

# Engineering Linguistic Creativity: Bird Flight and Jet Planes

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## Abstract

Man achieved flight by studying how birds fly, and yet the solution that engineers came up with (jet planes) is very different from the one birds apply. In this paper I review a number of efforts in automated story telling and poetry generation, identifying which human abilities are being modelled in each case. In an analogy to the classic example of bird-flight and jet planes, I explore how the computational models relate to (the little we know about) human performance, what the similarities are between the case for linguistic creativity and the case for flight, and what the analogy might have to say about artificial linguistic creativity if it were valid.

## 1 Introduction

The achievement of flight by man is often used as an example of how engineering practice may lead to the successful emulation of behaviours observed in nature. It is also used to illustrate the idea that a successful engineering solution (such as a jet plane) need not always mirror faithfully the natural phenomenon which inspired it (the flight of birds).

The task of engineering solutions for linguistic creativity is made difficult by an incomplete understanding of how we manage language and how we achieve creativity. Nevertheless, over the past few years a large research effort has been devoted to exploring issues such as computational creativity, automated story telling, or poetry generation. In these cases, there is also a combination of a naturally occurring source phenomenon and a set of engineering techniques that provide an emulation of it.

In this paper I review a number of such research and development efforts that I have been involved in or studied in detail, paying particular attention to identifying which traits of human activity are being modelled in each case. In an analogy to the classic example of bird-flight and jet planes, I explore how the computational models of linguistic creativity relate to (the little we know about) human performance, what the similarities are between the case for linguistic creativity and the case for flight, and what the analogy might have to say about artificial linguistic creativity if it were valid.

## 2 Creativity at Different Levels of Linguistic Decision

Creativity is a tricky word because it can mean different things to different people. There seems to be a historical reason for this, in as much as the actual word we now use seems to have been invented in the 19th century in an attempt to cover the different concepts of innovation that were accepted in art and science (Weiner, 2000). As it is very difficult to make progress without a minimal agreement on what we are talking about, I will set off with an attempt to clarify what I refer to when I use the word in what follows. This is not intended to be prescriptive of how it should be used or descriptive of what other people may mean when they use it. And it is not meant to be exhaustive.<sup>1</sup> The goal here is to provide a brief sketch for readers to have a general idea of what is being talked about.

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<sup>1</sup>Interested readers can refer to (Gervás, 2009) for a more detailed discussion of my personal view on creativity.

For me creativity suggests the idea of someone (a *creator*) generating something (an *output*) that is somehow new, but also somewhat unexpected or different from what others might have produced. This output should satisfy some *goal*, though in many cases the particular goal implied is not altogether clear. The expectation of novelty implicitly brings in a second agent (an *audience* which usually involves more than one individual) that perceives or evaluates the result.

When used in different contexts, the word creativity acquires different meanings by virtue of involving different concepts of author, product, goal, or audience. The assumption that there is a generic framework common to all the different cases should be taken with a pinch of salt, as commonalities may not go far beyond this basic sketch.

It may seem that restricting the study to linguistic creativity simplifies the issue. Surely once the domain is constrained to linguistic outputs, the description of creativity should indeed boil down to a simple common framework. This assumption may also be risky, as I discuss below.

There are several possible levels of decision at which the final form of a sentence is shaped. At any (or all) of these it is possible to exercise creativity in the sense described above. At the level of phonetics, the way letters are put together to make sounds can be explored in search of pleasing uses of rhyme, internal rhyme or alliteration, as done in sound poetry (Hultberg, 1993). If one considers rhythm, the stress patterns of words may shape the stress pattern of a sentence or a text into rhythms that are uncommon in the language, or in existing poetry, as Poe claims to have done in “The Raven” (Poe, 1846). With respect to lexical choice, the actual words chosen for the text may be words that the user does not know but which actually convey a certain meaning to the reader, as done by Lewis Carroll in the poem “Jabberwocky” (Carroll, 1872).

