Employing emotions to drive plot generation in a computer-based storyteller

Action editor: Gregg Oden

Rafael Pérez y Pérez

Coordinación de Humanidades, Proyecto Sociedad del Conocimiento y Diversidad Cultural, Universidad Nacional Autónoma de México, Ciudad Universitaria, México D.F. 04510, México

Departamento de Tecnologías de la Información, División de Ciencias de la Comunicación y Diseño, Universidad Autónoma Metropolitana Unidad Cuajimalpa, Prol. Canal de Miramontes 3855 Edif. A 4º Piso, México D.F. 14387, México

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Abstract

Emotions are an integral part of the creative process; however, it is hard to find computer models of creativity where emotions play a fundamental role. This paper describes a computer model for plot generation based on emotions and tensions between characters. In particular, the document illustrates how emotions are employed to progress a story in a coherent way and generate novel situations, and how the dramatic tension of the story in progress can be employed to evaluate its interestingness. The model is implemented in a computer program named MEXICA [Pérez y Pérez, R., & Sharples, M. (2001). MEXICA: a computer model of a cognitive account of creative writing. Journal of Experimental and Theoretical Artificial Intelligence, 13(2), 119–139]; this work concentrates on the role of emotions in plot generation. The main claim is that a story can be represented as a cluster or group of emotional links and tensions between characters that progresses over story-time; story-actions work as operators that modify such clusters. I present results showing how story generation is affected by various model parameters. This approach means the program is flexible, as it avoids using predefined story-structures or characters’ goals to drive story generation. Furthermore, evaluation of computer generated stories showed that MEXICA’s stories were most often selected as the best story. This suggests that the story-generation mechanisms within MEXICA are sufficiently rich to generate interesting and novel stories.

Keywords: MEXICA; ACAS-Constant; Creativity; Plot generation; Emotions; Engagement; Reflection; Storyteller

1. Introduction

Computer models of emotions constitute a fascinating research topic and, although there are some pioneering works in this domain (e.g. Abelson, 1963), only recently it has received the attention it deserves. The work of researchers like Dyer (1987), Ortony, Clore, and Collins (1994), Picard (1997), Cañamero (2001), etc., have enormously contributed to the development of the area. The kind of approaches, motivations and goals that researchers interested in computer and emotions pursue are very different. But, following Wehrle (2001), it is possible to classify their work in two main groups:

1. The scientific, whose purpose is to improve our understanding about the nature and implications of the emotional phenomena. In this way, one can find examples of computer models of emotions in fields such as neuroscience (e.g. Armony & LeDoux, 2000), cognitive science (e.g. Belavkin, 2001), education (e.g. Connati, 2002).

2. The technological, whose purpose is to employ computer models of emotions as tools to solve engineering problems. Wehrle suggests human computer interaction
is a good example of this category, where the goal is to develop systems that allow a more efficient and pleasant interaction between humans and computers. Some examples are Rosis de (2002), Paiva et al. (2003), Ward and Marsden (2003).

The relation between emotions and creativity is strong. Gelernter describes emotions “as the glue of thought” during the creative process (1994, p. 5); the poet Wordsworth describes creativity as “emotion recollected in tranquillity” (Wordsworth, cited in Sharples, 1999, p. 48). Nevertheless, even when this relation is clearly important, there are few works that describe computer models of emotions and creativity (e.g. Elliott, Brzezinski, Sheth, & Salvatoriello, 1998; Mateas & Stern, 2000). This paper offers an example of how to exploit the metaphor of emotions in computer models of creativity. It is based on a computerised storyteller named MEXICA. The challenge of computer models of writing consists in overcoming the complexity of generating coherent and interesting scenarios: “The automatic generation of narrative plot is extremely difficult... Guaranteeing a consistent, plausible, plot can easily degenerate into the classic AI search problem” (Elliott et al., 1998). The main claim of this document is that a story can be represented as a cluster of emotional links and tensions between characters that progress over story-time; story-actions work as operators that modify such clusters. This type of representation is flexible as it allows unfolding narratives in consistent surprising ways without the use of predefined story-structures or explicit characters’ goals.

MEXICA is a complex system; a description of its architecture and main processes can be found in Pérez y Pérez and Sharplees (2001). This document concentrates on explaining the model of emotions for plot generation used in MEXICA, particularly how emotions are employed to progress the story in a coherent way and generate novel situations, and how dramatic tension can be employed to evaluate interestingness.

The paper is organised as follows: Section 2 describes how emotional links and tensions between characters are represented in MEXICA and how they are employed to produce material; Section 3 provides a detailed example of plot generation; Section 4 analyses the procedure to create novel situations; Section 5 describes how tensions changes as the story progress; Section 6 evaluates MEXICA and the main characteristics of the model; finally, Section 7 offers a conclusion.

2. MEXICA

MEXICA is a computer program that develops frameworks for short-stories about the Mexicas, the ancient inhabitants of what today is México city, also inaccurately known as Aztecs (see Escalante Gonzalez, 1995). From now onwards, the program’s outputs are referred to as stories or short-stories. Figs. 1 and 2 show two stories produced by the system. MEXICA is based on (a) clusters of emotional links and tensions between characters, (b) primary operators (with their preconditions and postconditions) that transform such clusters. Stories are represented as clusters of emotional links and tensions between characters that progress over story-time; primary operators, also referred to as story-actions, transform such clusters by augmenting or decreasing their content.

The user of the system is able to define an important number of parameters that control the system. So, this person defines all primitive operators (i.e. all story-actions), the number of characters participating in each action, and their preconditions and postconditions. The user also associates a predefined text to each story-action; in this way, when the system finishes plot generation, all story-actions are automatically substituted by their corresponding texts. In MEXICA, all preconditions and postconditions are formed by emotional links and tensions between characters. For example, the operator princess healed jaguar knight includes as a precondition that the knight is injured or ill (the system represents this situation as a tension; see below for an explanation), and as a postcondition the fact that the knight is cured by the princess (so, the tension is deactivated) and that the knight develops a feeling of gratitude towards the princess (an emotional link). Each time the system applies a primary operator the story-time increases in one unit. The following lines describe how the system represents emotional links, tensions and how the system unfolds stories.

2.1. Emotional links

Emotions are essential elements in fiction. In their work, Ortony et al. (1994, p. 156) describe two classes of what they call Attraction Emotions: “One corresponds to liking or attraction and is occasioned by reacting positively toward some appealing object, and the other, corresponding to aversion or dislike, is occasioned by reacting negatively towards some unappealing object”. An example of the former is love and an example of the latter is hate. For centuries love and hate have played a fundamental role in the unravelling of stories; so, MEXICA employs them to drive plot development. Due to its complexity, other types of emotions are not included in the present prototype. Nevertheless, future versions of the system must include them.

