

1 **Remember rhythm and rhyme:**

2 **Memorability of narratives for science communication**

3 Aquiles Negrete

4 Centro de Investigaciones Interdisciplinarias en Ciencias y Humanidades

5 CEIICH-UNAM

6 aqny@unam.mx

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8  
9 *'Every man's memory is his private literature'*

10 Aldous Huxley

11  
12 ***Abstract***

13 Once upon a time narratives were considered to be a non-reliable way of representing and  
14 communicating science. Nowadays, narratives are widely accepted as an accurate way of  
15 conveying science, they represent an effective emotional trigger, a lasting memory structure  
16 and a powerful aid for learning. To study how memorable different ways of presenting  
17 information are is a fundamental task for science communication in order to evaluate  
18 materials that not only need to be understood by the general public, but also need to be  
19 retained in the long-term as a part of the communication process. In this paper I will give a  
20 brief introduction to cognitive psychology and the study of memory in relation to narratives.

21  
22 Evidence from the field of memory studies suggests that narratives represent a good recall  
23 device. They can generate emotion and this in turn is a way of focusing attention, promoting  
24 rehearsal in memory and inducing long-term potentiation. Similarly, a story produces  
25 semantic links that might assist in storing and retrieving information from memory. Studies  
26 suggests that memory span and paired associate recall have implications in storing and  
27 recalling narratives. Evidence also suggests that the use of stories as modelling tools can  
28 organise information, provide schemas and allow extrapolation or prediction. Finally  
29 literature on memory suggests that narratives have a value as mnemonic devices.

31 **1. Introduction**

32

33 The question of how knowledge can be presented to the public in order to convey as much  
34 information as possible with maximum fidelity is a central one for science communication,  
35 (Dornan, 1990; Durant *et al.*, 1989). Memory is one possible way of assessing learning  
36 (Sternberg, 2003), and therefore of judging the successful communication of information.  
37 Studying how memorable different text formats are, represents a fundamental task for science  
38 communication in order to produce materials that are not only expected to be understood by  
39 individuals but also stored in the long-term memory.

40

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

48

49 In general, we remember meaning better than wording (Cohen, 1989). The general rule for  
50 narratives (short stories, drama, comics, novels, etc.) appears to be that the meaning, the gist,  
51 the most important and most relevant facts are preserved by the memory (Cohen, 1989).  
52 Almost any material becomes easier to remember if it is included in a narrative (Bruner,  
53 1986; Bruner 1990; Crowley, 2018; ElShafie, 2018). There are several factors concerning  
54 memory that make narrative a lasting structure, some of them related to the memory process  
55 itself and others to the intrinsic characteristics of narratives as a means of expressing  
56 information.

57

58 **2. Objective and methodology**

59

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

62 In previous work (Negrete, 2009; Negrete and Lartigue, 2010; Negrete 2013; Rios and  
63 Negrete 2013; Negrete, 2014; Lartigue and Negrete 2016) we provided empirical evidence  
64 suggesting that science can be communicated and learned through narratives and that this  
65 represents a more enjoyable way of learning compared to traditional texts. In particular, we  
66 found that narrative information is retained for lengthier periods than factual information in  
67 long-term memory. Our evidence suggested that narratives constitute an important means for  
68 science communication to convey information in an accurate, memorable and enjoyable way.

69  
70 In this opportunity my aim is to examine what has been reported in literature regarding  
71 features of the memory process that contributes to make narratives a memorable device.  
72 Although narratives have implications in short memory processes, I will concentrate on long-  
73 term memory, the most relevant features for science communication.

### 74 75 **3. *Narrative representation***

76  
77 A dominant model of rationality implies a single type of discourse, one that puts forward  
78 hypotheses, reported evidence and systematically inferred conclusions. Stories, in contrast,  
79 frequently carry the connotation of falsehood or misrepresentation (Bruner 1986). However,  
80 several authors acknowledge that many scientific and mathematical hypotheses emerge as  
81 little stories or metaphors. In Howard's view (1991) there is a relationship between science  
82 and storytelling. This author considers, for instance, that science represents an example of  
83 constructing meaning through storytelling.