For other levels of decisions, such as syntax, semantics or narrative, it is more difficult to pinpoint specific examples of creative uses, because instances occur in larger contexts and because they occur much more frequently. They can be considered of two different kinds: those in which the main objective is the communication of a certain message or information, and those geared towards obtaining

a pleasing effect of some sort. The first kind occurs for instance when a speaker in a hurry waives the rules of correct syntax in his effort to get his message across briefly. In going beyond the accepted rules, such a speaker may be deemed to be behaving creatively. This type of linguistic creativity (say, corner-cutting creative communication) is worth exploring in detail, but it would require access to enough samples of specific instances of the phenomenon to provide starting material. The second kind, in contrast, tend to get explicitly recorded for this pleasing effect to be available at later times, and they provide an easier starting point for a study of this sort.

A number of examples of linguistic creativity of the second kind were reviewed in (Gervás, 2002). This study showed that creative behaviour does not occur in the same degree across all levels. Creativity applied simultaneously at several linguistic levels can be counterproductive for communication if abused. Instead, a conservative approach in some levels is required for a successful interpretation of creative innovations at other levels. An additional problem that would have to be tackled is the extent to which the interaction between the theories for the different levels complicates the picture significantly. Intuition suggests that it will to a considerable extent. Creativity may operate at each of the levels of decision involved in linguistic production, but it may interact between different levels in ways that are not evident.

Under this light, we can see that even within the realm of linguistic creativity we seem to be faced with a broad range of different types of creativity, with different concepts of product and goal, giving shape to widely differing phenomena. In the hope of reducing even further the scope of the problem, I will concentrate more specifically on instances where a computer program is written to generate pieces of text that, when produced by a human author, would be interpreted to have deliberate aspirations of creativity.

### 3 Some Automatic Creators in the Literary Field

An exhaustive study of existing automatic creators of this kind would take more space than I have avail-

able here. The selection below must not be understood to be exhaustive. It is not even intended to indicate that the particular creators mentioned constitute the most significant efforts in the field. I have selected only a few for purposes of illustration, and I have chosen examples where relevant features of the corresponding human processes have been considered. There are two main fields where computer programs attempt to generate literary material: storytelling programs and poetry generators. Again, a difference in genre introduces differences in product, goal and evaluation criteria, which leads to the application of different construction processes, so I will review each field separately.

### 3.1 Automatic Story Tellers

Research on storytelling systems has experienced considerable growth over the years. Although it has never been a popular research topic, nonetheless it has received sustained attention over the years by a dedicated community of researchers. In recent years the number of systems developed has increased significantly. The body of work resulting from these efforts has identified a significant number of relevant issues in storytelling. Successive systems have identified particular elements in stories that play a role in the process of generation. Only a few illustrative examples will be mentioned here.

It is clear that planning has been central to efforts of modelling storytelling for a long time. Most of the existing storytelling systems feature a planning component of some kind, whether as a main module or as an auxiliary one. TALESPIN (Meehan, 1977), AUTHOR (Dehn, 1981), UNIVERSE (Lebowitz, 1983), MINSTREL (Turner, 1993) and Fabulist (Riedl, 2004), all include some representation of goals and/or causality, though each of them uses it differently in the task of generating stories. An important insight resulting from this work (originally formulated by (Dehn, 1981) but later taken up by others) was the distinction between goals of the characters in the story or goals of the author. This showed that planning is a highly relevant tool for storytelling, both at the level of how the coherence of stories can be represented and how the process of generating them is related to goals and causality.

