Students' long-term memories from an ecology field excursion: Retelling a narrative as an interplay between implicit and explicit memories

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Available online: 15 Mar 2012
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This study aims to investigate the science content remembered by biology students 6 and 12 months after an ecology excursion. The students’ memories were tested during a stimulated recall interview. The authors identified three different types of memories: recall, recognition and narratives. The dual memory system model of learning was used to connect recall to the explicit memory system (declarative knowledge), and recognition to the implicit memory system (tacit knowledge). The results show that the students’ re-told narratives were scrambled and sometimes distorted. The students used small fragments to create their story and the next fragment of the story primarily depended on the antecedent unit. It is therefore suggested that in telling a narrative there is a constant interplay between the explicit (recall) and implicit (recognition) memory systems. The scientific terms (recall) were often replaced by everyday terms, indicating that the underlying meaning is not connected to the specific terms.

Keywords: long-term memories, ecology, narratives, implicit memory

On a sunny day in September, a biology teacher took his university students to the woods on an ecology field excursion. During the day he told them about birds, plants and the soil. In the afternoon the class stopped by a lake and the teacher discussed what had happened to the lake. This study aims to investigate what the students remembered of the excursion after 6 and 12 months, respectively. We have used the dual memory system model to make suggestions that could explain the underlying cognitive processes for remembering.

To our knowledge, there are only a few studies on students’ long-term memories from academic instruction. One example is Bahrick’s (1984) study, in which long-term memories of Spanish learned in school were investigated. Bahrick got two different results depending on the type of question: The first type was recall-questions such as “what is the Spanish word for boy?” Such memories had degraded within one to three years of study. The second type of question initiated a recognition process. The items posed had the character of multiple-choice questions, such as “which of these four words means boy in Spanish?” The memory for these kinds of items was associated with very long retention – up to 50 years – and was labelled “permastore.” Similar results have been replicated in other studies that have focused on...
long-term retention. For example, there are studies that show humans have a long-term retention ability with regard to recognizing people, although they are often unable to recall their names (Bahrick, Bahrick, & Wittlinger, 1975; Cleary, 2008). Furthermore, the retention for TV shows (Squire, 1989), past public events (Squire, 1974), and episodes from a movie (Furman, Dorfman, Hasson, Davachi, & Dudai, 2007) have all been tested in similar ways, which have generated the same results. The outcome of items testing for recall was a fast forgetting curve. In contrast, when a recognition process was used there was a slow decay in retention. Moreover, results indicate that subjects tended to recreate a story which appeared more coherent and consequential than the original one (Bartlett, 1932/1972, p. 66). Bartlett also showed that specific words in the story were sometimes replaced, for example “hunting seals” became “fishing”. When people retold stories the order of the events may have been scrambled or even forgotten (Bartlett, 1932/1972).

To conclude, if even motivated students will forget much of what they learn in school, this must be investigated further. In this study we suggest the use of a theoretical framework that could offer insight into students’ learning and memories.

Theoretical Framework

Dual-processing is a psychological model which implies that there are two different cognitive systems for reasoning, making judgments and social cognition (Evans, 2008). The essence of the model is that there is a distinct difference between rapid, automatic and non-conscious processes (implicit memory system) and slow and deliberate ones (explicit memory system). Additionally, neurophysiological research has identified two biologically separated memory systems in the human brain, namely the non-declarative and the declarative memory systems (Squire, 2004). Merging psychology and neurophysiological research allows for the idea of two separate systems for memory and learning to be strengthened: this is the dual memory system model (Björklund, 2007, 2008). Björklund has proposed the use of “implicit” and “explicit” memory systems as synonyms for Squire’s non-declarative and declarative systems. This proposal is also supported by neurological research on social cognition (Satpute & Lieberman, 2006).

The explicit memory system is characterized by dealing with what are traditionally referred to as facts, events, rules and labels in pedagogy and science education (Evans, 2008; Schilhab, 2007; Squire, 2004). It is possible to verbalize and communicate this explicit knowledge (Evans, 2008). Working memory, which is our conscious system, is associated with the explicit memory system (Sweller, van Merrienboer, & Paas, 1998). However, the explicit memory system is constrained by the limited capacity of working memory (Lieberman, Gaunt, Gilbert, & Trope, 2002; Marois & Ivanoff, 2005). Working memory may hold about four units at a time and the addition of any further units can lead to cognitive load (Cowan, 2000; Ross, 1969; Sweller & Chandler, 1991).