84  
85 Bruner originally proposed two modes of cognitive functioning: paradigmatic and narrative.  
86 Each provides a different way of organising experience, constructing reality and  
87 communicating knowledge. They are, at the same time, complementary and irreducible to  
88 one another. While paradigmatic knowledge is focused on what is common among items,  
89 narrative knowledge focuses on the particular and special characteristics of actions. Human  
90 action is the result of the interrelation of previous learning, experience, present and future  
91 expectation. While paradigmatic knowledge is carried in individual words that name a  
92 concept, narrative knowledge is maintained in stories with plot. Storied memories retain the

93 complexity of the situation in which an action was undertaken, and the emotional and  
94 motivational meaning connected with it. The collection of storied experiences provides a  
95 basis for understanding new action episodes by means of analogy (Amos and Wisniewski  
96 1995).

97

98 Narratives can take different forms. Among the different types of narratives, parables and  
99 myths have a particular interest for science communication. Both are aids in understanding  
100 difficult concepts. Although the latter may not match our current sense of reality, they can be  
101 used in science communication to analyse the values and limits of scientific knowledge  
102 (Blades 2001). Also science fiction is of paramount importance in science communication as  
103 it is the literary genre most frequently used to represent, explore and play with science.  
104 Science can be used as the subject of the narrative, as the basis for the plot, as a background  
105 or setting, or even as a metaphor (Willis 1998). Science fiction represents a valuable tool for  
106 science education (Gough, 1993 and Appelbaum, 1995) and communication.

107

108 For this work a narrative is a particular type of discourse production, in which events and  
109 actions are assembled in an organised unity with the help of an intrigue (Connelly and  
110 Clandinin, 1990). Narrative texts answer the question “What happened?” Characters, events  
111 and plot exist in a world where time goes by (Amos and Wisniewski, 1995). According to  
112 the cognitive model, narratives can be seen as memory enhancing devices (Atkinson and  
113 Shiffrin, 1971).

114

#### 115 **4. *Literary review on memory studies***

116

##### 117 **4.1 Cognitive Psychology**

118

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

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

133

#### 134 4.2 Long-term Memory

135

136 There are different ways of encoding in long-term memory (LTM) (Stenberg, 2003; Crowley,  
137 2018). Most information stored in long-term memory seems to be semantically encoded.  
138 There is evidence in early work on the area that other forms of encoding exist in long-term  
139 memory, such as visual encoding (Frost, 1972) and acoustic encoding (Nelson and Rothbart,  
140 1972), but they play a minor role in comparison to semantic encoding.

141

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

150

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

155

#### 156 4.2.1 Long-term Potentiation and Rehearsal

157

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

166

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

173

174 There are three important moments for Long-Term Potentiation (long lasting memory):  
175 attention, emotional response and rehearsal. It is interesting noting that a typical oral joke  
176 (normally the narrative of something funny happening to somebody) concentrate these tree  
177 elements. When someone is going to tell a joke people pay “attention” to the speaker. If the  
178 joke is good, they “laugh” (emotional response). Hours later or even the next day, when  
179 people remember the joke, they will laugh probably again (rehearsal). That is the way people  
180 learn the jokes and reproduce them with friends and colleagues. The joke has a precise  
181 structure in order to be funny. It is interesting how we are able to remember such structure  
182 with remarkable fidelity so we are able to retell the joke with the precision required to make  
183 people laugh. Humorous narratives should be considered as an important resource for science  
184 communication as they represent a tool that can induce Long-Term Potentiation by  
185 promoting attention, emotional response, and rehearsal (See for example Primo Levi’s  
186 narrative in section 4.6).

