https://doi.org/10.5194/gc-2020-20
Preprint. Discussion started: 15 June 2020

Remember rhythm and rime:
Memory and narratives in science communication

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'Every man's memory is his private literature'
Aldous Huxley

Abstract

To study how memorable different ways of presenting information are is fundamental task for science communication in order to evaluate materials that not only need to be understood by the general public, but also need to be retained in the long-term as a part of the communication process. In this paper I will give a brief introduction to cognitive psychology, the study of memory and the tasks used for measuring this. I will present theoretical evidence from the field of memory studies, which suggests that narratives represent a good recall device. I will also be discussing emotion as a way of focusing attention, promoting rehearsal in memory and inducing long-term potentiation. I will examine the use of stories as modelling tools that organise information, provide schemas and allow extrapolation or prediction. I will likewise show the value of stories as mnemonic devices. I will discuss memory as a context-dependent phenomenon, and as a cross-referencing system. Finally I will address the concept of memory span and paired associate recall and their implications in storing and recalling narratives.

1. Introduction

The question of how knowledge can be presented to the public in order to convey as much information as possible with a maximum of fidelity is a central one for science communication, (Dornan, 1990; Durant *et al.*, 1989). Memory is one possible way of

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assessing learning (Sternberg, 2003), and therefore of judging the successful communication of information. Studyng how memorable different text formats are, represents a fundamental task for science communication in order to produce materials that are not only expected to be understood by individuals but also stored in the long term memory.

Much of the information that we store in our memory is not acquired first hand through personal experience, but second hand, through reading or listening to other people talk about their experiences (Cohen, 1989). Memory for spoken information and memory for written information differ in important ways. Reading is a private and solitary occupation; it has no conversational context such as intention, intonation, gesture, facial expression, or personality of the speaker. Written material has to be much more formally structured and must conform to certain rules and formats to be intelligible to a wide range of potential readers.

In general, we remember meaning better than wording (Cohen, 1989). The general rule for narratives (short stories, drama, comics, novels, etc.) appears to be that the meaning, the gist, the most important and most relevant facts are preserved by the memory (Cohen, 1989). Almost any material becomes easier to remember if it is included in a narrative (Bruner, 1986; 1990). There are several factors concerning memory that make narrative a lasting structure, some of them related to the memory process itself and others to the intrinsic characteristics of narratives as a means of expressing information

2. Objective and methodology

The objective of this work is to provide a literary review of memory studies regarding narratives memorability.

In previous work (Negrete, 2009; Negrete and Lartigue, 2010; Negrete 2013; Rios and Negrete 2013; Negrete, 2014; Lartigue and Negrete 2016) I provided empirical evidence suggesting that narratives represent a memorable text format. In this opportunity my intention is to examine what has been reported in literature regarding features of the memory process that contributes to make narratives a memorable device. Although narratives have

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implications in short memory processes, I will concentrate on long-term memory, the most relevant features for science communication.

3. Literary review on memory studies

3.1 Cognitive Psychology

Cognition is a sub-discipline of psychology that studies how humans perceive, learn, remember and think about information (Sternberg, 2003). Memory is the means by which humans retain and draw upon past experience and use this information in the present (Tulving and Craik, 2000). It is the record of experience that underlies learning. Learning can be defined as a biological mechanism that permits us to face a changing world, i.e., it is a process by which long lasting changes in the behaviour potential take place as a result of experience.

In cognitive psychology three main memory operations are distinguished: (i) encoding, (ii) storage, and (iii) retrieval (Baddeley, 2000). Each operation represents a stage in memory processing. Through encoding the individual transforms sensory data into a form of mental representation; through storage, the encoded information is maintained in the memory and through retrieval, it is pulled out for use. Pioneer work by Tulving and Pearlstone (1966), as well as Murdock (1961), suggested that although encoding, storage, and retrieval phenomena are theoretically clearly defined, in practice they represent a considerable overlap and they are therefore too interdependent to allow for working with each as a separate unit.