The implicit memory system deals with non-conscious knowledge (Berry & Dienes, 1993; Evans, 2008). Implicit memories are stored as multimodal sensory patterns of phenomena that we perceive, even non-consciously, in a specific situation – what we hear, feel, see and smell. Logan (1988) suggested that “subjects store and retrieve representations of each individual encounter with a stimulus” (p. 501). It is therefore feasible to suggest that each representation is stored in the implicit memory system as a unique holistic pattern (Björklund, 2008). The implicit memory system will constantly perform pattern-matching processes and when we re-experience a situation, the match will help us feel and act in the same way as we did the last time (Lieberman,
2000). Hence, we will experience a feeling of familiarity with the situation. Pattern matching is an automatic and rapid process which can impact behaviour directly without being constrained by the processing limitations of working memory. Since the use of implicit memories should be considered as knowledge that is “hidden” from the practitioner, it could be characterized as tacit knowledge (Björklund, 2008; Polanyi, 1966). Although the process of pattern matching is non-conscious, the implicit memory system may trigger a corresponding declarable label in the explicit memory system (see Figure 1) (Stolpe & Björklund, 2011).

The explicit and implicit memory systems have different retention properties. Explicit memories degrade quickly (Fleischman, Wilson, Gabrieli, Bienias, & Bennett, 2004). This may serve as one possible explanation of why recall items, which request a declarable answer, have a shorter retention (Tunney, 2003). Implicit memories have been shown to be long-lasting, and even lifelong (Dennis, Howard Jr, & Howard, 2006; Jenkins & Hoyer, 2000). This would imply that the feeling of familiarity, or recognition, is more long-lasting (Tunney, 2003). Our starting point for this study is that recall tasks require explicit memories, while recognition tasks call for implicit memories. Furthermore, it has been proposed that talking about something (for example conducting a lecture) could be described as a constant interplay between the implicit and explicit memory systems (Stolpe & Björklund, 2011). We would argue that this idea is applicable also to recounting a narrative. This study will further elaborate the interplay between the explicit and implicit memory systems. We have formulated the following research questions to frame the study:

Figure 1. The process of recall. Stimuli will be constantly matched in the implicit memory system. If there is a match (A) with an already experienced pattern, working memory will be activated. We will become conscious that we recognize the situation (B). The pattern matching process will also trigger the corresponding explicit knowledge (C). In this case, the corresponding explicit knowledge does exist as label 1 and hence we will become conscious about the label (D). We will be able to verbalize the label (E) (Stolpe & Björklund, 2011).
How can the dual memory system model be used to understand the cognitive process behind recognition?

Why do the students use different labels for the same phenomenon/object depending on the situation?

How is a sequence of utterances constructed to recreate a narrative?

Method

Sample and Data Collection

The data collection for this study commenced during an ecological field excursion which took place in southern Sweden during September 2009. A biology teacher at university level took his class to the woods as a mandatory part of an ecology course. At some points the excursion took on a character similar to that of a lecture, with the students gathering to note down points made by the teacher. At other points, the students were active in group work. The excursion related to classification of soil types, nature conservation, traces from the last glacial period, threatened species, and signal species. The class visited a forest, a clear-cut area, a Dystrophic lake, a peat bog and a pasture. The excursion lasted for nine hours, including coffee and lunch. The students included both prospective masters of biology (Lotta, Ingrid and Kristin) and upper secondary school biology student teachers (Tina and Eskil).

The excursion was recorded on video and audio. From the video, we identified 16 episodes which represented the entire excursion. Each episode was represented by a picture or a short film clip, and these were collated in a Power Point presentation. For example, one picture showed a flower and another the group standing on the shore. We also constructed an interview guide with questions for each slide. The initial question was open and neutral (“Could you please tell me something about this picture?”). We would define this as a recall question. Later on, the questions were more focused (“Do you remember if anything special happened here?” or “Do you remember what the teacher talked about?”). At this stage, the questions were still of recall character. Finally, if the student did not remember the situation or species at hand, a recognition question was posed. For example, “If I tell you that this is Ptilidium, is that familiar to you?”

