

## WHAT MAKES A STORY AN INTERESTING WAY TO COMMUNICATE SCIENCE

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### Abstract

I conducted an experiment to explore the capabilities of narratives (short stories) to convey and preserve scientific information. The study consisted on a critical analysis of two short stories (Nitrogen by Primo Levi and The Crabs take Over the Island by Anatoly Dnieprov) to examine narrative structures and literary devices included in these texts. Following Propp's narrative analysis, I looked at characters, spheres of action and narrative functions. The functions and spheres of action proposed by Propp provided me the basis to contrast the stimulus narratives (short stories) with the reproductions of these narratives performed by the participants in the experiment. The results suggest that there is a relationship between how central the scientific information is to the development of the story and how memorable it becomes. In other words, the closer the scientific information moves to the important moments in the narration (e.g., revelations, peripetia, anagnorisis, outcome, central functions, spheres of action and literary tropes), the more likely it is to succeed in communicating and making such scientific knowledge memorable.

**Keywords:** Science and narratives, stories, science communication

### 1. Introduction

The word 'story', even today, carries certain connotations of falsehood or misrepresentation, as in the expression, 'that is only a story'. Poetry, drama, and storied narrative were considered unable to convey true knowledge. Instead, they were limited to communicating and generating emotional experiences, and, because of this, were seen as misleading vehicles for the transmission and representation of information. However many scientific and mathematical hypotheses (e.g. relativity as a thought experiment) start their lives as little stories or metaphors, reaching their scientific maturity by a process of conversion into verifiability, formal or empirical [1]. Bruner denoted the traditional logical-scientific mode of knowing as paradigmatic cognition, with storied knowing as narrative cognition [2]. Paradigmatic cognition has continually been identified as the only cognitive mode for the generation and transmission of valid and reliable knowledge. However, although the idea has long been ignored that more than one mode of rationality exists, it has in fact for centuries been part of human cultures [3]. Interesting examples of this are the Bible, the Koran and myths, narrative texts that have been used to transmit knowledge for centuries. Narrative knowledge is more than emotive expression; it is a legitimate form of reasoned knowing [2]. Today several scientists believe that both paradigmatic and narrative cognition generate useful and valid knowledge and that they are part of the human cognitive repertoire for reasoning and making sense of reality [4].

The two modes of thought proposed by Bruner provide different ways of organizing experience, constructing reality and communicating knowledge. They are, at the same time, complementary and irreducible to one another [2]. While paradigmatic knowledge is focused on what is common among items, narrative knowledge focuses on the particular and special characteristics of actions. Human action is the result of the interrelation of previous learning, experience, the present and of future expectation. While paradigmatic knowledge is carried in individual words that name a concept, narrative knowledge is maintained in emplotted stories. Storied memories retain the complexity of the situation in which an action was undertaken, and the emotional and motivational meaning connected with it. The collection of storied experiences provides a basis for understanding new action episodes by means of analogy.

To understand how narratives organize, represent and convey information, it is important to evaluate the advantages that this media offers for the communication of science. Narratives include several characteristics that make them memorable, understandable, enjoyable, and a good way to present and communicate knowledge. Some of these attributes are achieved through narrative structures, including literary devices (tropes).

One of the earliest studies of memory and narratives was carried out by Frederic Bartlett [5]. Unlike many psychologists of his day, Bartlett recognized 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 they distorted their recall to provide a story that was more comprehensive to them. Their previous 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.

Schemas allow identification, induce emotions and promote understanding - important elements for the learning and memory process [5]. Individually the narrative resources (or literary devices), in addition to their aesthetic value, can also work as mnemonic structures. Examples of narrative devices included in fictional literature are rhythm and rhyme that, adding to their pleasing sound, induce remembering and guessing of forgotten elements [6]; literary images, which represent powerful aids for storing and retrieving information from memory, a way of organizing information and an aesthetic narrative resource [7]; surprise and humour which, apart from their original function, work as long-lasting memory triggers [8][9]. Metaphors are also fundamental narrative devices. They represent conceptual models that enable us to perceive, apprehend, construct and communicate meaning out of reality [10][11].

Russian formalism, represented by the work of R. Jakobson, V. Slovskij, M. Bahtin, B. Uspensky, and B. Propp and the Rumanian-French writer Tzevetan Todorov, emphasises the role of form in conveying meaning in a narrative [12]. Perhaps the most famous and still more widely used work of the Russian structuralist is the analytical scheme proposed by Vladimir Propp [13]. (1968).

