were *identical* in the two stories (compare the vertically aligned stories in Figure 1).

The analogical episodes did not share identical objects and locations, but they shared the same system of relations (the actions performed by the characters and the causal relations between them). The relations were rarely named

the same way, i.e. the same words were rarely used for the description of the action (to reduce superficial similarity),

simply the actions were similar and the causal structure – the same. See the horizontally aligned stories in Figure 1.

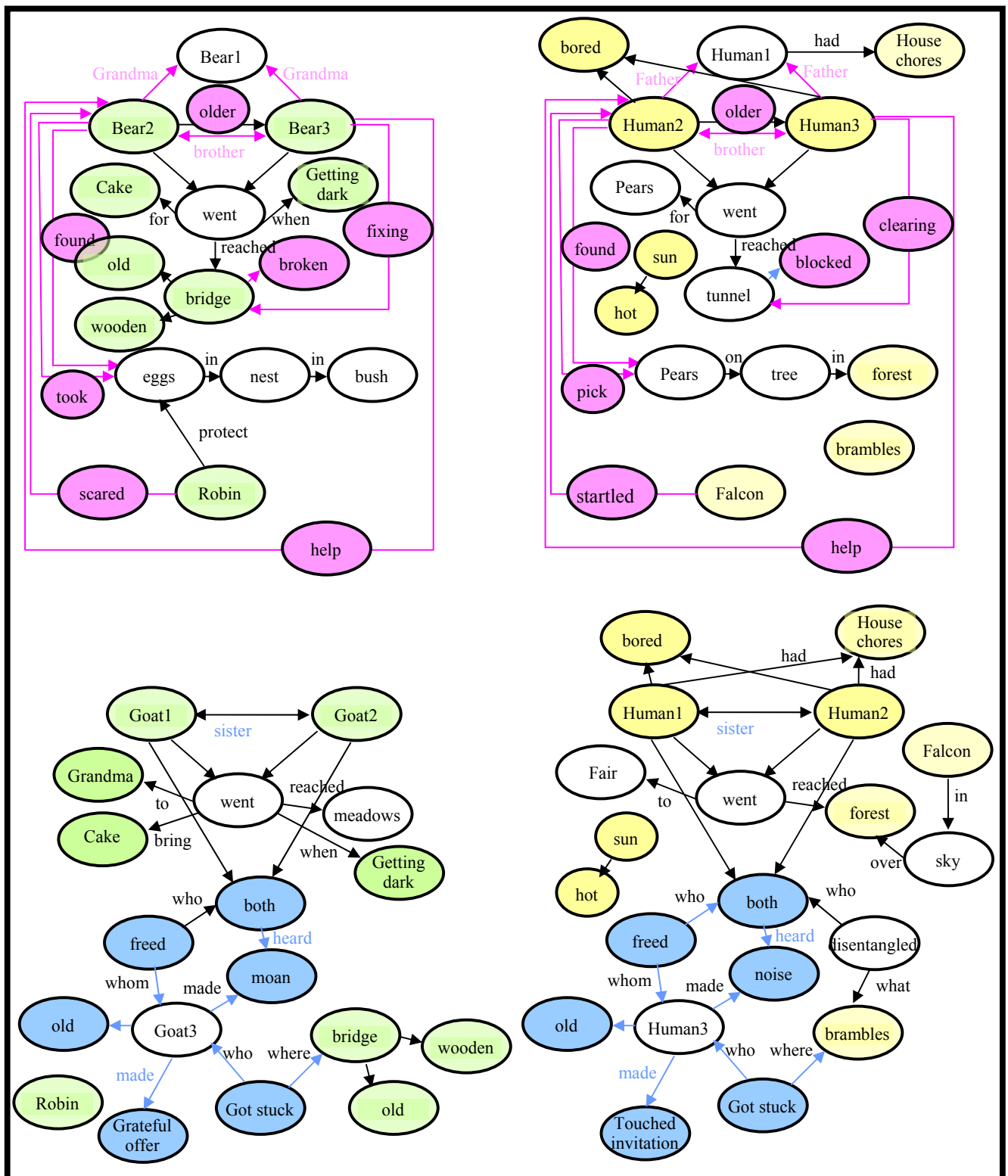


Figure 1. A schematic and abridged representation of the stories. The pink and blue colored elements are shared by the analogous stories (horizontally aligned), while the yellow and green ones by the superficially similar stories (vertically aligned).

The macro structure of the four stories is similar: in all four cases the main characters went somewhere with a goal in their mind, but were distracted by some event, they stopped to fix the problem and helped someone.

And here are the stories themselves.

#### ***Little Bear and Older Brother Bear***

Grandma Bear was sick and sent Little Bear and his Older Brother Bear shopping for products. She was going to make them a tasty cake, because they took loving care of her while she was getting better.