Six months following the excursion, four female students and one male student volunteered to participate in a stimulated recall interview. The interview was a stimulated recall setting, where the Power Point presentation was used to trigger the students’ memories (Lyle, 2003). The interviews lasted between 45 and 60 minutes and were video recorded and fully transcribed. The overall analysis of the interviews showed that the students had forgotten much of what had happened during the excursion. However, the 6-month interview revealed two categories of outstanding memories. The first was spectacular events (the appearance of a fox) and the second was the teacher’s narrative by the lake. Twelve months after the excursion, the students participated in a follow-up interview. Three pictures related to the two categories of outstanding memories were selected as stimuli for this second interview, which was carried out by telephone for geographical and time-saving purposes, despite the danger of losing some information conveyed by body language. The interviewer called the student and as the conversation began, the interviewer e-mailed the student a PDF containing the pictures. The document was designed so that the student could view only one picture at a time. As in the first interview, the initial question about each picture was open and
neutral (recall); the questions became more specific as the interview proceeded. The interviews lasted for 10 to 15 minutes and were audio recorded and fully transcribed.

In addition to the stimulated recall interviews, the teacher’s narrative about the dystrophic lake was transcribed from the video of the excursion. A recent study by the present authors analysed the excursion with a focus on the teacher (Stolpe & Björklund, 2011).

**Data Analysis**

The 6-month interviews were analysed by looking for examples of the students recalling the name of a species or something about it, such as where the species lived or what kind of plant it was. In order to answer the first research question, we searched for examples of the students recognizing the species from the picture or recognizing its name.

To answer the second and third research questions, the narratives from the 6- and 12-month interviews were analysed by searching for units in the story. This is similar to the subset of a sentence, which Fletcher et al. (1990) term a clause. We defined a unit as the shortest utterance which carried meaning. A sentence may contain only one meaning-carrying unit (MCU), but is more likely to consist of several MCUs. The following quotation exemplifies a sentence which carries one MCU:

> It’s there, we are talking about those perches, or what it was, in that lake, I think.

We argue that the student said that “There were perches in that lake.” She made an association between the lake and the perches. In a second step, we transformed these MCUs into pictures. One picture represented one of the entities, in this case the perches, and the other picture represented the second entity, the lake. From our analysis, it turned out that each MCU could be represented in the form of two associated pictures. This approach made it possible to investigate the meaning of what was said, rather than the exact terms used. However, the quotation is of great importance since the pictures represent the underlying meaning while the uttered terms only appear in the quotation (see Figure 2).

By representing the transcribed interviews through these double pictures, the next step of the analysis comparing the 6-month and 12-month interviews was made easier, since we could leave the specific terms out of account. We tried to see whether the MCUs were represented in the first and/or second narrative given by the students.

**Results**

The results consist of two sections. In the first, empirical evidence is provided for the recall and recognition processes. Then the narrative is discussed: Firstly, the original

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<th>Pictorial representation of the MCU</th>
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<td><img src="image1.png" alt="Perch" /> <img src="image2.png" alt="Lake" /></td>
<td>It’s there, we are talking about those perches, or what it was, in that lake, I think.</td>
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*Figure 2.* A pictorial representation of the meaning-carrying unit together with the corresponding quotation given by the student.
Recall and Recognition

During the excursion the students learnt to identify different plant species. In the stimulated recall interview we exposed the participants to pictures or small video clips of some of the species. The results showed that there were instances in the 6-month interview where the students were able to recall the name of the species. For example, from the video clip where the teacher identified the moss *Ptilidium*, Eskil immediately remembered the name of the species:

Eskil: Was it *Ptilidium*?!
I: Yes, you remembered.
E: Yes, we have seen it many times.

We identify this process as a recall of the name of the moss. There were also occasions where the students were unable to recall the name. In the following example, Tina was shown a picture. The picture in itself could not help her to identify the species. However, as the interviewer provided more of the context to Tina, she started to recognize the situation and recalled that the plant was an orchid:

Tina: I’m not totally sure.
I: […] There is a hillock, or large rock covered with vegetation.
T: Mm, well on the hillock there were some orchids growing. […]
I: Do you remember its name?
T: No, actually I don’t.
I: Do you recognize… creeping lady’s tresses [*Goodyera repens*].
T: Creeping lady’s tresses, yes I recognize it.