3.2 Long-term Memory

There are different ways of encoding in long-term memory (LTM). Most information stored in long-term memory seems to be semantically encoded. There is evidence in early work on the area that other forms of encoding exist in long-term memory, such as visual encoding (Frost, 1972) and acoustic encoding (Nelson and Rothbart, 1972), but they play a minor role in relation to semantic encoding.

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Information from short-term memory is transferred to long-term memory depending on whether the information involves declarative (declarative knowledge refers to recalling facts) or non-declarative memory. Some forms of non-declarative memory like priming and habituation are ephemeral and dissipate rapidly; others such as procedural and conditioning are maintained for longer periods, especially when rehearsed. For declarative knowledge to enter into LTM, two main processes are involved: attention and association (of new information with previous knowledge and also of schemas). The process of integrating new information into stored information is referred as consolidation (Squire, 1986).

Retention and enhancement of memory during consolidation can be promoted with different meta-memory strategies (Koriat and Goldsmith, 1996; Metcalfe, 2000). These strategies involve a conscious act of reflection by rehearsing and organising (mnemonics) new information destined to stay in long-term memory.

3.2.1 Long-term Potentiation and Rehearsal

Every experience leaves a trace in the brain. Every experience is potentially a memory but only some traces seem to become permanently imprinted into brain tissue. Every experience – whether it is a real or perceived event, a thought, a feeling, a fragment of the imagination, or a recollection of a previous experience – involves the activation of a unique neural firing pattern (Maren, 1999). Some events produce strong and long-lasting patterns, which tend to recur continually. When connections are repeatedly activated, they form even more robust links, which bind them into a single unit: long-term potentiation (LTP). Research suggests that memories generated in this way (LTP) can last a lifetime (Barhrick & Hall, 1991).

Rehearsal is perhaps the simplest and most effective strategy that can be used in a memory task. It is an interactive process by which information in short-term memory is continually articulated or ‘refreshed’. Its importance is that it maintains information in short-term memory by ensuring a sufficiently high level of activation and it facilitates the transfer of information to long-term memory and subsequent retrieval by allowing additional time for more elaborate item processing (Dempster, 1981).

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3.2.2 Oblivion

Oblivion is defined as the decline of performance after learning. It occurs after a certain period. To measure it, researchers observe behaviour after a period in which the learned behaviour has not taken place (retention period).

There is some controversy about the effect that time has on oblivion. Some authors believe that time does not produce oblivion, as time is not an event in itself. Therefore there are other events that cause it. An experiment by Squire (1986) showed that oblivion follows a potential curve (Anderson and Pichert, 1978).

It is worth noting that oblivion occurs quickly when we learn lists of unrelated words or unsystematic items. In contrast, if the text is meaningful, it is more likely that we will remember it for longer periods. Previous knowledge (proactive knowledge) can also reduce oblivion. Pioneer work by Sir Frederick Bartlett (1932) showed that a story which was difficult to understand was made modern and comprehensible by participants thanks to proactive knowledge. In the geosciences context, it has been suggested that Myths (a form of narratives) help in reducing oblivion of geological hazards (flooding, eruptions and earthquakes) and this proactive knowledge has helped to create a culture of prevention in different human groups (Lanza and Negrete, 2007).

3.3 Emotion and Attention

Experiencing emotion provides a basis for simple learning and memory (Sternberg, 2003). Emotional learning and memory such as fear conditioning are simple forms of associative learning that supports the acquisition of knowledge; it is acquired rapidly and retained over long periods (Maren, 1999). An effect of emotional stimulation is to direct attention towards the events that provoked it. This attention in turn augments the brain activation associated with the event. Attention is effectively the first stage of laying down memory (Rupp, 1998).

Evidence shows that what distinguishes enduring experiences from those that are lost is that when they occurred they either created or coincided with higher than normal levels of

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emotion (Baddeley, 1997). It is clearly vital for humans to remember events that are emotionally arousing because they are likely to be important ones. They can be used to guide present and future actions. They can be used, for example, to avoid danger (as geological hazards) or to steer us towards a desirable outcome (O'Brien, 2000). Interestingly, the same neuro-chemicals that are released into the bloodstream to put the body on alert also instruct the brain to store a lasting record of the moment. This is the case for acetylcoline, noradrenaline, dopamine and glutamate, which all participate in the creation of links between neurons (Rupp, 1998).