According to Harré, et al., the functions proposed by Propp apply not only to fairy tales but also to other forms of narrative [14]. Propp considered that the fairy tale is structured not by the nature of the characters that appear in it, but by the function that they play in the plot. Despite the great detail and large amount of characters that inhabit fairy tales, Propp suggested that the number of functions is rather small. This allowed him to maintain the classical distinction of structuralist between appearances (great detail and complexity) and reality (a simple underlying structure repeated in different ways) [15].

Propp suggested that fairy tales can be understood by using only four principles: (1) the functions of characters are stable elements in a tale, (2) the functions known in a fairy tale are limited, (3) the sequence of functions is normally the same in every story and (4) fairy tales are of one type with regard to the structure. According to Propp, functions are acts, episodes or entrances of people of various sorts. He further claims that fairy tales are based on 31 functions (acts or episodes).

In order to test how individuals use narrative structures to retell narratives, I presented two stimulus stories to a group of individuals and then ask them to retell the stories in three different occasions (the day of the reading, two weeks and a month later).

## 2. Methods

### Aim

To study how people use narrative structures including literary resources to understand, memorize and reconstruct the science included in a narrative.

The sample consisted of 26 first-year university Sociology students of the University of Bath, UK, who were not taking any course of science at the time of the test. The mean age of the participants in this sample was nineteen years of age and the mode was eighteen years. The gender composition was made up of 15 females and 11 males.

As narrative stimuli, two stories were used in the studies: (*The Crabs Take Over the Island* by Anatoly Dnieprov and *Nitrogen* by Primo Levi). These two narratives were chosen because in both cases the scientific content is central to the development of the plot (Crabs: the theory of evolution; Nitrogen: the element nitrogen).

*The Crabs Take over the Island* by Anatoly Dnieprov (hereafter referred to as "Crabs") is a story about an experiment in Darwinian natural selection involving robot crabs [16]. The aim of the experiment is to produce compact efficient crabs as weapons. Crabs (providers) could be used to eat the enemy's metal reserves. In the simulated struggle for the 'survival of the fittest', the crabs better adapted to kill the other members of the robot-crab species are the ones which survive. So in every generation those characteristics which resulted in better adaptations for survival are retained. For an unforeseen reason the experiment goes wrong and the survivor of the struggle is a gigantic crab. The last scene of the story shows the cyber-crab chasing the research team leader -the engineer- (villain) to obtain the last piece of metal on the island: a tooth filling inside the scientist's mouth. The protagonist (hero) rests in the beach waiting to be rescued (note: in brackets it is indicated the sphere of action that each of the characters play in proppian methodology, see Table 1).

*Nitrogen*, by Primo Levi, is the story of a chemist (hero) who is looking for nitrogen in order to produce a long lasting lipstick for a client (King-dispatcher) who is owner of a cosmetic factory [17]. The narrative presents the research that the chemist has to perform and the problems that he has to overcome (in the company of his wife -helper-)

in order to obtain and purify animal excrement where nitrogen is present in high concentrations. In the course of the story the author explains a series of scientific facts about nitrogen and the Alloxan molecule (the dye) where nitrogen is the structural part of the compound. Although in the end the protagonist is unable to purify Alloxan because organic chemistry is too complicated for an inorganic chemist, Levi succeeds in presenting a captivating and humorous story that includes an interesting amount of scientific information.

Table 1. Spheres of action according to Proppian analysis.

Spheres of Action
The Villain
The Provider
The Helper
The Princess and her Father (King)
The Dispatcher
The Hero
The false Hero

Table 2 Fairy tale functions proposed by Propp [13].