The quotation shows that Tina did not recall the name of the orchid. However, as the interviewer revealed the name, Tina recognized the word.

The results indicate that two different ways of remembering were exposed by the students – recall and recognition. In the following section we will attempt to demonstrate how these processes interacted as the students retold a narrative. However, we will begin by describing the teacher’s original narrative.

The Teacher’s Original Narrative

In the early afternoon, following a walk, the class stopped at a small lake. The teacher talked about the chemistry and properties of the lake. After about twenty minutes, he told a narrative about the lake and its history. This narrative took up about six and a half of the total 30 minutes spent at the lake. A brief description follows:

More than ten years ago, there were plans to develop the lake into a “put-and-take-water” for tourists. First, the naturally acidic lake was limed. Secondly, rotenone was used to eradicate other fish, and then rainbow trout were put out. The consequences propagated in the food
web, a so-called trophic cascade. The ecosystem collapsed and today there are no fish in the lake at all. Human activities can have a devastating effect on ecosystems.

The teacher stressed the importance of learning about food webs before manipulating the environment. He concluded the narrative by summarizing his main points:

Teacher: I believe this is an elegant example [of] on the one hand... general madness, and on the other hand, trophic cascades and top-down control. If I poke at something up here, it will have effects throughout the whole system, even down to the phytoplankton, the level of primary production.

Narratives as They Were Told by the Students

This section aims to describe how the students constructed their narratives in the first and second interviews, respectively. In doing so, we present selected examples from the data. The MCUs which the students used as they retold the narrative were to a large extent represented in the original narrative told by the teacher.

In the first interview, Lotta discussed why the project at the lake was a failure. In the second interview, she spoke about the chain of events that led to this failure. There was a slight difference in what exactly she was talking about in the two interviews. However, one MCU was conserved in both interviews, namely that perches graze (Figure 3a:2; Figure 3b:4). There was also one MCU that had been preserved in its wide sense of meaning, but with its label replaced. The overall meaning that fish eat fish was conserved (Figure 3a:1, 2; Figure 3b:6); however, in the first interview *rainbow ate perch* and in the

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<td><img src="image" alt="Figure 3a" /></td>
<td>The rainbow [trout] ate the perches like that… and the roaches, like…</td>
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<td><img src="image" alt="Figure 3a" /></td>
<td>[the perches and the roaches] usually graze [plants]</td>
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<td><img src="image" alt="Figure 3a" /></td>
<td>and then [the lake] got overgrown</td>
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<td><img src="image" alt="Figure 3a" /></td>
<td>so it became… to little oxygen in it</td>
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<td><img src="image" alt="Figure 3a" /></td>
<td>and then [the lake] died.</td>
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*Figure 3a.* Data obtained from Lotta in the 6-month interview.
second interview the opposite was stated: *perches ate trout fries*. It is also worth mentioning that in the second interview the label had changed from *rainbow* to *trout*.

In the 12-month interview, Lotta hesitated as she talked about an increased pH level (Figure 3b: 3). It was not clear to her how she could continue the narrative. One interpretation could be that Lotta did not have anything to associate with an increased pH level. In this respect, Lotta faltered as she tried to continue the sentence. The first association that she made was *increase*. Next, a word which was associated with *increase* was *growth*, which was followed by *plant*. In Swedish, part of the word *tillväxt* (growth) is identical to the word *växt* (plant), in both pronunciation and spelling. Finally, Lotta delivered the utterance that aquatic plants thrived. In this case, one interpretation of this behaviour could be that the student “searched” for a way to continue her story. She began to talk about aquatic plants, and the narrative took a new turn. The teacher had not discussed pH level and its relation to aquatic plants.

The following example shows that the label used for the fish changed during the same narrative. When Eskil talked about the game fish in the first MCU (Figure 4:1) he used the label *rainbow*; when he mentioned it again, only a few moments later, he talked about the *char* (Figure 4: 5). However, the names of the fish shared some properties that were essential for the message. Maybe that common property was that both rainbows and chars are game fish. The teacher used the label *rainbow* in the original narrative. Furthermore, Eskil referred to a non-specified fish (Figure 4: 3). He remembered that the humans had exterminated some fish, but he could not recall the label of that fish. However, the fact that Eskil did not use a specific term for the exterminated fish indicates that this type differs from a game fish. Once more, it was not the species itself that was conserved, but the underlying meaning.