187 4.2.2 Oblivion

188

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

192

193 It is worth noting that oblivion occurs quickly when we learn lists of unrelated words or  
194 unsystematic items. In contrast, if the text is meaningful, it is more likely that we will  
195 remember it for longer periods. Previous knowledge (proactive knowledge) can also reduce  
196 oblivion (Squire, 1986). Pioneering work by Sir Frederick Bartlett (1932) showed that a story  
197 which was difficult to understand was made modern and comprehensible by participants  
198 thanks to proactive knowledge. His experiments consisted of presenting an indigenous, North  
199 American story called *The War of Ghosts* to a group of participants in Britain. Bartlett found  
200 that his participants distorted their recall to provide a story that was more comprehensive to  
201 them. Their previous knowledge and expectations had a substantial effect on their  
202 recollection. In so doing, Bartlett developed the idea that in memory tasks we use our already  
203 existing schemas, which affect the way we recall and learn. In the geosciences context, it has  
204 been suggested that Myths (a form of narratives) help in reducing oblivion of geological  
205 hazards (flooding, eruptions and earthquakes) and this proactive knowledge has helped to  
206 create a culture of prevention in different human groups (Barthes, 2013; Crowley, 2018;  
207 Lanza and Negrete, 2007).

208

209 4.3 Emotion and Attention

210

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

217

218 Evidence shows that what distinguishes enduring experiences from those that are lost is that  
219 when they occurred they either created or coincided with higher than normal levels of  
220 emotion (Baddeley, 1997). It is clearly vital for humans to remember events that are  
221 emotionally arousing because they are likely to be important ones. They can be used to guide  
222 present and future actions. They can be used, for example, to avoid danger (as geological  
223 hazards) or to steer us towards a desirable outcome (O'Brien, 2000). Interestingly, the same  
224 neuro-chemicals that are released into the bloodstream to put the body on alert also instruct  
225 the brain to store a lasting record of the moment. This is the case for acetylcholine,  
226 noradrenaline, dopamine and glutamate, which all participate in the creation of links between  
227 neurons (Rupp, 1998; Zak 2007).

228

229 Durability of a particular memory seems to depend on how exciting the original experience  
230 was (or how excited the individual's brain was when it occurred), how much attention was  
231 paid to it and how often it is recalled (Stenberg, 2003). In Lotman's words (1990), 'narratives  
232 are a way of expressing ideas and amplifying emotions'. If emotions are generated, there is  
233 greater opportunity to concentrate attention and produce long-term potentiation are higher.  
234 Also, the possibility to rehearse the emotions is greater, since we tend to repeatedly remember  
235 passages that result from a meaningful or emotional experience (Stenberg, 2003).

236

#### 237 4.4 Memory in Context and Knowledge Networks

238

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

247

248 Memories that have similar connotations, forming links based on meaning, are called  
249 semantic links. Semantic links act like a cross-referencing system: once we have found a



250 useful piece of information, we can connect it with many more that might also be relevant  
251 (Cohen, 1989). Memories that are formed simultaneously are linked by association. These  
252 associative links are fundamental to our understanding of the world and often allow us to  
253 make predictions based on previous experience (see also section on *Models and Schemas*).  
254 Most of the time, semantic and associative links work unconsciously: as soon as one concept  
255 is activated in memory, activation spreads automatically to other ideas related through  
256 meaning or past experiences.

257

258 A story can be seen as an expressive device that by means of a plot associates characters,  
259 situations, places, and information to produce semantic links and a cross-referencing system  
260 that can assist in storing and retrieving information in, and from, memory (i.e. scientific  
261 knowledge).

262

#### 263 4.5 Human Memory Systems

264

265 According to Tulving (1972), there are six major human memory systems: semantic,  
266 episodic, procedural, perceptual, representational and short-term memory. There is  
267 reasonable evidence of the existence of the first two types: semantic and episodic memory.

268 With the aid of semantic memory, individuals are able to register and store information about  
269 the world in the broadest sense (i.e. not personally experienced) and are capable of retrieving  
270 it. Semantic memory allows people to think about things that are absent to the senses at the  
271 time (Tulving 1972). Semantic memory is automatic, i.e., it does not require a conscious  
272 recollection. It develops earlier in childhood than episodic memory (Tulving 1972).