In MEXICA emotional links work as preconditions and postconditions of primary operators. The system includes two predefined types of emotional links which, following Dyer (1987) who affirms that “all affects can be represented simply in terms of a positive or negative state of arousal...” (see also Ortony et al., 1994), are implemented in discrete terms with a value in the range of −3 to +3:

- **Type 1** represents a continuum between love (+3) and hate (−3); here, love is interpreted as brotherly love. Intermediate values indicate milder versions of these
Jaguar knight was an inhabitant of the great Tenochtitlan. Princess was an inhabitant of the great Tenochtitlan. Tlaloc — the god of the rain — was angry and sent a storm. The heavy rain damaged the old wooden bridge. When the jaguar knight tried to cross the river the bridge collapsed injuring badly jaguar knight’s head. Princess knew that jaguar knight could die and that princess had to do something about it. Princess had heard that the tepeschouhtli was an effective curative plant. So, princess prepared a plasma and applied it to jaguar knight’s wounds. It worked and jaguar knight started to recuperate! Jaguar knight realised that princess’s determination had saved jaguar knight’s life.

During the last war princess’s father humiliated enemy’s family. Now, it was time of revenge and enemy kidnapped princess. They went to the forest where enemy tied princess to a huge rock. Exactly at midnight enemy would cut princess up. Although it was very dangerous jaguar knight decided to do something in order to liberate princess. For some minutes jaguar knight prayed to Quetzalcoatl — the feathered snake, the god between the gods — and asked for wisdom and braveness. Now jaguar knight was ready to find out its fate.

Princess was really angry for what had happened and affronted enemy. Enemy’s frame of mind was very volatile and without thinking about it enemy charged against princess. Meanwhile jaguar knight decided to start a search for enemy. After hard work and difficult moments jaguar knight could finally find enemy. Jaguar knight, full of anger, took a dagger and attacked enemy. Jaguar knight threw some dust in enemy’s face. Then, using a dagger jaguar knight perforated enemy’s chest. Imitating the sacred ceremony of the sacrifice, jaguar knight took enemy’s heart with one hand and raised it towards the sun as a sign of respect to the gods.

Jaguar knight walked towards princess. Full of admiration for all the braveness that princess had shown in those hard moments jaguar knight liberated princess! Although at the beginning princess did not want to admit it, princess fell in love with jaguar knight. Princess was kissing jaguar knight when suddenly princess recognised jaguar knight’s tattoo. It was the same as the one used by the fraternity which had murdered princess’s father some months ago. At once all those terrible memories were present again. Princess had ambivalent thoughts towards jaguar knight. On the one hand princess had strong feelings for jaguar knight but on the other hand princess abominated what jaguar knight did. Princess felt a deeply odium for jaguar knight.

Invoking Huitzilopochtli, god of the dead, princess cut jaguar knight’s jugular. The blood covered the floor. Princess was really angry for what had happened and affronted enemy. Enemy’s frame of mind was very volatile and without thinking about it enemy charged against princess. Meanwhile princess had a special affection for prince. Even when prince knew about the sympathy that tlatoani felt, prince saw a unique opportunity to become rich and attempted to take advantage of the situation by asking tlatoani for an important amount of cacauatl (cacao beans). Tlatoani always felt a special affection for prince. Even when prince knew about the sympathy that tlatoani felt, prince saw a unique opportunity to become rich and attempted to take advantage of the situation by asking tlatoani for an important amount of cacauatl (cacao beans). Tlatoani was really angry for what had happened and affronted prince. Prince, knowing that tlatoani’s life was at risk, resolved not to cure tlatoani. Prince decided to go back to the Great Tenochtitlan City. The injuries that tlatoani received were very serious. However, tlatoani knew that when a Mexica dies fighting, the Gods protect that soul in order it arrives safely to the other world. So, tlatoani died in peace.

Fig. 1. The Princess who Cured the Jaguar Knight. A story generated by MEXICA (originally published in Pérez y Pérez and Sharples, 2004).

Tlatoani was an inhabitant of the Great Tenochtitlan. Priest was an ambitious person and wanted to be rich and powerful. So, priest kidnapped tlatoani and went to Chapultepec Forest. Priest’s plan was to ask for an important amount of cacauatl (cacao beans) and quetzalli (quetzal) feathers to liberate tlatoani. With a hidden knife tlatoani was able to cut all the ropes and escape. Tlatoani was really angry for what had happened and affronted priest. Priest thoroughly observed tlatoani. Then, took a dagger and attacked tlatoani. Suddenly, tlatoani and priest were involved in a violent fight. In a fast movement, priest wounded tlatoani. An intense haemorrhage arouse which weakened tlatoani. Priest felt panic and ran away.

Prince was an inhabitant of the Great Tenochtitlan. Early in the morning prince went to Chapultepec Forest. Suddenly, prince realized that priest wounded tlatoani. Tlatoani always felt a special affection for prince. Even when prince knew about the sympathy that tlatoani felt, prince saw a unique opportunity to become rich and attempted to take advantage of the situation by asking tlatoani for an important amount of cacauatl (cacao beans). Tlatoani was really angry for what had happened and affronted prince. Prince, knowing that tlatoani’s life was at risk, resolved not to cure tlatoani. Prince decided to go back to the Great Tenochtitlan City.

Fig. 2. The kidnapped Tlatoani. A story generated by MEXICA.

In this paper, an emotional link of type 1 is represented as a solid arrow joining two characters; the intensity of the link is indicated by a signed number. Fig. 3a illustrates the fact that a knight hates an enemy (emotional link of type 1 and intensity −3).

- Type 2 represents a continuum between being in love with and feeling hatred towards. Here, to be in love is interpreted as amorous love. In this paper, an emotional link of type 2 is represented as a dashed arrow joining two characters; the intensity of the link is indicated by a signed number. Fig. 3b illustrates the fact that the princess is in love with a knight and that the knight is also in love with the princess (two emotional links of type 2 and intensity +3). In order to simplify this notation, Fig. 3c shows the same emotional links represented as a double-headed arrow.
MEXICA allows establishing emotional links between characters and their family or friends; they are referred to as linked characters. For example, if a knight rescues the princess, she and all her friends (i.e. all linked characters) develop a positive emotional link of type 1 towards the knight.

2.2. Tensions

In MEXICA tensions play two fundamental roles:

As a way to evaluate interestingness. Claude Bremond (1966/1996) classifies the sequences of events in a narrative as processes leading towards either an improved or degraded state, which can or cannot be reached. In its simplest form, during a process of degradation a state of tension is created by introducing forces or obstacles that oppose a more satisfactory state. On the other hand, during the development of a process of improvement, an obstacle that stands against such a more satisfactory state is eliminated. These two processes can be combined in intricate ways producing complex stories. In MEXICA, it is assumed that a story is interesting when it includes degradation-improvement processes (i.e. conflict, complication and resolution). The tensional representation is a graphic that shows the value of the story-tension over time (see Fig. 4).