Durability of a particular memory seems to depend on how exciting the original experience was (or how excited the individual's brain was when it occurred), how much attention was paid to it and how often it is recalled. In Lotman's words (1990), 'narratives are a way of expressing ideas and amplifying emotions'. If emotions are generated, then opportunities to concentrate attention and produce long-term potentiation are higher. Also, the possibility to rehearse the emotions is greater, since we tend to repeatedly remember passages that result from a meaningful or emotional experience.

3.4 Memory in Context and Knowledge Networks

According to Gough (1993), context is of paramount importance in order to understand memory process. No subject exists in isolation. Knowledge does not remain neatly compartmentalised into disciplines, but spills over and 'transgresses' boundaries. Everything that happens has a context, not only circumstances and surroundings but also internal states, emotions and physical feelings. If an event is laid down as a memory, some of its context is laid down with it and becomes a hook for remembering (Rupp, 1998). Contextual elements can be valuable aids to recall because when one part of a memory is retrieved, it often 'hooks out' all the others.

Memories that have similar connotations, forming links based on meaning, are called semantic links. Semantic links act like a cross-referencing system: once we have found a useful piece of information, we can connect it with many more that might also be relevant (Cohen, 1989). Memories that are formed simultaneously are linked by association. These

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associative links are fundamental to our understanding of the world and often allow us to make predictions based on previous experience (see also section on *Models and Schemas*). Most of the time, semantic and associative links work unconsciously: as soon as one concept is activated in memory, activation spreads automatically to other ideas related through meaning or past experiences.

3.5 Human Memory Systems

According to Tulving (1972), there are five major human memory systems: semantic, episodic, procedural, perceptual, representational and short term memory. There is reasonable evidence of the existence of the first two types: semantic and episodic memory. With the aid of semantic memory, individuals are able to register and store information about the world in the broadest sense (i.e. not personally experienced) and are capable of retrieving it. Semantic memory allows people to think about things that are absent to the senses at the time (Tulving 1972). Semantic memory is automatic, i.e., it does not require a conscious recollection. It develops earlier in childhood than episodic memory (Tulving 1972).

3.6 Episodic Memory

This is the type of memory used to remember events in our lives. Therefore, episodic memory is related to the self-experiences in subjective space and time. An episodic memory consists of memories that come from different areas of the brain that are bound together to create an 'episode', rather than a collection of impressions or items of knowledge. In contrast with semantic memory and other kinds of memory systems, in this case the individual is able to transport into the personal past and future at will (Tulving 2000). In times of crisis the individual is able to bring the past to the forefront in order to reinterpret the events of a lifetime.

Tulving (1966) pointed out that retrieving information from each memory system is associated with distinct memory awareness experiences. According to this author, when an individual uses episodic memory, he is conscious of remembering past experiences, whereas

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in the case of semantic memory, a person's conceptual knowledge is characterised by memory awareness involving feelings of familiarity or "just knowing".

Episodic memory is characterised by two aspects of temporal structuring: the location of the event in a specific past time in relation to the present and a temporal sequencing within the episode remembered (Nelson 1972). Both of these aspects rely on a sense of the "extended self" and apparently the role of autobiographic memory is to provide a sense of continuity of the self across time from past to future (Nelson 1972).

There is a strong link between episodic memory and emotions. The way in which memories are formatted determines their emotional significance and the retrieval pathways to other episodic memories. Earlier experiences tend to be recalled from a third person's point of view (i.e. as an observer), while more recent events are usually recalled from the first person's point of view (i.e. as a participant). Emotions are usually stronger when memories are recalled from a participant's point of view, while the observer's point of view tends to be more objective.

3.7 Mnemonics

Before the invention of writing, and long afterwards in many cultures, stories were sung or recited from memory. Rhythm, rhyme and melody were used to provide a framework that aided in their memorisation. Mnemonics was one method employed to aid recitation from memory. It is defined as the art of improving memory, or a system to aid the memory, i.e., any strategy that helps people remember. It normally means signals for learning that will later induce the experience to be remembered.