273

#### 274 4.6 Episodic Memory

275

276 This is the type of memory used to remember events in our lives. Therefore, episodic memory  
277 is related to the self-experiences in subjective space and time. An episodic memory consists  
278 of memories that come from different areas of the brain that are bound together to create an  
279 ‘episode’, rather than a collection of impressions or items of knowledge (Crowley, 2018). In  
280 contrast with semantic memory and other kinds of memory systems, in this case the  
281 individual is able to transport into the personal past and future at will (Tulving 2000). In

282 times of crisis the individual is able to bring the past to the forefront in order to reinterpret  
283 the events of a lifetime.

284

285 Tulving (1966) pointed out that retrieving information from each memory system is  
286 associated with distinct memory awareness experiences. According to this author, when an  
287 individual uses episodic memory, they are conscious of remembering past experiences,  
288 whereas in the case of semantic memory, a person's conceptual knowledge is characterised  
289 by memory awareness involving feelings of familiarity or "just knowing".

290

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

296

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

304

305 Narratives offer information that is contextualised in real-life situations (episodes). When an  
306 episode in a narrative work evokes emotion in the reader, this incident may become  
307 memorable. Narratives (fictional or non-fictional) provide the opportunity to create episodes.  
308 If the narrative episode evoke emotions and part of it contain science, then it would be  
309 reasonable to expect that information contained in it (included science) will form a lasting  
310 memory.

311 The following narrative is a shortened version (performed by the author) of Primo Levi's  
312 "Nitrogen" (1985). It provides an example of an episode that includes science and has proved  
313 to be a memorable device (Negrete 2009).

314  
315 *The client explained to me that he was the owner of a cosmetics factory and he wanted to*  
316 *produce a certain kind of lipstick. He needed a few kilos of alloxan. He would pay a good*  
317 *price for it, provided I committed myself by contract to supply it only to him. He had read*  
318 *that alloxan in contact with the mucous membrane confers on it an extremely permanent red*  
319 *colour, because it is not a superimposition, in short a layer of varnish like lipstick, but a true*  
320 *and proper dye, as used on wool and cotton. I gulped, and to stay on the safe side replied*  
321 *that we would have to see: alloxan is not a common compound nor very well known, I don't*  
322 *think my old chemistry textbook devoted more than five lines to it, and at that moment I*  
323 *remembered only vaguely that it was a derivative of urea and had some connection with uric*  
324 *acid. I dashed to the library at the first opportunity and hastened to refresh my memory as to*  
325 *the composition and structure of alloxan.*

326  
327 *Alloxan is a hexagonal ring of oxygen, carbon, hydrogen and nitrogen; it is a pretty*  
328 *structure! It makes you think of something solid, stable, well linked. In fact it happens also*  
329 *in chemistry as in architecture that "beautiful" edifices, that is, symmetrical and simple, are*  
330 *also the most sturdy: in short, the same thing happens with molecules as with the cupolas of*  
331 *cathedrals or the arches of bridges. Alloxan was known for almost seventy years, but as a*  
332 *laboratory curiosity: the preparation method described had a pure academic value, and was*  
333 *made from expensive raw materials which (in those years right after the war) it was*  
334 *optimistic to hope to find on the market. The sole accessible preparation was the oldest: it*  
335 *did not seem too difficult to execute, and consisted in an oxidising demolition of uric acid.*  
336 *Just that: uric acid, the stuff connected with gout, intemperant eaters, and stones in the*  
337 *bladder. It was a decidedly unusual raw material, but perhaps not as prohibitively expensive*  
338 *as the others.*

339  
340 *Subsequent research taught me that uric acid, very scarce in the excreta of man and*  
341 *mammals, constitutes, however, 50 percent of the excrement of birds and 90 percent of the*