	Function	Description
I	Absentation	Family member absents him/herself
II	Interdiction	An interdiction is made to the hero
III	Violation	Hero violates interdiction. Villain appears
IV	Reconnaissance	Villain or hero attempts reconnaissance
V	Delivery	Information about victims is delivered to victims
VI	Trickery	Villain attempts deception of victim
VII	Complicity	Victims submit to deception
VIII	Villainy	Villain causes harm to family members
IX	Mediation	Misfortune or deficiency is made known
X	Counteraction begins	Hero agrees /decides on counteraction
XI	Departure	Hero leaves home
XII	Donor's first function	Hero is tested
XIII	Hero's reaction	To donor
XIV	Provisional receipt	Of magic agent
XV	Guidance	Spatial transfer of hero is made to vicinity of object of search.
XVI	Struggle	Hero and villain are in direct combat
XVII	Branding	Hero is marked
XVIII	Victory	Villain is defeated
XIX	Liquidation	Initial misfortune or deficiency is made good
XX	Return	Hero returns
XXI	Pursuit	Hero is pursued
XXII	Rescue	Hero is rescued from pursuit
XXIII	Unrecognized arrival of hero	At home or in another place
XXIV	Unfounded claim by false hero	Hero is at home
XXV	Difficult task	Proposed by false hero
XXVI	Solution	Task is achieved
XXVII	Recognition	Hero is recognised, often by special sign
XXVIII	Exposure	False hero is exposed
XXIX	Transfiguration	Hero is given new appearance or possessions
XXX	Punishment	Villain is punished
XXXI	Wedding	Hero marries, ascends throne or is rewarded

The stories were adapted to enable the participant to read the story and retell the narrative in a half-hour session (two A4 pages, approx. 1500 words each). The study included a critical analysis of the stimulus stories to examine narrative structures and literary devices incorporated in the texts in detail. Following Propp's narrative analysis, I looked at characters, spheres of action and narrative functions. I chose Proppian analysis for my research because it offers great detail in the description of characters and especially in the story functions (other authors condense such functions into a smaller group offering less resolution for the analysis –e.g. [18]-. The functions and spheres of action proposed by Propp provided me the basis, on the one hand, to compare the two stimulus stories and, on the other, to contrast the reproductions performed by the participants with the original stimulus narratives (Table 1 and 2).

I also included a description of the general dramatic structure of the stories [19][20] and I classified the principal literary resources used to construct the stories [21][22] (Table 3). I examined in what way these previous elements interact with the scientific information contained in the stories.

Table 3. Dramatic terms used by Aristotle in Poetics to describe a narrative (From [23][24] and [3]).

Dramatic terms	Definition
Dramatic Genera	Tragedy, comedy, romance and satire
Structure	Beginning, middle and end
Revelation	The illumination (the acquisition of information) determined by the singularity of an experience lived in an unusual situation.
Anagnorisis	The moment of recognition (of truth) when ignorance gives way to knowledge. A story can have several revelations but only one anagnorisis.
Peripetia	The reversal of fortune, a fall. In drama, usually the sudden change of fortune from prosperity to ruin.

Finally, the narrative resources of each of the stories were analyzed and categorized. An inventory of literary resources was constructed; each resource was described in literary terminology (as a trope or other narrative effect) and examined with respect to the role that it plays in the narrative, i.e., the information that it provides, introduces or is linked to in the story. The literary resources used for the analysis in the present study appear in Table 4.

I used the structures identified in the stimulus stories to compare the reproductions generated by the participants in the study. The analysis of the interaction of narrative structure and literary resources with the scientific information was also used to compare the original stories with the ones reproduced by the participants.

Table 4. Dramatic terms used by Aristotle in Poetics to describe a (From [23] [24] and [3]).

Literary Resource	Definition
Humour	The quality of a phrase, fragment or idea of being amusing or comic. A literary resource that produces laughter (Cuddon, 1999) (Chapter III).
Metaphor	Figure of speech (trope) in which a word or phrase is applied to an object which is not literally applicable. A thing regarded as representative or symbolic of something else, especially something abstract (chapter III).
Analogy	Comparison of one thing to another, typically for the purpose of explanation or clarification (Chapter III).
Rhyme	Correspondence of sound between words or end of words (Chapter III).
Rhythm	A strong, regular repeated pattern of sound. The measured flow of words and phrases in verse or prose as determined by the relation of long and short or stressed and unstressed syllables (Chapter III).
Other Literary Resources	Any story telling device other than tropes used to produce a narrative or stylistic effect.

### 3. Results and discussion

Focusing on the kinds of usage of narrative in reconstruction and the processes of remembering (Bartlett tradition), I found the following interesting results. The majority of the participants in both stories retold the narratives in the third person singular or plural, converting themselves into omniscient narrators. In general terms the most reproduced characters in both stories were the ones that delivered the scientific information (the hero in both cases). Elements of tragicomedy (humour) were relatively common in *Nitrogen*. In contrast, in the retellings of *Crabs* very few participants reproduced those elements. One possible explanation is that the comic turn of the narrative in *Nitrogen* is explicit; it comes in the form of jokes embedded in the story. In contrast, humour in *Crabs* is reached through the dialogue and dialogue was not commonly reproduced in *Crabs*. Therefore, the humor associated to it was also not retold.