In Yates' view (1992), a feature of Cosmas Rossellius´s book (*Thesaurus artificiosae memoriae*) are the mnemonic verses given to help memorize orders of places in Hell, or the order of the signs of the zodiac. These verses were written by Dominican inquisitor. These carmina by the Inquisitor constitute an interesting example of the use of artificial memory via mnemonics (Yates, 1992).

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According to Lotman (1990), mnemonics can be seen as a way of internal communication that is made up of messages to the self with the purpose of retaining information and includes different sorts of memoranda and reminders. Essentially, such reminder devices add meaning (or personal meaning) to otherwise meaningless, unrelated or arbitrary lists of items for the individual. Mnemonics superimposes an artificial, logical structure (which can be seen as a model) on data, which is not necessarily related. A mnemonic device can be an image, an acronym, a verse, a peg word, a catch phrase or a story that helps us to remember (Luria, 1986).

Most of the world's great religions have strong oral traditions in which sacred texts are memorised in their entirety for prayer and to preserve them for posterity. For example, in the *Mishna*, the Jewish written record of the oral law, some literary resources such as metaphors, digressions and poetic images can actually be viewed as mnemonic aids. The *Qur'an* also contains mnemonic aids. This religious book was written both as a work of rhythmic prose and as an epic poem; thus, rhythm, rhyme, and meaning connect every word making it memorable (Luria, 1986).

3.8 Memory Span and Paired Recall Association

In early work in this area, Dempster (1981) defined memory span as the maximum length of a series of words, images or items that can be reproduced at different stages in time. One of the most practical and important implications of memory study is in education. As short-term memory span is indicative of overall intellectual ability it can be used as a diagnostic tool both for helping educators (and communicators) to adapt teaching (and learning materials) to the specific needs of the learner and for measuring improvements in intellectual ability Dempster (1981). Higher spans are the result of grouping and organisation (Estes, 1974). Organization, in turn, is one of the key elements of paired recall association.

Pioneer work by Epstein, Rock and Zuckerman (1960), suggested that when two objects have been perceived or imagined to be interacting, recalling the name of one, in response to the

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name of the other, is more frequent than when the objects have been perceived or imagined to be side by side. This effect in memory is called paired recall association. As a result of the relationship between two objects, they develop certain properties and interactions. A relation or interaction constitutes a feature that characterises both objects, which enables the individual to retrieve one when the other is provided (Wilton, 1989).

When words are used as units of meaning, the semantic components of the words are activated (Wilton, 1990). If two words are associated semantically, this assures that common structures are activated in that task. Therefore, in the search for recall, the items to be recalled are found together. On the other hand, when words are used as a collection of symbols without semantic meaning, the common structures are not activated and recall is disorganised.

3.9 Models and schemas

Memories are not simple records of past events. Memories are, in fact, reconstructions or models of what occurred (Baddeley, 1997). Models and schemas (abstract, content-free information about certain structure) are useful to organise knowledge acquired in previous experiences, to fill in gaps in memories, to make educated guesses about things that are not remembered fully and to extrapolate on those that are not known but where there is a previous knowledge that allows it.

3.9.1 Story schemas

One of the earliest studies of memory and narratives was carried out by Frederic Bartlett (1932). Unlike many psychologists of his day, Bartlett recognised the need to study memory retrieval with connected texts rather than studying unconnected strings of digits, words or nonsense syllables. He introduced the idea that schemas, or mental frameworks, built up from prior knowledge and experience, are influential in determining and shaping the memory of a story. His experiments consisted in presenting an indigenous, North American story called *The War of Ghosts* to a group of participants in Britain. Bartlett found that his participants distorted their recall to provide a story that was more comprehensive to them. Their previous

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knowledge and expectations had a substantial effect on their recollection. In so doing, Bartlett developed the idea that in memory tasks, we use our already existing schemas, which affect the way in which we recall and learn.