342 *excrement of reptiles. Fine. I phoned the client and told him that it could be done, he just had*  
343 *to give me a few days' time: before the month was out I would bring him the first sample of*  
344 *alloxan, and give him an idea of the cost and how much of it I could produce each month.*  
345 *The fact that alloxan, destined to embellish ladies' lips, would come from the excrement of*  
346 *chickens or pythons was a thought which didn't trouble me for a moment. The trade of chemist*  
347 *teaches you that matter is matter, neither noble nor vile, infinitely transformable, and its*  
348 *proximate origin is of no importance whatsoever. Nitrogen is nitrogen, it passes miraculously*  
349 *from the air into plants, from these into animals, and from animals to us; when its function*  
350 *in our body is exhausted, we eliminate it, but it still remains nitrogen, aseptic, innocent. We*  
351 *-I mean to say we mammals- who in general do not have problems about obtaining water,*  
352 *have learned to wedge it into the urea molecule, which is soluble in water, and as urea we*  
353 *free ourselves of it; other animals, for whom water is precious (or it was for their distant*  
354 *progenitors), have made the ingenious invention of packaging their nitrogen in the form of*  
355 *uric acid, which is insoluble in water, and of eliminating it as a solid, with no necessity of*  
356 *having recourse to water as a vehicle.*

357

358 *I returned home that evening and informed my wife that the next day I would leave on a*  
359 *business trip: that is, I would get on my bike and make a tour of the farms on the outskirts of*  
360 *town in search of chicken shit. She did not hesitate, she would come along with me. But she*  
361 *warned me not to have too many illusions: finding chicken shit in its pure state would not be*  
362 *so easy. In fact it proved quite difficult. First of all, the pollina—that's what the country*  
363 *people call it, which we didn't know, nor did we know that, because of its nitrogen content,*  
364 *it is highly valued as a fertiliser for truck gardens—the chicken shit is not given away free,*  
365 *indeed it is sold at a high price. Secondly, whoever buys it has to go and gather it, crawling*  
366 *on all fours into the chicken coops and gleaning all around the threshing floor. And thirdly,*  
367 *what you actually collect can be used directly as a fertiliser, but lends itself badly to other*  
368 *uses: it is a mixture of dung, earth, stones, chicken feed, feathers, and chicken lice, which*  
369 *nest under the chickens' wings. In any event, paying not a little, labouring and dirtying*  
370 *ourselves a lot, my undaunted wife and I returned that evening with a kilo of sweated-over*  
371 *chicken shit.*

372

373 *The next day I examined the material: there was a lot of gangue, yet something perhaps could*  
374 *be got from it. But simultaneously I had an idea; just at that time, in the Turin subway gallery*  
375 *an exhibition of snakes had opened: Why not go and see it? Snakes are a clean species, they*  
376 *have neither feathers nor lice, and they don't scabble in the dirt; and besides, a python is*  
377 *quite a bit larger than a chicken. Perhaps their excrement, at 90 percent uric acid, could be*  
378 *obtained in abundance, in sizes not too minute and in conditions of reasonable purity. This*  
379 *time I went alone: my wife is a daughter of Eve and doesn't like snakes. The director and the*  
380 *various workers attached to the exhibition received me with stupefied scorn. Where were my*  
381 *credentials? Where did I come from? Who did I think I was showing up just like that, as if it*  
382 *were the most natural thing, asking for python shit? Out of the question, not even a gram;*  
383 *pythons are frugal, they eat twice a month and vice versa; especially when they don't get*  
384 *much exercise. Their very scanty shit is worth its weight in gold; besides, they—and all*  
385 *exhibitors and owners of snakes—have permanent and exclusive contracts with big*  
386 *pharmaceutical companies. So get out and stop wasting our time. I devoted a day to a coarse*  
387 *sifting of the chicken shit, and another two trying to oxidise the acid contained in it into*  
388 *alloxan. The virtue and patience of ancient chemists must have been superhuman, or perhaps*  
389 *my inexperience with organic preparations was boundless. All I got were foul vapours,*  
390 *boredom, humiliation, and a black and murky liquid which irremediably plugged up the*  
391 *filters and displayed no tendency to crystallise, as the text declared it should. Best to return*  
392 *among the colourless but safe schemes of inorganic chemistry.*

393

#### 394 4.7 Mnemonics

395

396 Before the invention of writing, and long afterwards in many cultures, stories were sung or  
397 recited from memory. Rhythm, rhyme and melody were used to provide a framework that  
398 aided in their memorisation. Mnemonics are one tool employed to aid recitation from  
399 memory. It is defined as the art of improving memory, or a system to aid the memory, i.e.,  
400 any strategy that helps people remember. It normally means signals for learning that will later  
401 induce the experience to be remembered (Stenberg, 2003).