As postconditions and preconditions of primary operators. Primary operators can trigger or deactivate tensions. Examples of situations that produce an increment in the story-tension are: the death of a character (Actor dead), when two different characters are in love with a third one (Love competition), when the life of a character is at risk (Life at risk) (see Table 1). In this paper, tensions between personae are represented as sharp arrows joining two characters; the type of tension is indicated by a mnemonic (Ad when an actor dies, Lc for love competition, Lr when the life of a character is at risk, and so on). For example, if the jaguar knight and the tlatoani (the king) fall in love with the same princess, a tension between them due to Love Competition is triggered (each tension has associated a value defined by the user). Fig. 3d illustrates this situation. If the princess dies, the love competition between the knight and the tlatoani ends and the tension in the story decreases. The structure tensional representation records the value of the tension on the story over time.

2.3. Unfolding stories

The previous sections have described the structural components of the model. In this section, I describe how the knowledge structures are initialised from these (structural) components (phase alpha) and how MEXICA manipulates these components dynamically to generate stories (phase beta).

Phase a. Fig. 5 summarises how phase a works: the user provides a group of story-actions or operators, and their corresponding preconditions, postconditions and texts. For example, the precondition of the action \( A \) cures \( B \) is that character \( B \) is ill or wounded (a tension of type health at risk); the consequences of performing this action are that \( A \) heals \( B \) (deactivation of the tension health at risk) and that character \( B \) is very grateful towards character \( A \) (an emotional link from \( B \) towards \( A \) of type 1 and intensity +3):

\[
\text{A cured B} \\
\text{Precondition} \\
B \text{ is ill or wounded (tension of type health of B is at risk)} \\
\text{Postcondition} \\
A \text{ heals B (deactivation of the tension health at risk)} \\
\text{B is very grateful towards A (an emotional link from B towards A of type 1 and intensity +3)} \\
\text{Additional Text} \\
@A \text{ went in search of some medicinal plants and cured } \@B. \text{ As a result } @B \text{ was very grateful to } @A
\]

In the same way, the user also provides a set of previous stories (sequences of story-actions). MEXICA employs this material to create in memory three types of knowledge structures: atoms (clusters of emotional links and tensions between characters, which are associated to operators that transform such clusters), the tensional representation (a vector representing the value of the tension in the story over time) and the concrete representation (a copy of the file of previous stories employed to break impasses). The following is an example of a previous story:

\[
\text{A cured B} \\
\text{Precondition} \\
B \text{ is ill or wounded (tension of type health of B is at risk)} \\
\text{Postcondition} \\
A \text{ heals B (deactivation of the tension health at risk)} \\
\text{B is very grateful towards A (an emotional link from B towards A of type 1 and intensity +3)} \\
\text{Additional Text} \\
@A \text{ went in search of some medicinal plants and cured } \@B. \text{ As a result } @B \text{ was very grateful to } @A
\]
The enemy wounded the knight.
The princess cured the knight.
The knight killed the enemy.
The knight rewarded the princess.
The end.

MEXICA transforms this sequence of story-actions in a cluster of emotional links and tensions between characters that evolves over time (see Fig. 6). Fig. 6a shows how the story starts: as a consequence of performing the first action, the enemy triggers a tension of type Health at Risk towards the knight and the knight establishes an emotional link of type 1 and intensity \(-3\) towards the enemy (the knight hates the enemy) (these are the postconditions of the action wounded defined by the user). Fig. 6b illustrates the first transformation of the cluster after the operator cured is...
performed: the tension of type Health at Risk is deactivated by the princess and the knight develops an emotional link of type 1 and intensity +3 towards the princess (the knight is very grateful towards the princess). Fig. 6c shows the second transformation after the action killed is executed: the knight triggers a tension of type Actor Dead towards the enemy and, since the enemy is dead, the emotional link of type 1 and intensity $-3$ that the knight developed towards the enemy is eliminated. Finally, Fig. 6d depicts the last transformation after the action rewarded is performed: the princess develops an emotional link of type 1 and intensity +3 towards the knight (she is very grateful towards the knight). MEXICA records the progress of emotional links and tensions through the previous story and the operators employed to transform each cluster in a group of knowledge structures known as atoms; thus, the system establishes appropriate ways of transforming clusters (see Fig. 7). Notice that inside an atom the program substitutes all characters by variables (cf. Figs. 6 and 7). In this example, MEXICA registers in the first atom that when character B is wounded by character A and character B hates character A, the cluster evolves adequately if a third character (character C) performs the operator $C$ cured $B$; Fig. 7a shows this situation. In the same way, Fig. 7b illustrates how the system registers that when character B hates character A and at the same time B is very grateful towards character C, one logical way of transforming the cluster is executing the operator $B$ killed $A$; and so on. Atoms can be very complex and when the system is given enough Previous Stories they might include several possible operators to evolve one cluster. Atoms are employed during the engagement–reflection cycle to generate a new story.

During phase $\alpha$ MEXICA creates the structure Tensional Representation for each of the tales in the Previous Stories (see Fig. 8). In order to assure interestingness, during the engagement–reflection cycle MEXICA employs these structures to guide the development of the Tensional Representation of the story in progress (it is assumed that all Previous Stories are interesting).

Phase $\beta$. MEXICA develops stories as a result of an engagement–reflection cycle. The system creates for each persona in a story in progress a structure known as Character’s Context; this structure represents what a persona is aware of in the story-world. Like Atoms, Characters’ Contexts are comprised of emotional links and tensions between characters. That is, Characters’ Contexts are clusters that evolve over story-time. Thus, engagement consists in finding interesting ways of transforming them. The process works as follows (see Fig. 9). The user provides a story-action that generates the initial characters’ contexts. Then, MEXICA probes memory looking for an atom equal to any of the characters’ contexts; if the search fails, MEXICA looks for an atom similar to any of the characters’ contexts in at least 50%: this parameter is known as the ACAS-Constant and can be modified by the user. So, MEXICA will match an atom which is between the ACAS-Constant (in this case 50%) and 100% alike the
characters’ contexts. Once an atom is matched, MEXICA eliminates all those operators that do not satisfy a group of constraints known as guidelines (see below for an explanation of the guidelines). The next step is to select at random between the remainder operators one to transform the Characters’ Contexts (i.e. the system selects a story-action to continue the story in progress). Then, the cycle starts again. Engagement ends when a fixed number of transformations of clusters have been performed (this is a parameter defined by the user whose default value is 3) or when the system cannot match any atom and an impasse is declared. During reflection MEXICA:

1. Verifies that all preconditions in the narrative are satisfied; if it is necessary, the system inserts in the story in progress actions to meet unfulfilled preconditions and in this way assure coherence. Notice that during engagement preconditions are ignored.