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*Figure 3b.* Data obtained from Lotta in the 12-month interview.
Some of the MCUs in Tina’s two interviews were similar, but presented in different orders (scrambled) (see lines 1–4 and 11, 12, 14, 15).

1. He told us a lot about the experiment to grow fish here,
2. that they had had, tried to poison away all...
3. [poison] all fish that they didn’t want. […]
4. so they had tried to put fish in
5. for all the German tourists that they could come there and pay for fishing,
6. if it was… trout that they wanted.
7. […] Because they had killed everything
8. so there were no circulation in the lake
9. [because there were no circulation in the lake] everything had died.
10. [Everything died] so it [the lake] are on its way to become overgrown.
   (Tina’s 6-month interview. Each line represents one MCU)
11. They had added poison
12. to kill those fishes
13. and it had worked in a way. However, there are still some [fish] left [in the lake].
14. And then they had put out those [fish],
15. but it hadn’t worked out well because there were no… because they had [added]
16. [poison which had] killed, so they had killed the insects [benthic fauna]
17. so those fishes [which normally eat benthic fauna]
18. didn’t get enough food [so they didn’t grow big enough]
19. because they didn’t reach that threshold where they could eat other fishes.
   (Tina’s 12-month interview. Each line represents one MCU)

There were also MCUs that were unique to the different interviews, which led the narratives to take different turns. In the first interview, human intervention led to the death of all animals, which caused the lake to become overgrown. In the second interview the fish were
still alive at the end of Tina’s story. However, since there were no insects (benthic fauna) in
the lake, the fish (rainbow trout) would not grow large enough for fishing purposes.

Moreover, some of Tina’s labels changed in the time between the interviews. In the first
interview, the label “trout” was uttered instead of “rainbow” (which was the term used by
the teacher) (line 6). Furthermore, it is interesting to note that Tina did not use any scientific
labels in her 12-month interview. She talked about fish that the humans tried to kill (line
12) and about the fish that were put out in the lake (line 14). In the first interview, she
also specified that the tourists were from Germany, even though the teacher did not
mention this in the narrative.

Discussion

The results of the study show that the students’ ability to remember depended largely on
how the questions were formulated. Eskil recalled the name of a moss from merely looking at
the picture (Figure 4). We suggest that Eskil’s implicit memory was triggered by the video
shown to him during the stimulated recall interview (Figure 1A). Furthermore, we propose
that a feeling of familiarity with an earlier encountered situation was evoked (Figure 1B).
However, the fact that Eskil was able to utter the name of the moss indicates that the knowl-
edge also existed in a declarative form. Declarative knowledge, such as species names, is
stored in the explicit memory system. We suggest that an implicit pattern matching may
trigger corresponding explicit knowledge – in this case, the name Ptilidium (Figure 1C).
Hence, such interpretation of the data exemplifies the interplay between the implicit and
explicit memory systems (Stolpe & Björklund, 2011). However, the results show that
recall of names was unusual, in accordance with earlier results on long-term retention
(Tunney, 2003). So what did the students actually remember from the excursion? The
results indicate that the students recognized names and pictures, even 12 months after the
excursion. Using the dual memory system model, we will now offer a description of the cog-
nitive process behind recognition.

Tina was not able to recall the name of the flower that she was exposed to during the inter-
view. However, as the interviewer told her the name of the flower, Tina said that she recog-
nized the name. In this regard, we propose that the uttered name of the flower had been stored
in the implicit memory system. As the name was spoken, a pattern match occurred, which
gave Tina a feeling of familiarity with the name (Figure 5). We would argue that she
showed confidence in the way she made her utterance. Research suggests that multimodal
patterns of encountered situations are stored in the implicit memory system (Björklund,
2008; Lieberman, 2000). When Tina reencountered a situation, the uttered word together
with the picture of the flower was matched against a pattern already stored in her implicit
memory system (Figure 5A). Given this reasoning, we would suggest that one possible expla-
nation for why Tina was unable to utter the name of the flower herself was that the knowledge
only was stored in her implicit memory system and was thereby tacit (Björklund, 2008;
Squire, 2004). Furthermore, it seems that Tina did not have any corresponding label stored
in the explicit memory system. These results support the fact that participants in earlier
studies may recognize even without being able to recall (Bahrick et al., 1975; Cleary,
2008; Furman et al., 2007; Squire, 1974, 1989).