The little bears set off, but when they reached the old wooden bridge, they saw that some of the boards were broken. They could not continue onwards, so Older Brother Bear got down to work and started fixing the bridge. He needed to hurry because it was getting dark and their mother would be mad if they got home late, in the dark.

While he was waiting, Little Bear noticed a nest with eggs in the nearby bushes. He decided to take the eggs, so that they did not have to go to the shop for them. However, the mother robin turned out to be close by and started flying close to the ground near him, screeching in an attempt to protect her nest. Little Bear got scared and started crying.

The Older Brother Bear heard the sudden racket, ran to help him and saw Little Bear curled up under the fluttering bird. He rushed to protect his little brother and pushed him the bushes. After that, he hugged him and calmed him down.

#### ***The little brothers Bobby and Marto***

Lately Bobby's father had a lot of house chores and no time to pick the pear tree at the cottage. So, he decided to send Bobby and his brother Marto to pick the pears before they rotted. The children had nothing to do anyway; they could do something useful in this way.

The sun was shining hot and they decided to take the shady path through the forest. As they were walking, however, they reached a tunnel blocked up by stones. Marto started clearing the stones so that they could pass through.

Meanwhile, it occurred to Bobby that he could find some pears in the forest and tell their father that they had picked the pear tree. He went searching and soon saw a pear tree. He climbed the tree and started picking the fruit. Suddenly, however, a scared falcon appeared among the branches. It startled Bobby, who staggered and cried out in distress, but managed to hold on to a branch and hung onto it.

Marto heard the cry and ran towards him. He made his way through the brambles, climbed the tree and managed to help his brother. After they got down, Marto made sure that Bobby was all right.

#### ***The goat kids Lili and Mimi***

The goat kids Lili and Mimi had been walking all day in the colorful forest meadows. They were on their way to their grandmother, who was sick, and they were bringing her some tasty cake. However, it was beginning to get dark and they started worrying that they had got lost. They should have arrived at their grandmother's house a long time ago.

Suddenly, they heard a quiet moan coming from behind the nearby trees. They stopped and looked at each other in fear. However, they were good kids and could not just go on their way. They got nearer to where the noise was coming

from and heard a cry for help. They ran towards it and saw a goat that was stuck between the broken boards of an old wooden bridge and could not get free.

They helped the old goat and set him free. He was very grateful and offered to accompany them to their grandmother's house, since it was getting dark. So, the little kids and the goat continued on their way singing and laughing. A robin was fluttering around them and chirping together with them along the forest path.

#### ***The little sisters Ellie and Annie***

The little sisters Ellie and Annie were on their way to the nearby village, where the Annual Fair was. They had looked forward to this day because they had got bored staying in the village. They had nothing interesting to do and only house chores all day long.

So, the day came and they started on their way to the fair. It was a very hot day. The sun was shining hot and there was only a single falcon in the sky. The sisters decided to have a rest in the shade of the forest. As they were about to take off, they heard a noise. They looked at each other in wonder and tried to see where the noise was coming from. They made their way quietly and what did they see? An old woman had got stuck in the thorny bushes of the nearby brambles.

Ellie and Annie went to help her, carefully disentangled the bushes and freed the old woman. She was touched and in return for their good deed, invited them to spend the night at her place, since they had strayed from the road because of her.

### **Participants**

Our sample consisted of 29 participants (16 male and 13 female) who were paid for their participation in the experiment. They were students from NBU aged from 19 to 29 (average 24).

### **Results and discussion**

Each story was decomposed in advance into basic elements and each of these elements was labelled (A1, A2, ..., B1, B2, ..., C1, C2, ..., D1, D2, ...). The stories were roughly containing the same number of elements each (21-22). The stories recalled by the participants were recorded with a voice recorder and then transcribed. Then each protocol was blindly encoded by two independent experts – labelling each of the elements of each story with the unique labels listed above. Thus for each story we obtained a series of labels (e.g. A1, A2, B4, A5, A6, A7, C3, A15, A16, A21). If the sequence contains labels originating from two or more different stories this means that the participant has blended the two (three) stories. The specific measure that was used as dependent variable is the proportion of intruders within the whole list of recollected items in a specific story. In the example above we have 2/10 intruders and 8/10 correct responses. Again in the example above we have equal number of intruders from the analogical case (1/10) and the superficially similar one (1/10). Figure 1 shows the proportion of correctly and incorrectly recalled items from the stories. It turns out that there is a fairly high percentage (22.50%) of incorrectly recalled elements – intruders from

the other stories (intruders from sources other than the 4 stories were not encoded, so potentially the number of intruders could be even higher). In summary, almost one fourth of the elements were incorrect and a consequence of blended episodes. Please, take into account that even theoretically it is not possible to have more than 50% of intruders, since in that case the subject would be retelling the other story and the intruders will be again less than 50%.