Another aspect that is obviously relevant for storytelling is emotion. This has been less frequently

addressed in automatic storytellers, but has an outstanding champion in the MEXICA system. MEXICA (Pérez y Pérez, 1999) was a computer model designed to study the creative process in writing in terms of the cycle of engagement and reflection (Sharples, 1999), which presents a description of writing understood as a problem-solving process where the writer is both a creative thinker and a designer of text. MEXICA was designed to generate short stories about the Mexicas (also wrongly known as Aztecs), and it is a flexible tool where the user can set the value of different parameters to constrain the writing process and explore different aspects of story generation. An important aspect of MEXICA is that it takes into account emotional links and tensions between the characters as means for driving and evaluating ongoing stories. The internal representation that MEXICA uses for its stories (a Story World Context) is built incrementally as a story is either read or produced (the system can do both, as it learns its craft from a set of previous stories). This representation keeps track of emotional links and emotional tensions between characters. These elements are represented as preconditions and postconditions of the set of available actions. The system evaluates the quality of a partial draft for a story in terms of the the rising and falling shape of the arc of emotional tensions that can be computed from this information.

In general, most storytelling systems, being AI-style programs, can be said to operate by searching a space of solutions, guided by a traversal function that leads to new points in the space and an evaluation function that rates each point of the space in terms of quality. In general, most systems concentrate on the development and innovation efforts in the function for generating new stories (the traversal function), hoping that the candidates generated will progressively get better. However, human authors seem to learn their craft mostly by learning to distinguish good stories from bad stories (which would involve focusing more on the evaluation function). A fairly recent proposal (Gervás and León, ) describes a story generation system that outputs new stories obtained by exploring a restricted conceptual space under the guidance of a set of evaluation rules. The interesting feature in this system is that it uses exhaustive enumeration of the search space as its only

exploration procedure, and relies solely on its evaluation rules to identify good stories. This is a direct application of the generate & test paradigm of problem solving. This system also models the way in which the evaluation rules can evolve over time, leading to the production of new results.

### 3.2 Automatic Poetry Generators

Automatic poetry generators differ significantly from storytellers in two aspects: they are expected to satisfy very specific metric restrictions (in terms of number of syllables per line, and position of stressed syllables within the line) on the form of the output text (which story tellers do not usually take into account), and they are allowed a certain poetic licence which boils down to relaxing, sometimes quite dramatically, any expectations of meaning or coherence in the output (which are fundamental for storytellers). As a result, there is a larger sample of poetry generators. The review presented below attempts to cover some of the basic techniques that have been used as underlying technologies.

The generate & test paradigm of problem solving has also been widely applied in poetry generators. Because metric restrictions are reasonably easy to model computationally, very simple generation solutions coupled with an evaluation function for metric constraints are likely to produce acceptable results (given an assumption of poetic licence as regards to the content). An example of this approach is the early version of the WASP system (Gervás, 2000). Initial work by Manurung (Manurung, 1999) also applied a generate & test approach based on chart generation, but added an important restriction: that poems to be generated must aim for some specific semantic content, however vaguely defined at the start of the composition process. This constitutes a significant restriction on the extent of poetic licence allowed.

Manurung went on to develop in his Phd thesis (Manurung, 2003) an evolutionary solution for this problem. Evolutionary solutions seem particularly apt to model this process as they bear certain similarities with the way human authors may explore several possible drafts in parallel, progressively editing them while they are equally valuable, focusing on one of them when it becomes better valued than others, but returning to others if later modifications

prove them more interesting.

Another important tactic that human authors are known to use is that of reusing ideas, structures, or phrasings from previous work in new results. This is very similar to the AI technique of Case-Based Reasoning (CBR). Some poetry generators have indeed explored the use of this technique as a basic generation mechanism. An evolution of the WASP system (Gervás, 2001) used CBR to build verses for an input sentence by relying on a case base of matched pairs of prose and verse versions of the same sentence. Each case was a set of verses associated with a prose paraphrase of their content. An input sentence was used to query the case base and the structure of the verses of the best-matching result was adapted into a verse rendition of the input. This constituted a different approach to hardening the degree of poetic licence required to deem the outputs acceptable (the resulting verses should have a certain relation to the input sentence).