2. Evaluates the interestingness of the story in progress. A story is interesting when its Tensional Representation includes degradation-improvement processes (all Previous Stories satisfy this condition). The system employs the Tensional Representation of the Previous Stories as models to guide the development of the Tensional Representation of the current story. In this way, if the system detects that the behaviour of the tension in the story in progress is not similar to any of the previous ones, e.g. the narrative is boring because the tension does not increase, a message known as the interestingness-guideline is sent to the engagement process. The purpose of this message is to request the selection of operators that increment the dramatic tension in the tale. Thus, during engagement, all the retrieved operators that do not satisfy this constraint are eliminated. The interestingness-guideline might also request to decrease the tension, or keep it on the same level.

3. Evaluates the novelty of the story in progress. MEXICA compares the sequence of actions in the current tale against the Previous Stories. If they are too similar the novelty-guideline is activated requesting the selection of operators that have not been employed more than twice in the past.

Fig. 8. The tensional representation of three of the previous stories.

![Previous Story 1](image1)

![Previous Story 3](image2)

![Previous Story 7](image3)

Fig. 8. The tensional representation of three of the previous stories.

An initial action is provided by the user.

The action is executed and a new context (cluster of emotional links and tensions) is generated.

A set of operators or story-actions are retrieved from memory: those that do not satisfy the guidelines are eliminated.

One action is selected at random.

The system evaluates the coherence, interestingness and novelty of the story in progress; based on this evaluation, guidelines are set to constrain the retrieval of actions during engagement.

If no atom is matched an impasse is declared.

The system attempts to break the impasse inserting a new action.

After three actions have been generated during engagement.

Fig. 9. Phase β: the engagement–reflection cycle.
4. Breaks impasses. MEXICA tries to break an impasse by “copying” the way actions have been used in Previous Stories. The process consists of: (a) obtaining from the Concrete Representation all those actions that have followed in Previous Stories the deed which triggered the impasse; (b) joining the action to the end of the tale in progress (modifying Characters’ Contexts) and switching back to the Engaged State.

The last process that MEXICA performs is the Final Analysis. This process consists in analysing the story in progress in order to insert events that represent explicit goals to achieve by the characters in the tale. The Final Analysis helps to improve the coherence of the whole story.

3. An example of how emotions drive story generation

During the engagement–reflection cycle MEXICA represents stories in two possible ways: (a) as evolving clusters of emotional links and tensions between characters, (b) as a sequence of primitive operators (story-actions). Each representation has its own characteristics:

- Clusters are employed only during engagement. They register all events in the story in progress; therefore, the system always counts with a structure which comprises the core elements of the story produced so far in terms of emotional links and tensions between characters (MEXICA includes a group of routines to avoid that clusters grow in an unmanageable way). So, clusters work as constraints that drive story-generation; that is why MEXICA does not employ predefined story-structures. At the same time clusters are flexible enough to allow developing the story in surprising ways.

- Primitive operators or story-actions are employed during reflection; they are indispensable to illustrate the story in a suitable representation for a reader. They represent concise events and lack any information about the content or structure of the story as a whole. Story-actions’ preconditions are essential to assure coherence in the plot.

Fig. 1 shows an example of a story developed by MEXICA titled The princess who cured the Jaguar Knight. This section describes how the story is created in two parts: the first (engagement) illustrates how the initial three clusters evolve at the beginning of the story generation; the latter (engagement and reflection) shows the interplay between engagement and reflection in terms of story actions during the unfolding of the whole story.

3.1. Engagement

The user selects an initial primary operator; in this case princess healed jaguar knight. This operator creates the initial Characters’ Contexts in the story in progress (although during the generation of a story MEXICA builds a context for each character, for the sake of clarity this example is illustrated employing only one character’s context). The cluster in Fig. 10 at \( T = 0 \) represents the emotional link of type 1 and intensity +3 that the knight develops towards the princess. In this way, a link between the knight and the princess is established (this operator also produces that the princess deactivates the tension Health at risk (HR); however, at this moment such a tension is not active). During engagement MEXICA employs Characters’ Contexts as a cue to probe memory and tries to match an atom equal to any of the characters’ contexts in order to retrieve the operators necessary to transform three times the contexts. If the search fails, MEXICA looks for an atom similar to any of the characters’ contexts in at least the ACAS-Constant (for this example its value is equal to 50%). Then, the system switches to reflection (see Fig. 9).

In this case, the system matches an atom that is 50% equal to the character’s context and recovers the operator enemy kidnapped the princess. So, the first transformation (see Fig. 10 at \( T = 1 \)) increases dramatically the tension in the story in progress: the antagonist (the enemy) is introduced in the plot; he triggers a tension by making the princess a prisoner (automatically, the system locates the enemy and the princess in a hidden place in the forest; Fig. 10 indicates the location of each character); as a result, the princess and the knight hate the enemy (emotional link of type 1 and intensity –3); finally, when the system detects that the princess hates the enemy and both characters are located in the same place, it triggers a tension of type Potential danger (Pd) that the princess develops towards the enemy. MEXICA employs the new Characters’ Context to retrieve a second operator from memory: enemy reacted attacking the princess (in this case, the character’s context employed as cue to probe memory is 100% equal to the matched atom). Thus, during the second transformation the enemy puts the life of the princess at risk (Lr) (see Fig. 10 at \( T = 2 \)); as a consequence, the tension is again incremented. Finally, the system retrieves the operator jaguar knight looked for and finally found enemy’s camp (in this case, the matched atom is 50% equal to the character’s context). Thus, during the last transformation (see Fig. 10 at \( T = 3 \)) MEXICA locates the three characters in the same place: since the knight hates the enemy and both are at the same place, the system increases the tension in the story by triggering Potential danger (Pd) from the knight towards the enemy. At this point MEXICA has established some of the core characteristics of the story in progress: an obstacle to overcome (to rescue the princess), a victim (the princess), an antagonist (the enemy), and a possible hero to rescue the victim (the knight). At this moment the knight is only a possible hero because nobody (including the system) knows the direction that the story is taking. Although the initial emotional link between the princess and the knight (he feels grateful towards her) offers a reason why the knight might go and rescue the princess, MEXICA avoids characters’ goals and therefore the story can follow any
direction; for example, the knight might become an accomplice of the enemy, or he might be a coward and avoids confronting the enemy, or he might go and save the princess. What happens next depends on previous stories and the engagement–reflection process.