Tina was not able to recall the name of the flower from the picture alone. However, when
the interviewer provided her with more information about the context by describing the
hillock on which the flower grew, a new pattern was matched in Tina’s implicit memory
system. In this case, we hypothesize that the implicit memory system triggered the label orchid, stored in the explicit memory system. Hence, she was able to recall a label for the flower. This result indicates that context is of importance for labels to be evoked. This is an important insight for teachers, especially in regard to the construction and evaluation of exams. It is important that teachers are aware that the question itself may function as a trigger for pattern matching in the implicit memory system. The more information the teacher provides in a question, the more likely it is that the student will be able to recall the label from the specific situation. This is due to non-conscious pattern matching of earlier encountered situations stored in the implicit memory system, which evokes the corresponding declarable knowledge in the explicit memory system. It is not the declarable knowledge in itself that is evoked. As Tina received further cues from the interviewer with which to reencounter the original context, the label orchid was evoked. In biology many different labels could be used for the same phenomenon. The label orchid is in one sense correct, even though the species name Creeping Lady’s Tresses would have been a more specific answer. We would suggest that different patterns could evoke the same label. Moreover, several labels could be connected to the same pattern, as is illustrated in the following example.

Eskil used two different labels for the game fish while retelling the narrative in the 12-month interview. In the first case Eskil referred to the game fish as rainbow (Figure 4:1). In correspondence to the former line of reasoning, the implicit pattern matching triggered the explicit label rainbow (Figure 1). Shortly afterwards, Eskil talked about the

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Figure 5. The process of recognition. Patterns will be constantly matched in the implicit memory system. If there is a match (A) with an already experienced pattern, we will become conscious that we recognize the situation (B). We are able to express a feeling of familiarity (C).
game fish once more, now using the label char (Figure 4:5). Similar results were found by Bartlett (1932/1972) who showed that terms in a narrative were replaced. In between these utterances, Eskil declared that some other fish had been eradicated from the lake (Figure 4:3). However, he did not remember the specific label of that fish. On one hand, this would indicate that the specific explicit label of that fish (which should have been perch) had disappeared. On the other hand the MCU that someone had taken away something triggered the explicit, more general, label fish. The fact that Eskil did not use one of the labels for game fish (rainbow or char) indicates that he has at least one more MCU representing fish in the lake, connected to this different context.

Our results indicate that scientific terms were replaced by everyday terms between the six and 12-month interviews. In Tina’s six-month interview she used specific terms like German tourists and trout. However, in the 12-month interview she referred to the tourists as they and the trout as fish. Furthermore, she used insects instead of the term benthic fauna, which was used by the teacher. This supports the results stated above, that explicit labels are forgotten. However, since there are several labels corresponding to each implicit pattern, those which are of everyday character will prevail. This means that the scientific labels that are not used frequently will disappear. We would suggest that even if Tina used a language which could be characterized as less scientific, the underlying meaning has been conserved. Since the underlying meaning seems to be more long-lasting than the explicit labels, we

![Diagram of the dual memory system](image)

**Figure 6.** The process of telling a narrative. The first steps are the recall process (A-E) (Stolpe & Björklund, 2011). The recall process results in an uttered label (E). The label is made available for a new pattern matching process (F) and a new recall process will begin. The patterns stored in the implicit memory system hold the meaning of the narrative and are meaning-carrying units.
suggest that the meaning is stored in the implicit memory system. To back up such a suggestion we need to look in more detail at the construction of the narrative.