During the decade of the 1970s, Bransford and Johnson (1973) challenged the idea that schemas work at retrieval stage. They constructed texts that described a situation in such a way that the reader was unable to understand its meaning unless some clues were provided. The researchers suggested that when new information cannot be related to an appropriate schema, very little is remembered. Other researchers found similar results in comparative experiments of prose retention (see Dooling and Lachman, 1971).

Today two kinds of schemas are distinguished: event schemas and story schemas. Event schemas consist of knowledge about the subject matter of the story (Cohen, 1989). For example, the event schemas activated in remembering *The Man Who Mistook His Wife for a Hat* by Oliver Sacks might include knowledge of psychiatric hospitals, self-identity, physiology of the brain, sensory ghosts, disembodiment, or autism. Story schemas consist of abstract, content-free knowledge about the structure of a typical story.

3.9.2 Models

According to the classical work by Giere (1979), models can be classified into three categories: scale models that represent reality to a particular scale; analogue models which are useful for understanding other proposed new models; and theoretical models, the most abstract form of a model as they are imaginary and often explained with analogical models.

In Casti's (1993) view, models can serve three purposes: they can be predictive, explanatory and prescriptive. Prescriptive models give us the opportunity not just to explain or predict but also to manipulate some aspect of the world through 'handles' on the model (*op.cit.*).

Casti (1993) compares modelling with painting and other artistic disciplines. When an artist paints, he never creates on canvas the exact image of the subject in front of him. Instead he

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tries to capture the essence of meaningful characteristics so that the viewer is able to know more about the object painted than from looking at the real thing. In this sense the object art (paint, sculpture, music, or literature) shows hidden characteristics by using magnifying glasses, special lights, tones, rhythms or narrative resources. Giere´s (1979) and Casti's (1993) arguments claim that stories can be seen as narrative models that has the power to explain, the capacity to show scale, an ability to predict the future, to produce analogies and metaphors as well as to theorise.

Yuri Lotman (1977) suggested that semiotic systems are models that explain the world in which we live. Amongst all semiotic systems, language is the primary modelling system in which we apprehend the world by means of the model that it provides. Myth, cultural rules, religion, paint, music, literature (narratives) and science are secondary modelling systems. All of them are of equal interest as models to understand and talk about the world.

In Johnson-Laird's (1983) words: '. . . stories are represented as mental models in the reader's mind". To construct a mental model of a story is to imagine what was happening in the narrative. A mental model is a global representation that integrates information from different parts of the story. It is constructed as the story unfolds, and represents the scene, characters, and events, incorporating spatial, temporal, and casual relations (Johnson-Laird, 1983). Mental models have the intuitively appealing feature of treating memory for stories and memory for real-world events as essentially the same (Yates, 1992).

Narratives as mnemonic devices for Science Communication

In the previous section I provided a literature review on memory studies supporting the idea that narratives represent a memorable structure. In the following part I will summarise these findings and highlight their importance for Science Communication.

There are three important moments for Long Term Potentiation (long lasting memory): attention, emotional response and rehearsal (see section 3.2.1). It is interesting noting that a typical oral joke (normally the narrative of something funny happening to somebody)

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concentrate these tree elements. When someone is going to tell a joke people pay “attention” to the speaker. If the joke is good, they“laugh” (emotional response). Hours later or even the next day, when people remember the joke, they will laugh probably again (rehearsal). That is the way people learn the jokes and reproduce them with friends and colleagues. The joke has a precise structure in order to be funny. It is interesting how we are able to remember such structure with remarkable fidelity so we are able to retell the joke with the precision required to make people laugh. Humorous narratives should be considered as an important resource for science communication as they represent a tool that can induce Long Term Potentiation by promoting attention, emotional response, and rehearsal.

A story can be seen as an expressive device that by means of a plot associates characters, situations, places, and information to produce semantic links and a cross-referencing system that can assist in storing and retrieving information in, and from, memory (see section 3.4). Following this line of argument, it would be plausible that stories represent a means of increasing memory span, a way to facilitate retrieval from memory by paired recall association and a powerful device to convey science to the general public in a long lasting way (see section 3.8).