3.2. Engagement and reflection

The story developed so far also can be represented in terms of primary operators or story actions (the initial action is represented in bold):

***NEW STORY:

**Time = 0:** Princess healed jaguar knight.

**Time = 1:** Enemy kidnapped princess.

**Time = 2:** Enemy reacted attacking the princess.

**Time = 3:** Jaguar knight looked for and finally found enemy’s camp.

These are the operators employed so far to transform the Characters’ Contexts. MEXICA’s outputs are the result of the interaction between engagement and reflection; that is why the material produced so far during engagement does not flow adequately. The degree of this interaction is illustrated through a set of structures called engagement–reflection maps. They allow visualising MEXICA’s dynamics in terms of engagement and reflection during the development of a story. Fig. 11 shows the engagement–reflection map of the story *The princess who cured the Jaguar Knight*. The following lines explain how to interpret this map. As mentioned above, the initial action is given by the user at time = 0, the first action during engagement is generated.
at time = 1, the second at time = 2, and the third at time = 3. The engagement–reflection map 1, illustrated in Fig. 12a, shows these first steps. The cell in black indicates the initial action given by the user. Cells in white indicate the actions generated during engagement; cells in grey indicate the actions generated during reflection. The number of the map and the percentage of events generated during reflection and engagement is indicated at the bottom of the map. The numbers in the second column indicate the story-time in which actions are generated. The position of the entry indicates the position of events within the story, with the start of the story at the top and the end of the story at the bottom of the map. The order in which actions are presented in one cell is the same order they appear in the story. Thus, map 1 indicates that the order of actions in the story produced so far is 0, 1, 2, 3.

During reflection the system inserts four actions at times 4, 5, 6 and 7 to satisfy the preconditions of the story in progress. Three of those actions are inserted at the beginning of the story and the fourth just after the action generated at time = 1. All these are represented in the engagement–reflection map 2 illustrated in Fig. 12b.

***NEW STORY:

**Time = 4:** The character jaguar knight was introduced in the story.

**Time = 5:** The character princess was introduced in the story.

**Time = 6:** Jaguar knight suffered an accident.

**Time = 0:** Princess healed jaguar knight.

**Time = 1:** Enemy kidnapped princess.

**Time = 7:** Princess decided to affront the enemy.

**Time = 2:** Enemy reacted attacking the princess.

**Time = 3:** Jaguar knight looked for and finally found enemy’s camp.

MEXICA inserts actions at time 4 and 5 to satisfy the general precondition that states that all characters participating in an action must be located in the same place. Action at time 6 is inserted to satisfy the preconditions of the action where the princess cures the knight (to cure...
someone that person must be ill or injured; a tension due to health at risk). Action at time 7 is inserted to fulfill the preconditions of the event where the enemy attacks the princess. Italics indicate actions generated during reflection. So far, map 2 shows that the first three actions that the reader finds in the story in progress are generated during reflection at time = 4, time = 5 and time = 6. The fourth event in the story is given by the user at time = 0. The fifth event that the reader finds in the story in progress is generated during engagement at time = 1, and so on. Now MEXICA switches back to engagement and generates three events at time = 8, time = 9 and time = 10. It switches to reflection but all the preconditions are satisfied, so no event is inserted. It switches back to engagement and produces an action at time = 11, at time = 12 and then an impasse is declared. The engagement–reflection map 3 represented in Fig. 12c illustrates the development of the story at this moment.

***NEW STORY:

**Time = 4:** The character jaguar knight was introduced in the story.
**Time = 5:** The character princess was introduced in the story.
**Time = 6:** Jaguar knight suffered an accident.

**Time = 0:** Princess healed jaguar knight.
**Time = 1:** Enemy kidnapped princess.
**Time = 7:** Princess decided to affront the enemy.
**Time = 2:** Enemy reacted attacking the princess.
**Time = 3:** Jaguar knight looked for and finally found enemy’s camp.
**Time = 8:** Jaguar knight decided to attack the enemy.
**Time = 9:** As a result of the fight jaguar knight killed enemy.
**Time = 10:** In this way jaguar knight rescued the princess.
**Time = 11:** As a consequence the princess fell in love with jaguar knight.
**Time = 12:** Princess decided to kill jaguar knight.

At time = 14 all characters are dead and therefore the story is finished. MEXICA switches to reflection to perform the Final Analysis and inserts three events: at time = 15 MEXICA makes explicit the princess’ decision of curing the knight; at time = 16 MEXICA makes explicit the knight’s decision of rescuing the princess; and at time = 17 MEXICA makes explicit the internal conflict that the princess experiments towards the knight. So, the map is finally completed (see Fig. 11).

***NEW STORY:

**Time = 4:** The character jaguar knight was introduced in the story.
**Time = 5:** The character princess was introduced in the story.
**Time = 6:** Jaguar knight suffered an accident.

**Time = 0:** Princess took the decision of healing jaguar knight.
**Time = 1:** Enemy kidnapped princess.
**Time = 5:** Jaguar knight took the decision of rescuing the princess.
**Time = 7:** Princess decided to affront the enemy.
**Time = 2:** Enemy reacted attacking the princess.
**Time = 3:** Jaguar knight looked for and finally found enemy’s camp.
**Time = 8:** Jaguar knight decided to attack the enemy.
**Time = 9:** As a result of the fight jaguar knight killed enemy.
**Time = 10:** In this way jaguar knight rescued the princess.
**Time = 11:** As a consequence the princess fell in love with jaguar knight.
**Time = 12:** Princess decided to kill jaguar knight.
**Time = 13:** But suddenly the princess discovered that jaguar knight murdered her father.
**Time = 14:** Finally, princess decided to kill herself.

The only difference between map 3 and map 2 is that five events have been included during engagement to the story in progress between time = 8 and time = 12. MEXICA switches to reflection and inserts an action at time = 13 to satisfy the preconditions of the action generated at time = 12 (it is necessary to justify why the princess kills the knight; see more about this point in the next section). An event is inserted at the end of the story at time = 14 to try to break the impasse. Map 4 in Fig. 12d reflects all these changes.

***NEW STORY:

**Time = 4:** The character jaguar knight was introduced in the story.
**Time = 5:** The character princess was introduced in the story.
**Time = 6:** Jaguar knight suffered an accident.