It is interesting that both stimulus stories occur at about the same interval (of Proppian functions), that is, between function 9 and 20 in *Nitrogen* and 9 and 22 in *Crabs*. Perhaps the reason for this is that both stories are the narrative of the scientific research and both authors concentrated their attention in functions such as Guidance, Mediation, Struggle, Victory and Branding. Guidance is the function that introduces the place where the experiment will take place (*Crabs*)

or the place where the compound will be found (Nitrogen); Mediation explains the objective of the experiment or research; Struggle narrates the difficulties of the experiment and Victory and Branding is a way to determine an outcome (result) of the research, experiment and story. It is likely that previous functions to Mediation and the ones that happen after Rescue were omitted by these authors because the space in a short story by definition is limited and these functions were not central to the development of the plot or simply because in general these functions are irrelevant for the narrative of a scientific research.

The majority of the participants in both stories reproduced in all sessions a narrative that incorporated elements of the research enterprise (narrative of an experiment). Both stimulus stories plots are essentially the narration of an experiment. The reproductions of the participants show that this form of narrative was recognized and reproduced by the majority of the individuals. The narrative of an experiment is common in literature (e.g. *Frankenstein*, *The Island of Dr. Moreau*). It is a narrative form (perhaps even a sub-genre) familiar to people. In this sense it could be considered as a schema that individuals possess and apply to interpret and make sense of this type of narrative. The fact that several participants mentioned 'the island' as a 'desert island' suggests that these individuals were applying a preformed idea (schema) that the experiment was going to take place in an isolated place (desert island) as occurs in many examples in literature (e.g. *The Island of Dr. Moreau*, *The Lost World*, *Jurassic Park*, *Robinson Crusoe*, etc.). This result matches Bartlett's idea that people apply schemas or mental frameworks which are built up from prior knowledge and experience and which determine and shape the recollection of a story.

From the totality of the literary resources contained in the two stories, humour, dialogue, rhyme, rhythm and expectation proved to be the best remembered. In relation to irony (and expectation), according to Baddeley [25], individuals are particularly good at remembering anything that comes as a surprise. People normally remember a joke because of its unexpected outcome, which is precisely what makes them laugh [26]. The evidence suggests that individuals tend to remember what made them laugh because the humorous image is rehearsed in the mind several times, reproducing a pleasurable sensation. Emotions are important not just for rehearsal but also as conditions for long-term potentiation. In regard to rhyme and rhythm, according to Luria [27], these are the elements that underpin many effective memory strategies, so in a way it was not surprising that they were well remembered.

From the total number of literary resources identified in each story, in *Crabs* almost a third are linked to science and in *Nitrogen* over two thirds. Over half of the most used literary resources (by more than half of the participants in all sessions) in *Crabs* are linked to science. In the *Nitrogen* story the two more reproduced literary resources (more than 9 reproductions in all sessions) are linked to science. The results suggest that there is a relationship between how central the scientific information is to the development of the story and how memorable it becomes. In other words, the closer the scientific information is to the important moments in the narration, and the higher in hierarchy with respect to the plot, the more likely it is to succeed in communicating and making such scientific knowledge memorable to the reader. This idea is backed in the present study by the following evidence: (1) In both stories the most frequently reproduced and best remembered characters were the ones that presented the scientific information or were the scientific artifacts themselves (robots), (2) the most quoted and remembered functions were those that concentrated more scientific information and (3) a high proportion of the most quoted and best remembered literary resources in both stories were precisely the ones linked to scientific knowledge. The previous results also put forward the idea that both stories used as stimuli can be seen as good models of narratives that communicate science in an efficient and memorable way.

In both stories, the functions that concentrate more scientific information (Provisional Receipt, Struggle-Farms and Struggle-Exhibition in *Nitrogen*; Mediation in *Crabs*) were also the most reproduced by the participants in all the sessions. These results suggest that science as a theme is central to the development of the plot in both stories and this conforms to Cohen's remark [28] that the rule for stories appears to be that the meaning, the gist, the most important and most relevant facts (scientific in this case) are preserved by memory.