Another important mechanism that has been employed by automatic poets is grammar-based generation. By using a grammar to produce grammatically correct combinations of words, the results obtained start to resemble understandable sentences. As Chomsky mentioned in 1957, the fact that a sentence is grammatically correct does not imply that it will be interpretable. However, in the context of automatically generated poetry, sentences like Chomsky's classic counterexample ("Colorless green ideas sleep furiously") acquire a special interest, as they provide both a sense of validity (due to their syntactic correctness) and a sense of adventure (due to the impossibility of pinpointing a specific meaning for them). On reading such sentences, the human mind comes up with a number of conflicting interpretations, none fully compatible with its literal meaning. This multiplicity of shifting meanings is very attractive in the light of modern theories about the role of reader interpretation in the reading process.

In 1984 William Chamberlain published a book of poems called "The Policeman's Beard is Half Constructed" (Chamberlain, 1981). In the preface, Chamberlain claimed that all the book (but the preface) had been written by a computer program. The program, called RACTER, managed verb conjugation and noun declension, and it could assign cer-

tain elements to variables in order to reuse them periodically (which gave an impression of thematic continuity). Although few details are provided regarding the implementation, it is generally assumed that RACTER employed grammar-based generation. The poems in Chamberlain's book showed a degree of sophistication that many claim would be impossible to obtain using only grammars, and it has been suggested that a savvy combination of grammars, carefully-crafted templates and heavy filtering of a very large number of results may have been employed.

The use of n-grams to model the probability of certain words following on from others has proven to be another useful technique. An example of poetry generation based on this is the cybernetic poet developed by Ray Kurtzweil. RKCP (Ray Kurtzweils Cybernetic Poet)<sup>2</sup> is trained on a selection of poems by an author or authors and it creates from them a language model of the work of those authors. From this model, RKCP can produce original poems which will have a style similar to the author on which they were trained. The generation process is controlled by a series of additional parameters, for instance, the type of stanza employed. RKCP includes an algorithm to avoid generating poems too close to the originals used during its training, and certain algorithms to maintain thematic coherence over a given poem. Over specific examples, it could be seen that the internal coherence of given verses was good, but coherence within sentences that spanned more than one verse was not so impressive.

#### 4 Discussion

The selection of automatic creators reviewed above provides a significant sample of human abilities related with linguistic creativity that have been modelled with reasonable success. These include: the ability to recognise causality and use plans as skeletons for the backbone of a text, the ability to identify emotional reactions and evaluate a story in terms of emotional arcs, the ability to relax restrictions at the time of building and delay evaluation until fuller results have been produced, the ability to iterate over a draft applying successive modifications in search of a best fit, the ability to measure metric forms, the

ability to reuse the structures of texts we liked in the past, the ability to rely on grammars for generating valid text, and the ability to use n-grams to produce a stream of text with surface form in a certain style. This list of abilities is doubtless not exhaustive, but it covers a broad range of aspects. The important idea is that although existing systems have identified and modelled these abilities, very few have considered more than one or two of them simultaneously. And yet intuition suggests that human authors are likely to apply a combination of all of these (and probably many more additional ones that have not been modelled yet) even in their simplest efforts.

It may pay to look in more detail at the set of tools that we have identified, with a view to considering how they might be put together in a single system if we felt so inclined. The engagement and reflection model (Sharples, 1999) may provide a useful framework for this purpose. Sharples' concept of engagement seems to correspond with the ability to generate a new instance of a given artefact, without excessive concern to the quality or fitness for purpose of the partial result at any intermediate stage of the process. According to this view, planners, case-based reasoning, grammars, or n-gram models can provide reasonable implementations of procedures for engagement. The concept of reflection captures the need to evaluate the material generated during engagement. Abilities like identifying emotional reactions and evaluating a story in terms of emotional arcs, or measuring metric forms would clearly have a role to play during reflection. However, it is important to consider that we are looking at a number of possible mechanisms for use in engagement, together with a number of possible mechanisms for use in reflection. This does indeed have a place in the general scheme proposed by Sharples. Sharples proposes a cyclic process moving through two different phases: engagement and reflection. During the reflection phase, the generated material is revised in a three step process of reviewing, contemplating and planning the result. During reviewing the result is read, minor edits may be carried out, but most important it is interpreted to represent "the procedures enacted during composition as explicit knowledge". Contemplation involves the process of operating on the results of this interpretation. Planning uses the results of contemplation to create plans or