**Time = 0:** Princess healed jaguar knight.
**Time = 1:** Enemy kidnapped princess.
**Time = 7:** Princess decided to affront the enemy.
**Time = 2:** Enemy reacted attacking the princess.
**Time = 3:** Jaguar knight looked for and finally found enemy’s camp.
**Time = 8:** Jaguar knight decided to attack the enemy.
**Time = 9:** As a result of the fight jaguar knight killed enemy.
**Time = 10:** In this way jaguar knight rescued the princess.
**Time = 11:** As a consequence the princess fell in love with jaguar knight.
**Time = 13:** But suddenly the princess discovered that jaguar knight murdered her father.
**Time = 17:** The princess felt huge clashing emotions towards the knight.
**Time = 12:** Princess decided to kill jaguar knight.
**Time = 14:** Finally, princess decided to kill herself.
MEXICA substitutes all Primitive Actions with associated texts producing the final story shown in Fig. 1.

4. How emotions drive novelty

There is a peculiar moment in the development of the tale when, after the knight rescues the princess and she falls in love with him, the story seems to take a senseless direction.

***NEW STORY:

Time = 10: In this way jaguar knight rescued the princess.
Time = 11: As a consequence the princess fell in love with jaguar knight.
Time = 12: Princess decided to kill jaguar knight.

An action which, at least at that moment, does not have any connection with the previous events in the story and which appears to be completely illogical (the princess killing her beloved jaguar knight) is chosen during engagement at time 12 as the next event in the tale. The following lines explain how this case arises. Although the system always employs the context of all alive characters to probe memory (in this case the jaguar knight and the princess), for the sake of a clear example jaguar knight’s context is ignored. Princess’ context after action at time 11 is performed can be seen in Fig. 13. Princess’ context encodes the most relevant characteristics of the core events in the story in progress:

- **Jaguar knight has an emotional link of type 1 and intensity +3 towards princess:** this emotional link is triggered when the princess heals the knight.
- **Princess has an emotional link of type 1 and intensity −3 towards enemy:** this emotional link is triggered when the enemy kidnaps the princess.
- **Jaguar knight has an emotional link of type 1 and intensity −3:** because jaguar knight is a linked character to the princess, this emotional link is also triggered as a consequence of the kidnapping.
- **Princess has an emotional link of type 1 and intensity +3 towards jaguar knight:** this emotional link is triggered as a consequence of the action where the knight rescues the princess.
- **Jaguar knight has an emotional link of type 1 and intensity +2 towards himself:** because the knight is a linked character to the princess, he develops a very positive emotional link towards himself as a consequence of rescuing the princess.
- **Princess has an emotional link of type 2 and intensity of +3 towards jaguar knight:** this emotional link represents when the princess falls in love with the knight.
- **Enemy is dead due to jaguar knight’s attack:** this tension represents that the knight killed the enemy.

Now, MEXICA employs princess’ context as a cue to probe memory and tries to match an atom; however, the system fails. Then, MEXICA attempts to find an atom at least 50% similar to princess’ context; this time, it matches the structure shown in Fig. 14a. Fig. 14b clearly illustrates how princess’ context is equal to 54% of the atom (cf. Fig. 13).

The previous story that originated the matched atom describes a princess who falls in love with a knight that rescues her from a kidnapper; when she realises that the knight is in love with another woman (tension due to love competition) the princess decides to kill her rival. This is recorded in the set of operators of the atom as \( V_c \) killed...
Vb (atoms substitute characters by variables: in this case Vc represents variable c and Vb variable b). Fig. 14a represents this structure. Although this atom encodes a context different to the actual context of the story in progress, MEXICA recognises enough similarities between them and matches the atom. This makes sense because both stories share a similar prior episode (an enemy who kidnaps the princess and a knight who rescues her). So, it is not strange that at least 50% of the atom is equal to the princess’ context.

Once MEXICA matches the atom in memory it correlates all characters in princess’ context with all variables representing characters in the atom. However, character Vb cannot be associated (the correlation between characters is established as follows: Va corresponds to jaguar knight; Vb is undetermined; Vc corresponds to princess; Vd corresponds to enemy). The comparison of Fig. 14a and b illustrates this point. So, the atom only includes one operator or possible story-action to be performed which is not fully instantiated: princess killed someone. To solve this problem MEXICA employs a set of routines developed to instantiate characters. (The instantiation of characters is a key problem during automatic plot generation. The system needs to introduce new characters to progress the story; however, all characters within the narrative must have a purpose, otherwise the program might generate an inconsistent tale. For details of the instantiation routines in MEXICA, see Pérez y Pérez, 1999.) In this case, the system uses a routine that applies a rule taught in courses of theatre and improvisation that Johnstone (1989) refers to as reincorporating. It works as follows: to avoid lack of structure and coherence when improvising a story, characters used previously in a tale must be reincorporated. In this example, the only available character to be reincorporated is jaguar knight (the enemy is dead). So, the next action generated by MEXICA in the story in progress is princess killed jaguar knight. The circumstances preceding the action where the princess kills the lady (in the tale in the Previous Stories) are completely different to the circumstances preceding the action where the princess kills jaguar knight (in the story in progress). In the former case, a tension due to a Love Competition between the princess and the lady causes the murder of the lady; in the latter case there is no reason to justify the action. During reflection MEXICA must look for an action that explains princess’ behaviour in order to produce a coherent story. The relevant point to observe here is how the emotional links and tensions are used to represent the story-world and, together with the instantiation routines, generate a unique situation absent from the tales in the file of Previous Stories (a princess killing her lover).

MEXICA switches to reflection and detects that it is necessary to justify why the princess killed her lover. Now, in order to perform the action where character A kills character B, it is necessary that A hates B. This action has two consequences: character B is dead; all friends and family of B (linked characters) hate character A:

<table>
<thead>
<tr>
<th>Action</th>
<th>Preconditions</th>
<th>Postconditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A kills B</td>
<td>A hates B</td>
<td>B is dead</td>
</tr>
</tbody>
</table>

All characters linked to character B hate character A

So, the princess must hate the knight in order to kill him. However, in the current example the princess is in love with the knight. Thus, it is necessary to produce a tension due to clashing emotions (i.e. it is necessary that, at the same time, the princess loves and hates the knight) in order to satisfy the action’s requirement. MEXICA is provided by the user with a set of actions that are employed to solve this type of situations; the purpose of these special actions is to create an event where character A realises about an unforgivable action performed by character B which produces that A hates B:

A discovers an unforgivable action performed by B

<table>
<thead>
<tr>
<th>Action</th>
<th>Preconditions</th>
<th>Postcondition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A hates B</td>
<td>A likes very much B</td>
<td>A hates B</td>
</tr>
</tbody>
</table>

Some texts associated to this action are:

TEXT1: @A was kissing @B when suddenly @A recognised @B’s tattoo. It was the same as the one used by the fraternity which had murdered @A’s father some months ago. At once all those terrible memories were present again.