The following findings in this study support Bartlett's idea that people apply schemas to guide understanding and memorize narrative information. (1) Two of the most quoted and best remembered literary resources (Metaphor and Analogy in *Nitrogen* and Expectation in *Crabs*) are common expressions in the spoken and written world. It is plausible that these two elements were remembered because they were familiar to the participants and formed part of their previous knowledge (repertoire when speaking or writing). The participants therefore applied them to remember and reconstruct the narratives. (2) The participants referred to the island as a desert island and this, as mentioned before, represents a commission because the stimulus story never mentions this as a fact. This result suggests that people read the story or rewrote the story with a preconception of what to expect from a narrative of an experiment. (3) Functions were reproduced by the majority of the participants in the original order in which they were presented in the stimulus stories (stimulus stories preserved, with very few exceptions, the functions order proposed by Propp). If the order of functions is mostly the same in any story as Propp suggests, it is reasonable to expect that people are already familiar with this structure (functions and their order) and this pre-knowledge assists the participants in the understanding and reconstruction of the story. (4) The presence in the majority of the stories of the classical structure of beginning, middle and end suggests that people guide understanding and reproduction of narratives using this well-known and basic structure. (5) The presence in the majority of the retellings of elements of the classical structure of a can also be interpreted as structures that people expect in the text (schema) in order to make sense of the story and later as memory triggers that assisted the participants in their retelling of the stories.

The fact that the participants reproduced the classical structure of a story (especially the beginning, middle and end) and the information contained in such a narrative with certain accuracy can be related to what Amos and Wisniewski [29] indicate about plot functions. The plot limits or contains a temporal range which marks the beginning and the end of the story, provides criteria for the selection of events to be included in the story, temporally orders the events into an unfolding sequence, and culminates in a conclusion and clarification or making explicit the meaningful events as contributors to the story and as a unified whole. Or, as Carr synthesises: the plot functions to select from a myriad of events those that are direct contributors to the final outcome of the story [30].

The relatively high number of literary resources reproduced in the retold stories suggests that these narrative devices represented a memorable structure (and perhaps a meaning maker aid) for the individuals in the sample. In both stories the majority of the most quoted and best remembered literary resources were the ones linked to scientific information. The science linked to such literary effects proved to be also well remembered.

The result also suggests that dialogic forms should be contemplated as an interesting narrative resource to communicate science and that reproducing or emulating the dialogue proposed by the contextual model [31][32] in a narrative might be an effective way to capture the interest of the public [33] and communicate science in an efficient, understandable and memorable way.

What exactly triggers memory is difficult to specify, but it is certainly reasonable to expect that these triggers appear in the act of retelling a story. It is plausible, as has been discussed throughout this paper, that some of the elements that trigger memory could precisely be the components of the structure of a narrative: functions, characters (spheres of action), revelations, peripetia, anagnorisis or literary resources. For example, let us suppose that someone is retelling *Crabs* in the third person plural (as many participants did through the character “the scientists” fusing the king-dispatcher and the hero), and the tale is approaching its end. At this moment the person remembers the outcome of *Crabs* being one character devoured by a crab and the other surviving. The narration is forced to change because the individual “remembered” the outcome of the story and now the narrative has to be retold in terms of two separate characters. As there are two characters now, the person retelling the story is likely to remember (or infer) in turn that these characters had two different spheres of action in the original narrative: the one played by the engineer and the other one played by the helper (narrator). In this example the end or outcome of the story (part of the structure of the story) can be interpreted as a memory trigger for the characters and their spheres of action.

Finally it is interesting to mention that the title of *Crabs*, “The Crabs take Over the Island” was repeatedly quoted by the participants in the body of their reproductions. This suggests that selecting appropriate titles should be considered of paramount importance. In the case of stories with scientific content, the title could be used to point the attention of the reader to a particular aspect of the narrative where attention should be focused on or to effectively communicate some scientific information.

## 4. Conclusion

My interpretation of the results of the qualitative analysis as a whole is that the participants in the sample remembered the narrative structures linked to scientific information (or the scientific information linked to such structures) for two reasons: (1) because the scientific information linked to the narrative structures was central to the development of the narrative (the plot), and (2) because the narrative structures included in the stimulus stories attracted the participants’ attention [34], helped them to retain the scientific information linked to such structures (e.g., attractive literary resources) [35][36][25][11], assisted the individuals in the retrieval and helped them in the mental reconstruction [37] [38] [39] [40] as well as in the retelling of the story as a whole [25].

## 5. Further reading

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