402

403 According to Lotman (1990), mnemonics can be seen as a way of internal communication  
404 that is made up of messages to the self with the purpose of retaining information and includes  
405 different sorts of memoranda and reminders. Essentially, such reminder devices add meaning  
406 (or personal meaning) to otherwise meaningless, unrelated or arbitrary lists of items for the  
407 individual. Mnemonics superimposes an artificial, logical structure (which can be seen as a  
408 model) on data, which are not necessarily related. A mnemonic device can be an image  
409 (*Alloxan is a hexagonal ring of oxygen, carbon, hydrogen and nitrogen; it is a pretty*  
410 *structure! It makes you think of something solid, stable, well linked. In fact it happens also*  
411 *in chemistry as in architecture that "beautiful" edifices, that is, symmetrical and simple, are*  
412 *also the most sturdy: in short, the same thing happens with molecules as with the cupolas of*  
413 *cathedrals or the arches of bridges), an acronym, a verse, a rhyme (*matter is matter, neither*  
414 *noble nor vile), a peg word, a catch phrase or a story that helps us to remember (Luria, 1986).*  
415*

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

421  
422 Most of the world's great religions have strong oral traditions in which sacred texts are  
423 memorised in their entirety for prayer and to preserve them for posterity. For example, in the  
424 *Mishna*, the Jewish written record of the oral law, some literary resources such as metaphors,  
425 digressions and poetic images can actually be viewed as mnemonic aids. The *Qur'an* also  
426 contains mnemonic aids. This religious book was written both as a work of rhythmic prose  
427 and as an epic poem; thus, rhythm, rhyme, and meaning connect every word making it  
428 memorable (Luria, 1986).

429  
430 Narratives can be seen as mnemonic structures that superimpose an artificial, logical structure  
431 on data which is not necessarily related. In this way scientific factual information can be  
432 communicated by being embedded in a mnemonic structure (the story) which facilitates  
433 future recollection.

434 4.8 Memory Span and Paired Recall Association

435

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

444

445 Pioneering work by Epstein, Rock and Zuckerman (1960), suggested that when two objects  
446 have been perceived or imagined to be interacting, recalling the name of one, in response to  
447 the name of the other, is more frequent than when the objects have been perceived or  
448 imagined to be side by side. This effect in memory is called paired recall association. As a  
449 result of the relationship between two objects, they develop certain properties and  
450 interactions. A relation or interaction constitutes a feature that characterises both objects,  
451 which enables the individual to retrieve one when the other is provided (Wilton, 1989). An  
452 interesting example, of the effectiveness of rhythm and paired recall association as mnemonic  
453 aids is clear when we try to remember the lyrics of a song and it suffices to recollect its  
454 rhythm in order to do so.

455

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

462

463 Following this line of argument, it would be plausible that stories represent a means of  
464 increasing memory span, a way to facilitate retrieval from memory by paired recall

465 association and a powerful device to convey science to the general public in a long lasting  
466 way.

467

#### 468 4.9 Models

469

470 According to the classical work by Giere (1979), models can be classified into three  
471 categories: scale models that represent reality to a particular scale; analogue models which  
472 are useful for understanding other proposed new models; and theoretical models, the most  
473 abstract form of a model as they are imaginary and often explained with analogical models.  
474 Examples of the latter are the thought experiments. A thought experiment is an idealisation  
475 or abstraction of existing physical conditions. A thought experiment implies the use of visual  
476 imagery abstracted from phenomena that we have actually experienced. This imagery allows  
477 intuition, an impression of how things are connected, innovation and the possibility of  
478 modelling in the mind. This kind of thinking was used by famous scientists such as Galileo,  
479 Einstein, Maxwell, Bohr and Heisenberg.