TEXT 2: @A was very happy to have a strong relationship with @B. Suddenly, an old strange man arrived and observed carefully @B; there was no doubt, @B was the murder of @A’s brother. @A was shocked and a huge anger rose inside @A.

Where @A is substituted by character A and @B is substituted by character B. Notice that since the princess is in love with the knight she belongs to the group of characters linked to him. The postconditions of the action where character A kills character B specify that all characters linked to B hate the murderer; so, as a consequence of her action, the princess hates herself. In this way, the precondition of the action where the princess commit suicide (character A kills character A) is fulfilled.

5. The tensional representation

Fig. 4 illustrates the tensional representation of the story The Princess who Cured the Jaguar Knight where three well-defined parts or episodes, each one coinciding with the three degradation-improvement processes in the story, can be observed. The following lines describe the characteristics of each episode.
**Episode 1.** The first episode ranges from the first action to the event where the princess cures jaguar knight. The first two actions introduce the main characters in the story. The accident suffered by the knight constitutes the event with the highest tension in the episode. The reaction of the princess produces that jaguar knight develops a strong emotional link towards her. In this way, when the enemy kidnaps the princess, the knight has a motive to go and rescue her.

**Episode 2.** The kidnapping action marks the beginning of the second episode, which ends when the princess falls in love with the knight. The kidnapping action introduces the antagonist in the story; in this example that role is played by the enemy. This episode can be subdivided in two sections. The first section includes the events where the enemy kidnaps the princess, the princess insults the enemy and he responds by attacking her. The second section includes the events where the knight finds, attacks and kills the enemy, rescues the princess and the princess falls in love with him. During the first section the Tension to the Reader is incremented (to make the story more interesting) not just by making the princess a prisoner of the enemy, but also by putting her life at risk when the enemy attacks her; so, this first section drives the story towards the climax. During the second section the Tension to the Reader reaches one of its highest points when the knight faces the enemy and decides to attack him. Then, when the enemy is killed and the princess is rescued, all tensions are released. This is followed by the action where the princess falls in love with the knight. Thus, this second section reaches the climax and releases all tensions.

**Episode 3.** The third episode starts when the princess realises about knight’s tattoo and finishes with the last action in the tale. The story takes an unexpected twist when the princess realises that the knight participated in her father’s murder. The story ends with the princess killing the man she loves and also killing herself. Thus, this episode introduces an abrupt new direction in the unfolding of the story, which leads towards an unforeseen end.

MEXICA evaluates this story as interesting because it includes three degradation-improvement processes.

6. Evaluation

MEXICA was evaluated by means of an Internet questionnaire; 50 subjects from 12 different countries answered it. The questionnaire was presented as a research in computer-based story generation. Seven stories were included: four produced by MEXICA, one produced by a program based on story-grammars known as GESTER (Pemberton, 1989), one produced by a program based on a computer model of creativity known as MINSTREL (Turner, 1994), and one written by the author of this research known as the Human story (this fact was not mentioned to the subjects participating to avoid prejudices in their answers). Two of MEXICA’s stories were generated employing the full engagement–reflection cycle (ER) and two employing only the engagement mode (E), i.e. the process to break impasses, the final analysis and the evaluation of interestingness, coherence and novelty were deactivated. To include another variable in the analysis, one of the ER stories and one of the E stories were forced to have low values for the variable Tension to the Reader, i.e. MEXICA was forced to produce two “boring” stories. In this way, it was possible to evaluate if the method employed to generate interesting stories worked. So, the four MEXICA stories were identified as ER, ER-boring, E, E-boring. GESTER is a program that generates story outlines based on a story-grammar derived from medieval French epics. MINSTREL writes short stories about King Arthur and his knights of the round table. It is a case-based system where past stories are recorded in an episodic memory. All the elements that comprise a story are represented as schemas. Thus, writing consists of instantiating a predefined schema that make up the theme. When MINSTREL cannot find events to instantiate a theme a set of heuristics (called Transform Recall Adapt Methods or TRAMS) are employed to modify episodes in memory and in this way create novel scenes. The human story provides a comparison between human and computer-generated stories.

The questionnaire was divided in two parts:

1. In the first part subjects were asked to evaluate the flow and coherence, structure, content, suspense and overall quality of each of the seven narratives on a five-point scale (5 = very good, 1 = very poor). The results of the first part of the questionnaire are originally published in Pérez y Pérez and Sharples (2001). MEXICA-ER got the highest rates, including the Human story, in all categories.

2. In the second part of the questionnaire subjects ranked the seven stories: one for the best, seven for the worst. Fig. 15 shows those stories ranked as the best: 58% of the subjects considered MEXICA ER as the best story, 24% chose the human story as the best one, 12% selected MINSTREL and 6% MEXICA E-boring story.

These results suggest that:

- The use of emotional links and tensions are an adequate manner of producing coherent sequences of events.
- The use of the Tensional Representation as a way to evaluate interestingness is adequate. The rates obtained from the seven narratives in the suspense class situated the two MEXICA boring stories in the last positions and MEXICA ER, with higher values of Tension, in the first position.
- MEXICA is able to develop stories at least similar to those produced by previous programs.
MEXICA and MINSTREL are the programs that obtained the highest scores. Each row of Table 2 compares the comments made by the same subject about the stories produced by these programs. These comments are included since they allow visualising how some subjects perceived the evaluated stories, information that cannot be inferred from the answers in the questionnaire.

One of the main claims of this work is that MEXICA’s outputs are the result of the *interaction* between engagement and reflection. To evaluate the degree of this interaction the engagement–reflection maps are employed. They are useful to visualise MEXICA’s dynamics in terms of engagement and reflection during the development of a story. The engagement–reflection map of the story analysed in this paper (see Fig. 11) clearly shows:

- How the order in which the story is presented to the reader is not the same order in which it is generated.
- Engagement and reflection both contribute to writing different parts of the story in a dynamic manner. Furthermore, the story develops in a non-linear way rather than linearly progressing from the start of the story to its end.
- Most importantly, it clearly shows how the final story is the result of interactions between engagement and reflection: 50.0% of the story is created during reflection and 44.4% during engagement (the user gives the first action, i.e. 5.6% of the story). Notice how, as a result of the engagement–reflection cycle, MEXICA intercalates different events during the development of the story. Each time a new action is inserted the story context is modified affecting the possible following actions to be retrieved. In the same way, all those events retrieved from memory whose preconditions are not satisfied provoke new actions to be included in the story.