Narratives offer information that is contextualised in real-life situations (episodes). When an episode in a narrative work evokes emotion in the reader, this incident may become memorable. Fictional narratives provide the opportunity to create episodes (see section 3.6). If the narrative episode evoke emotions and part of it contain science, then it would be reasonable to expect that information contained in it (included science) will form a lasting memory.

Narratives can be seen as mnemonic structures that superimpose an artificial, logical structure on data which is not necessarily related (see section 3.7). In this way scientific factual information can be communicated by being embedded in a mnemonic structure (the story) which facilitates future recollection.

For science communication, one of the advantages of stories schemas is that the majority of people have been exposed to them since childhood in such forms as religious instruction,

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drama, or reading fictional literature. Therefore it represents a widespread and well-established knowledge held by the general public that can be used, without previous instruction, to the benefit of popularisation of science.

Finally, narratives can also be seen as secondary modelling systems in which information is represented and organised by means of a plot (see section 3.9.2). This enables us to make sense of reality and prepare information in an organised structure ready for future recall. Stories can be seen as narrative models as they depict the model which has the capacity to explain. For example in *Carbon* by Primo Levi (1985), the capacity to show scale as in *The Crabs Take Over the Island* by Anatoly Dnieprov (1966), an ability to predict the future as in *The Time Machine* by H.G. Wells (1895), or to produce analogies and metaphors as in *Flatland* by Edwin A. Abbot (1884) and to theorise as in Italo Calvino's *Cosmicomics* (1969). Again, needless to say, a great opportunity for science communication to use a powerful tool (narratives) to communicate science.

Final note

The evidence from literature that I have exposed in this paper, together with empirical work that I published in previous work (Negrete, 2009; Negrete and Lartigue, 2010; Negrete 2013; Rios and Negrete 2013; Negrete, 2014; Lartigue and Negrete 2016) suggest that narratives represent an interesting tool for science communication to convey science not only in an attractive and reliable format, but also in a memorable way.

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Bibliography

Anderson R.C. & Pichert, J.W.: Recall of previously unrecallable information following a shift in perspective, Journal of Verbal Learning and Verbal Behaviour, 17**,** 1-12, 1978

Baddeley, A.D.: Human memory: theory and practice, Minneapolis: Alyn & Bacon, USA, 1997.

Baddeley, A.D.: The episodic buffer: A new component of working memory. Science-Fiction Studies, 4, 417-423, 2000.

Bartlett, F.C.: Remembering: a study in experimental and social psychology. New York: Cambridge University Press. USA, 1932.

Bahrick, H.P. and Hall, L.K.: Lifetime maintenance of high school mathematics contents. Journal of Experimental Psychology 120 (1), 20-33, 1991.

Bransford, J.D. and Johnson, M.K.: Considerations of some problems of comprehension, In: Visual information processing, edited by Chase W.G., Cambridge Academic Press, 1973.

Casti, J.: Be worlds would, John Willey & Sons Inc., New York, 1993.

Cohen, G.: Memory in the real world, Lawrence Erlbaum Associates Ltd, London, 1989.

Dempster, F.N.: Memory span: sources of individual and developmental differences. Psychological Bulletin 89 (1), 63-100, 1981.

Dornan, C.: Some problems of conceptualizing the issue of 'science and the media, Critical Studies in Mass Communication 7, 48-49, 1990.

Dooling, D.J. and Christiaansen, R.E.: Episodic and semantic aspects of memory for prose, Journal of Experimental Psychology, 3, 428-436, 1977.

Dooling, D.J. and Lachman, R.: Effects of comprehension on retention of prose, Journal of Experimental Psychology 88, 216-222, 1971.

Durant J. R., Evans, G. A. and Thomas, G.P.: The public understanding of science, Nature 340, 11-14, 1989.

Epstein, W., Rock, I., and Zuckerman, C.B.: Meaning and familiarity in associative learning. Psychological Monographs: General and Applied 74, 1-22, 1960.

Estes, W.K.: Learning theory and intelligence, American Psychologists 29, 740-749, 1974.

https://doi.org/10.5194/gc-2020-20
Preprint. Discussion started: 15 June 2020

Frost, N.: Encoding and retrieval in visual memory tasks. Experimental Psychology, 9, 317-326, 1972.