480

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

484

485 Casti (1993) compares modelling with painting and other artistic disciplines. When an artists  
486 paint, they never creates on canvas the exact image of the subject in front of them. Instead  
487 they try to capture the essence of meaningful characteristics so that the viewer is able to know  
488 more about the object painted than from looking at the real thing. In this sense the object art  
489 (paint, sculpture, music, or literature) shows hidden characteristics by using magnifying  
490 glasses, special lights, tones, rhythms or narrative resources. Giere's (1979) and Casti's  
491 (1993) arguments claim that stories can be seen as narrative models that have the power to  
492 explain, the capacity to show scale, an ability to predict the future, to produce analogies and  
493 metaphors as well as to theorise.

494 Yuri Lotman (1977) suggested that semiotic systems are models that explain the world in  
495 which we live. Amongst all semiotic systems, language is the primary modelling system in



496 which we apprehend the world by means of the model that it provides. Myth, cultural rules,  
497 religion, paint, music, literature (narratives) and science are secondary modelling systems.  
498 All of them are of equal interest as models to understand and talk about the world.

499

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

507

508 Narratives can also be seen as secondary modelling systems in which information is  
509 represented and organised by means of a plot. This enables us to make sense of reality and  
510 prepare information in an organised structure ready for future recall. Stories can be seen as  
511 narrative models as they depict the model which has the capacity to explain. For example in  
512 the capacity to show scale as in *Carbon* by Primo Levi, the possibility to show in few pages  
513 processes that take millions of years as in *The Crabs Take Over the Island* by Anatoly  
514 Dnieprov (1966), an ability to predict the future as in *The Time Machine* by H.G. Wells  
515 (1895), or to produce analogies and metaphors as in *Flatland* by Edwin A. Abbot (1884) and  
516 to theorise as in Italo Calvino's *Cosmicomics* (1969). Using narratives provide a powerful  
517 tool to communicate Science.

518

#### 519 4.10 Story schemas

520

521 One of the earliest studies of memory and narratives was carried out by Frederic Bartlett  
522 (1932). Unlike many psychologists of his day, Bartlett recognised the need to study memory  
523 retrieval with connected texts rather than studying unconnected strings of digits, words or  
524 nonsense syllables. He introduced the idea that schemas, or mental frameworks, built up from  
525 prior knowledge and experience, are influential in determining and shaping the memory of a  
526 story (see section 3.2.2)

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

533

534 Today two kinds of schemas are distinguished: event schemas and story schemas. Event  
535 schemas consist of knowledge about the subject matter of the story (Cohen, 1989; Christy et  
536 al, 2017). For example, the event schemas activated in remembering *The Man Who Mistook*  
537 *His Wife for a Hat* by Oliver Sacks (a collection of different narratives about Oliver Sacks’  
538 patients) might include knowledge of psychiatric hospitals, admire characters, self-identity,  
539 physiology of the brain, sensory ghosts, disembodiment, or autism. Story schemas consist of  
540 abstract, content-free knowledge about the structure of a typical story.

541

542 For science communication, one of the advantages of story schemas is that the majority of  
543 people have been exposed to them since childhood in such forms as religious instruction,  
544 drama, or reading fictional literature. Therefore it represents a widespread and well-  
545 established knowledge held by the general public that can be used, without previous  
546 instruction, to the benefit of popularisation of science.

547

#### 548 ***Final note***

549

550 It is still necessary to invest considerable amount of effort to investigate about the use of  
551 narratives in science communication as it is a rather recent field as well as a promising one.  
552 For instance, it is necessary to explore in more depth the adequate characteristics of narrative  
553 text for effective science communication (i.e. the use of powerful mnemonic devices). From  
554 my perspective, science communication via narratives should follow a series of rules, as it  
555 happens with other narrative sub-genera such as the thrillers, horror stories, historic novel,  
556 etc. I have named this kind of narratives “SciComm narratives” (Negrete, 2014) and they  
557 could be considered as a new narrative sub-genera with their own characteristics and rules.

558 Therefore, it is important to generate more knowledge that enables us to provide a solid  
559 theoretical body around narratives for science communication (SciComm narratives).  
560

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