<sup>2</sup>[http://www.kurtzweilcyberart.com/poetry/rkcp\\_overview.php3](http://www.kurtzweilcyberart.com/poetry/rkcp_overview.php3)

intentions to guide the next phase of engagement. The evidence that we have presented so far suggests that a specific mechanism (or maybe more than one) may have been chosen to be used during a particular cycle of engagement. The process of reviewing mentioned by Sharples might simply be one of explicitly considering the choice of mechanism to use in engagement. The process of contemplating might be an application of the full set of evaluation mechanisms particular to reflection. The process of planning could be a complex process which would include among other things a decision of whether to change the engagement mechanism in use (or the configuration of any parameters it may need), and which mechanism to apply in each situation.

But we should not only study how closely automatic creators resemble human ones, assuming any divergence is a negative factor. Particular attention must be paid to the question of whether certain characteristics of human creativity are necessary conditions for creativity or simply the ingenious solution that makes it possible for the human mind while remaining within its limitations. This is particularly important if one is to consider modelling creativity in computer systems, which have different limitations, but also different advantages.

Humans have limited memory. Many of the solutions they seem to apply (such as providing constraints over a generative system so that it generates only “appropriate” solutions) are intended to avoid problems arising from the large amount of memory that would be required to consider all possible solutions provided by the generative system. But computers do not usually have the same problem. Computers can store and consider a much larger number of solutions. This has in the past been the big advantage presented by computers over people. It is such a significant advantage that, for some tasks such as chess playing, computers can perform better by computing all options and evaluating them all (very fast) than people can by using intelligent heuristics.

Though little definite is known about how the brain works, it seems to follow a highly parallel approach to computation. This is not true of most modern day computers. The most widely extended model for modern computers is the Von Neumann architecture, a computer design model that uses a

single processing unit and a single separate storage structure to hold both instructions and data. Over this simple model, subsequent layers of abstraction may be built, resulting in very complex models of performance as perceived by a human user running the computer. Many of these complex behaviours (such as, for instance, evolutionary problem solving techniques) have often been considered prime candidates for simulating creative behaviour in computers on the grounds that they implement a parallel search method, but they are reckoned to be slow, taking a long time to produce results. The lack of speed is highly influenced by the fact that, when run on computers with a Von Neumann architecture, each possible solution must be built and evaluated sequentially by the underlying single processing unit. If any computational solution based on parallel search methods shows merit for emulating creativity, it should not be discounted until it has been tested over hardware that allows it to operate in a really parallel manner, and instances of these are becoming more and more popular. Nowadays it has become more difficult to buy a new computer without finding it has at least two cores. For gaming consoles, this trend has gone even further, with the new generations sporting up to nine processing units.

## 5 Our Latest Efforts

Although the aim of the paper is not to report original work, a brief description of my ongoing work constitutes an example of the type of system that can be considered along the lines described above. The WASP poetry generator is still going strong. Only recently a selection of 10 poems produced by WASP has been published in a book about the possibilities of computers writing love poems (Gervás, 2010). The version of WASP used here is more advanced than previous ones, and some of the ideas outlined in the discussion have been introduced as modifications on earlier designs.

This version of WASP operates as a set of families of automatic experts: one family of content generators (which generate a flow of text that is taken as a starting point by the poets), one family of poets (which try to convert flows of text into poems in given strophic forms), one family of judges (which

evaluate different aspects that are considered important), and one family of revisers (which apply modifications to the drafts they receive, each one oriented to correct a type of problem, or to modify the draft in a specific way). These families work in a coordinated manner like a cooperative society of readers/critics/editors/writers. All together they generate a population of drafts over which they all operate, modifying it and pruning it in an evolutionary manner over a pre-established number of generations of drafts, until a final version, the best valued effort of the lot, is chosen.