We suggest that the reconstruction of a narrative could be described as a repeated recall process. A narrative is initiated when a stimulus, for example a question or a picture, is matched against a MCU in the implicit memory system (Figure 6A). This first pattern recognition results in an utterance (Figure 6B-E). In Lotta’s six-month interview, she said: “The rainbow ate the perches like that…” (Figure 3a). The utterance will become a new stimulus which evokes the next MCU via a pattern match (Figure 6F). A new label is triggered in the explicit memory system that enables Lotta to provide the next utterance: “and the roaches, like…” (Figure 3b). One consequence of this line of reasoning is that the antecedent utterance leads to the next one via pattern matching in the implicit memory system. The result is also supported by the findings by Fletcher et al. (1990), who suggest that there are causal connections between a new clause (MCU) and the antecedent. Our interpretation is that a narrative is based on a number of MCUs stored in the implicit memory system. As suggested above, every MCU could trigger several different labels. Consequently, a student may use unspecific labels in the narrative but nevertheless hold a coherent meaning of every MCU. MCUs are stored in the implicit memory system and will thereby be long-lasting. Students are able to recreate a narrative since they remember the underlying meaning of each MCU. However, the labels may change since they are stored in the explicit memory system and hence degrade more quickly.

In Lotta’s description of the increased pH level (Figure 3b: 3), she was not able to recall the specific entity which corresponded to the increase. This could be inferred from her falttering and hesitation during this part of the delivery. In her attempts to continue the narrative she went through several recall processes. The first recall process rendered the label increase. One MCU may have several corresponding labels and in this case, Lotta came up with a new label which, to her, has the same meaning: tillväx (growth). This utterance was used as the stimulus for the next pattern matching, which rendered the label väx (plant). We suggest that the word (tillväx evoked the MCU in the implicit memory, with the corresponding label väx in the explicit memory system. A change of label may lead the narrative to take a new turn, since it is always the latest label which functions as the stimulus in the recall process. These results in scrambled MCUs. The changed labels correspond to earlier research (Bartlett, 1932/1972).

Conclusions

We conclude that it is possible to evoke different types of memories by using recall and recognition questions, respectively. Furthermore, we suggest that the recall questions of labels and scientific words engage declarable knowledge that is stored in the explicit memory system. Explicit memories have been shown to last only a short time (Fleischman et al., 2004). Recognition questions employ tacit knowledge from the implicit memory system, a knowledge which is more long-lasting (Dennis et al., 2006). This answers our first research question, since we have described the cognitive process behind recognition using the dual memory system model. It may be possible to interpret our data from other theoretical perspectives; however we suggest that the dual memory system model may aid understanding of why certain episodes are remembered and not others. This will be the subject of future analysis.
In considering students’ memories of a narrative, we found that the retold narrative consisted of several fragments, which we termed meaning-carrying units (MCUs). A MCU was defined as the shortest utterance that still carried a meaning. However, our results indicate that the meaning was not carried by the specific terms themselves. Meaning could be preserved even though the labels had changed. The students changed more specific terms into more general ones between the six- and 12-month interviews. For example, the specific term perch was used less often than the general term fish. To answer our second research question, we suggest that since explicit knowledge has shown to be short-lived in comparison with implicit knowledge, this may indicate that the terms/labels are stored in the explicit memory system. Furthermore, since meaning is preserved even after 12 months, we suggest that MCUs are stored in the implicit memory system.

To answer the third research question, we suggest that the cognitive process behind the retelling of a narrative could be seen as several recall processes – a continuous interplay between the explicit and implicit memory systems. We suggest that the interplay is directed by pattern matching in the implicit memory system, which in turn triggers the corresponding label in the explicit memory system. An utterance may function as a stimulus which could be matched in the implicit memory system to find the next MCU (Figure 6). This means that a change of label may make the narrative appear scrambled and lead to a new conclusion. Labels can change depending on the specific situation, since the same MCU could evoke several different labels in the explicit memory system.

We suggest that one way to assess a student’s understanding is by asking them to deliver a narrative. As teachers, this is a way for us to evoke both implicit and explicit knowledge. When students recount a narrative it is possible to see in what way the MCUs fit together to form a meaningful whole. We propose that students who are able to use their MCUs to form different relevant narratives could be said to have an understanding of the content. However, we should also be aware that the specific terms are short-lived; hence we could neglect the exact terms used (if such terms are not the purpose of the study) and examine the underlying meaning. There are strong indications that the meaning is what the students will remember.

References