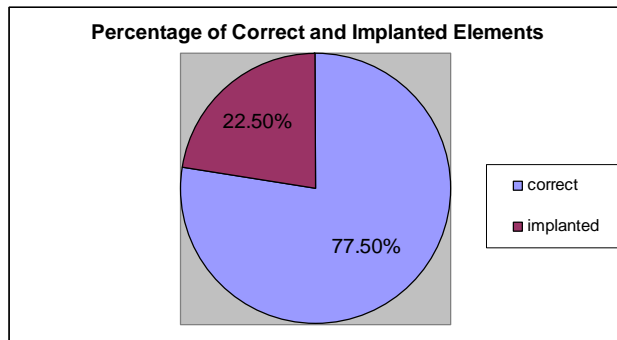


Figure 2. Amount of blending in the recall task after three days of retention interval. Almost one fourth of the recalled elements were incorrect and originating from another story.

Now the really interesting question comes: are the implanted elements randomly coming from various other stories as a kind of noise, or are they predominantly coming from the most similar episode (sharing characters, objects, locations), or from a more distant but analogous episode. The data are presented in Figure 3 and they are very clear. The result shows that the highest percentage of implants (15%) comes from the analogous story and they are double as much as the sum of the percentages of implants coming from the other two types of stories (7.5%). The main effect of the type of source story is significant [ $F(2,27)=13,285$ ,  $p<0.001$ ]. The only significant difference in the pair-wise comparison is between the analogous source and the other two sources [ $p<0.001$ ]. This is exactly what was expected.

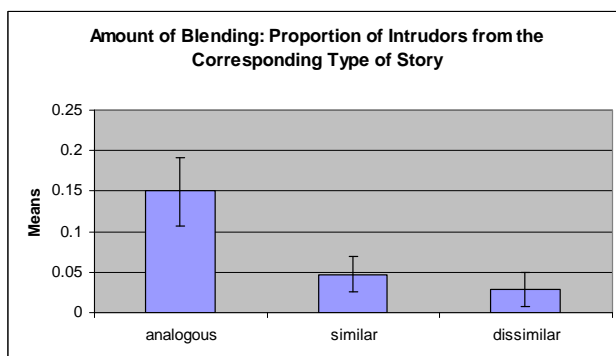


Figure 3. Amount of blending in the recall task after three days of retention interval. There is a main effect of the type of source story from which the implant came in [ $F(2,27)=13,285$ ,  $p<0.001$ ], and the only significant difference in the pair-wise comparison is between the analogous sources and the other two types of sources [ $p<0.001$ ].

## General Discussion

We contrasted two alternative types of explanation of where memory distortions come from and more specifically what are the mechanisms of memory construction that will more likely produce the type of blending errors that we often observe in human memory of past events. According to classic theories (such as interference theory) and classic models (such as CHARM, TODAM, Trace synthesis, CLS) blending occurs when two events are represented with highly similar vectors (there is a large overlap of the representing features) and as results of this the two vectors cannot be accurately disentangled and reconstructed. In contrast, the AMBR model views recall as reconstruction by analogy, i.e. a new episode is constructed analogous to the old one. In this construction process there is a competition between various elements originating from various episodes to be transferred over to the target question. Now, if two episodes are sharing the same structure than the competition is higher since each of the two sets of hypotheses will be strongly supporting each other. That is why the very existence of analogous episodes in memory results in greater possibilities for blending. In addition, when an analogy between two episodes is established in the past, this results in building permanent links between the episodes in LTM. This makes it even more probable that the two episodes will be activated together and therefore start to compete with each other. All these mechanisms predict that the higher the structural similarity between two episodes, the greater the chances of blending. Therefore, unlike classic theories, AMBR predicts that if all other chances are equal, it will be more probable to blend structurally similar episodes, even when they are semantically more distant, than superficially similar episodes.

The experiment presented in this paper tests this prediction and tries to tell apart and contrast the two alternative views. Four stories were constructed that would have equal number of similarities, but in one group of pairs the similarities will be more superficial (mainly similarities in the objects, their semantic categories, their properties, locations, etc., but also some similar relations, which, however, are not systematically bound into the same structure), and in the other group of pairs the similarities are mostly at the system level – the same structure of relations (including causal relations, actions).

The results from the experiment show that first of all, people do blend quite a lot the stories – almost one fourth of the produced story elements were incorrect and they were originating from one of the other stories. If we would take account of the elements originating from general knowledge or other episodes (learnt outside of the experiment) the results would be even more frustrating for those who believe in the accuracy of human memory. The second important conclusion from the experiment is that the structural similarity plays much more important role in human memory than all classic memory theories predict. People blend mostly elements from analogous episodes, and far less from superficially similar episodes. This is not to say that AMBR is a correct model of human memory, but it provides evidence that it was useful in predicting new memory phenomena.

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