The overall style of the resulting poems is strongly determined by the accumulated sources used to train the content generators, which are mostly n-gram based. The poems presented in the book were produced with content generators trained on collections of texts by Federico García Lorca, Miguel Hernández and a selection of Sixteenth Century Spanish poets. Readers familiar with the sources can detect similarities in vocabulary, syntax and theme. A specific judge is in charge of penalising instances of excessive similarity with the sources, which then get pushed down in the ranking and tend not to emerge as final solutions.

The various judges assign scores on specific parameters (on poem length, on verse length, on rhyme, on stress patterns of each line, on similarity to the sources, fitness against particular strophic forms...) and an overall score for each draft is obtained by combining all individual scores received by the draft.

Poets operate mainly by deciding on the introduction of line breaks over the text they receive as input.

Revisers rely on scores assigned by judges to introduce changes to drafts. Modifications can be of several types: deletion of spans of text, substitution of spans for newly generated ones, word substitution, sentence elimination, and simple cross-over of fragments of poems to obtain new ones.

Because an initial draft produced by an n-gram based content generator is then processed many times over by poets and revisers, final results oscillate between surprising faithfulness to the sources and very radical surreal compositions.

## 6 Conclusions

In view of the material presented, and taking up the analogy between linguistic creativity and bird flight, we can say we are still trying to model birds. So far, we have only achieved small models of parts of birds. The various features of automatic creators that have been vaguely related to human abilities in section 4 are clearly tools that human writers apply in their daily task. Having systems that model these techniques, and testing how far each technique goes towards modelling human activity are steps forward. Bird's wings or bird's feathers do not fly, but having good models of them is crucial to understanding what makes flight possible.

Yet humans do not apply any of them in isolation, but rather rely on them as a set of tools and combine them at need to produce new material, using different combinations at different times. In the same way as research into flight considered how the parts of birds interact to achieve flight, in the realm of linguistic creativity more effort should be made to model the way in which humans combine different techniques and tools to achieve results. This could not have been done a few years back for lack of a valid set of tools to start from, but it is feasible now.

Aside from this positive optimistic analysis, there is a darker thought to keep in mind. Because we recognise that the models we are building at the current stage are only reproductions of parts of the whole mechanism, it would be unrealistic to demand of them that they exhibit right now creativity at the level of humans. As long as they focus on one aspect and leave out others, they are likely to perform poorly in the overall task when compared with their human counterparts. Yet even if they do not they are still worthy pursuits as initial and fundamental steps on which to build better solutions.

Once the various elements that contribute to the task have been identified and modelled with reasonable success, and the way in which they interact when humans apply them, a new universe of possibilities opens up. Future research should address the way in which humans apply these various elements, especially the way in which they combine some with others to achieve better results. In doing this, researchers should inform themselves with existing research on this subject in the fields of psy-

chology, but also in the study of poetry, narratology and literary theory in general.

By doing this, it will become more likely that computer programs ever produce output comparable to that of human authors. Yet the overall goal should not just be to obtain a pastiche of specific human artifacts, indistinguishable from the corresponding human-produced versions. Jet planes are perfectly distinguishable from birds. Which does not mean they are worthless. Jet planes are different from birds because the engineering solutions that scientists found for achieving flight required different materials (metal rather than bone and feathers), different applications of the basic principles (static rather than flapping wings) and different means of propulsion (jet engines rather than muscle power). However, these departures from the original model have made the current solution capable of feats that are impossible for birds. Jet planes can fly much faster, much higher, and carrying much more weight than any bird known. Yet all this was made possible by trying to emulate birds. If we carry the analogy to its full extent, we should generally consider departures from human models of linguistic creativity wherever they result in methods better suited for computers. This is already being done. However, we should at some stage also start considering departures from the models for the output as generated by humans. I would say a second, more idealistic, purpose of computational creativity might be to look for things that machines can do that people cannot do, but which people might yet learn to appreciate.

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