Giere, R.: Understanding scientific reasoning, The Dryden Press, Sunders Collage Publishing, New York, 1979.

Gough, N.: Laboratories in fiction: science education and popular media, Geelong: Deakin University, Australia, 1993.

Hyde, T. and Jenkins, J.J.: Differential effects of incidental tasks on the organization of recall of lists of highly associated words, Journal of Experimental Psychology, 3, 472-481, 1969.

Johnson-Laird, P.N.: Mental models, Harvard University Press, USA, 1983.

Kintsch, W. and Van Dijk, T.A.: Toward a model of text comprehension and production. Psychological Review, 85(5), 363-394, 1978.

Koriat, A. and Goldsmith, M.: Monitoring and control processes in the strategic regulation of memory accuracy. Psychological Review, 103, 490-517, 1996.

Lartigue C. Negrete A.: Photocomic Narratives as a Means to Communicate Scientific Information about Use, Treatment and Conservation of Water, Modern Environmental Science and Engineering, 2, 800-808, 2016.

Lotman, M.Y.: Primary and secondary communication-modeling systems, In: Soviet Semiotics, edited by: Lucid D.P., John Hopkins University Press, USA, 1977.

Lotman, M.Y.: Universe of the mind. A semiotic theory of culture, Indiana University Press, USA, 1990.

Luria, A.R.: The Mind of the mnemonists, Harvard University Press, USA, 1986.

Nelson, T.O. and Rothbart, R.: Acoustic savings for items forgotten from long-term memory, Journal of Experimental Psychology, 93, 357-360, 1972.

Maren, S.: Long-term potentiation in the amygdala: a mechanisms for emotional learning and memory, Trends in Neuroscience, 22, 561-567, 1999.

Metcalfe, J.: Metamemory: theory and data, In: The Oxford handbook of memory, edited by Tulving E. and Craick M., Oxford University Press, New York, 197-211, 2000.

Murdock B.B.: Short-term retention of single paired-associates, Psychological Reports, 8,280-289, 1961.

https://doi.org/10.5194/gc-2020-20
Preprint. Discussion started: 15 June 2020

Negrete A.: So what did you learn from the story? Science communication via narratives, VDM Verlag & Co, Germany, 2009.

Negrete, A. and Lartigue C.: The science of telling stories: Evaluating science communication via narratives (RIRC method), Journal of Media and Communication Studies, 2(4), 98-110, 2010.

Negrete A.: Constructing a comic to communicate scientific information about sustainable development and natural resources in Mexico, Social and Behavioral Sciences, 103, 200 – 209, 2013.

Negrete A.: Tell me how much science you can tell: the RIRC method, Lambert Academic Publishing. Germany, 2014.

O´Brian, L.: Learn to remember, Duncan Baird Publishers, New York, USA, 2000.

Rios and Negrete.: The object of art in science: Science communication via art installation, Journal of Science Communication, 12(03), 1-18, 2013.

Rupp, R.: Committed to memory, Aurum Press Ltd, New York, USA, 1998.

Squire, L.R.: Mechanisms of memory, Science, 232(4758), 1612-1619, 1986.

Stenberg, R.J. : Cognitive psychology, Thomson Wadsworth, New York, USA, 2003.

Tulving, E. and Pearlstone, Z.: Availability versus accessibility of information in memory for words, Journal of Verbal Learning and Verbal Behaviour 5, 381-391, 1966.

Tulving, E.: Episodic and semantic memory, In: Organization of memory, edited by Tulving E. and Donalson W., New York Academic Press, New York, USA, 1972.

Tulving, E. and Craick, F. I.: The Oxford handbook of memory, Oxford University Press, New York, USA, 2000.

Wilton, R.N.: The structure of memory: evidence concerning the recall of surface and background colour shapes, Quarterly Journal of Experimental Psychology, 41A, 579-598, 1989.

Wilton, R.N.: The mediation of paired associate recall by representation of properties ascribed to objects in perception and imagination, Quarterly Journal of Experimental Psychology 42A, 611-634, 1990.

Yates, F.A.: The art of memory, London: Pilmico Press, UK, 1992.