![Fig. 15. Evaluation of the best story.](image)

<table>
<thead>
<tr>
<th>MINSTREL’s story</th>
<th>MEXICA’s ER-story</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 was hard to place. It was a good story, but it made many obvious statements about what was happening—statements that could be easily inferred. Narrative #6 has a good content but contains a couple of the irritating telegram phrases that narrative #2 [GESTER story] is full of. #6 Comment: story is suspenseful. There are linguistic problems: sentence 3 and 4 duplicate information which is confusing. Too much is spelled out throughout the story. More should be implicit. Let the readers do the inference! This is a cool story, I really liked it a lot, the ending is unexpected and funny!!! Was it really machine generated or is this a filler?? Narrative 2, 4, 5 and 6 are OK. They can have some inconsistencies but overall are fine.</td>
<td>7 was poorly written but was the most interesting. Narrative #7 is good. Only in the end it becomes a bit incoherent. #7 Anaphora resolution specially bad! The ending is a anti-climactic. The overall connection of the story and complexity is impressive, though. The princesses’ conflict is well worked on and makes a good story. Narrative 7 is dense, there are different characters with ambiguous feelings and there is a story (action) really happening.</td>
</tr>
</tbody>
</table>

The first column includes the comments about MINSTREL (story 6 in the questionnaire) and second column the comments about MEXICA-ER (story 7 in the questionnaire).
MEXICA develops novel stories by finding ways of transforming characters’ contexts; such transformations produce either structures that can be matched in memory with existing atoms or structures which are new in the system (e.g. see Section 4). Its ability at finding ways of transforming known and unknown clusters of emotional links and tensions provides MEXICA with an important flexibility during plot generation. However, this flexibility might become a problem. In the case studied in this paper, at time = 12 the system selects as the next action in the story princess killed jaguar knight; this event does not fit in the story because in the previous scene the knight had rescued the princess. This situation occurs because the actual cluster of emotional links and tensions of the story in progress is only 54% alike the matched atom in memory (the ACAS-Constant has a value of 50%). In this example, the system is able to justify princess’ actions and a good story is generated.

These observations suggest that the ACAS-Constant is an important parameter for story generation. To evaluate the importance of modifying this parameter, three stories generated by the system with different values for the ACAS-Constant are compared. MEXICA creates stories as a result of an interaction between engagement and reflection. During the engagement–reflection cycle the system performs multiple processes which depend on several variables and parameters whose values change during plot generation. The interaction of all these processes determines the final output. Thus, the effects of modifying the ACAS-Constant might not be obvious in the final story and require a detailed explanation of the whole MEXICA system which is out of the scope of this paper. However, the engagement process is mainly driven by the ACAS-Constant and the knowledge-structures in memory. Therefore, we investigate the material generated during the engagement as the ACAS-Constant is varied. In this case, the three actions generated during the first engagement cycle (just after the user provides the initial action) are examined as well as their influence upon the rest of the tale. The current version of MEXICA cannot eliminate actions that have been incorporated into the story in progress. Therefore, the first three actions play a key role on the coherence and direction that the narrative follows. The story The princess who cured the Jaguar Knight (see Fig. 1) is employed as a reference to perform this comparison. That is, the initial action provided by the user, all knowledge structures in memory and all the parameters employed by the system to develop The princess who cured the Jaguar Knight – except the ACAS-Constant – are used with the same values to develop the new two stories. The ACAS-Constant for story number 1 is set to 10% and the ACAS-Constant for story number 2 is set to 80%.

When the ACAS-Constant has a medium value (50%). During the first engagement cycle the system generates the following sequences of actions:

Time = 0: Princess healed jaguar knight
Time = 1: Enemy kidnapped princess 50% (40)
Time = 2: Enemy reacted attacking the princess 100% (60)
Time = 3: Jaguar knight looked for and finally found enemy’s camp 50% (80)

The initial action is represented in bold; the number on the right side of each primary operator indicates the percentage of alikeness between the character’s context employed as cue to probe memory and the matched atom; the final number in parenthesis indicates the value of the tension after the action is performed.

The initial character’s context is employed as cue to probe memory and matches an atom which is 50% alike the context; this atom has associated the action Enemy kidnapped princess which is selected as the next event in the tale. In the previous stories, when a character is healed she goes home or rewards the person that cured her. However, in this example the story takes a different direction: the princess heals the knight and then she is kidnapped. None of the previous stories has a similar sequence of actions (although the context that this sequence produces already exists in memory. This occurs because different actions can have the same consequences). Despite the fact that the system has generated a novel sequence of events, the second action is clearly linked to the initial one through the princess, i.e. the same character participates in both actions (which is very important to maintain the coherence of the story) and the second action increments the tension in the story (i.e. it makes the story more interesting). In this way, the system advances key characters through activities within the setting to produce a plot.

The new character’s context matches an atom which is 100% alike the context; this atom has associated the action Enemy reacted attacking the princess which is selected as the next event in the tale. Because the atom and the character’s context are 100% alike, the system is only copying what occurred in one of the previous stories. The action generated at time = 2 advances the interaction between the enemy and the princess and increments the tension in the story.

The new character’s context matches an atom which is 50% alike the context; this atom has associated the action Jaguar knight looked for and finally found enemy’s camp which is selected as the next event in the tale. Again, none of the previous stories includes this sequence of actions although there exists a story where someone is kidnapped and then rescued by another character. That is why the system finds an atom 50% alike the character’s context. The action at time = 3 contributes to the coherence and interestingness of the story by reintroducing the knight, situating the three characters in the same location and, as a consequence, incrementing the tension of the story.

After generating the first three actions MEXICA switches to reflection to continue the story; the engage-
ment–reflection cycle produces the story analysed in Section 3.1.

When the ACAS-Constant has a low value (10%). MEXICA always attempts to match the most similar atom to the character’s context employed to probe memory. Thus, if there are atoms in memory which are 50% alike the character’s context, the system matches these structures even when the ACAS-Constant has a value of 10%. This characteristic complicates the evaluation of the system for low values for the ACAS-Constant. To avoid this situation and test the behaviour of the system under the desired conditions, MEXICA was forced to match atoms which were only between 10% and 40% alike the character’s structure. During the first engagement cycle the system generates the following sequences of actions:

**Time = 0:** Princess healed jaguar knight

**Time = 1:** Eagle knight was very attached to the princess 33% (0)

**Time = 2:** The princess fell in love with jaguar knight 18% (0)

**Time = 3:** Eagle knight was in love with the princess 18% (0)

The initial character’s context is employed as cue to probe memory and matches an atom which is 33% alike the context; this atom has associated the action Eagle knight was very attached to the princess which is selected as the next event in the tale. This sequence of actions does not exist in the previous stories. However, although the second action is linked to the initial one through the princess, it does not increment the tension and therefore does not help to push the story forward.

The new character’s context is employed as cue to probe memory and matches an atom which is 18% alike the context; this atom has associated the action The princess fell in love with jaguar knight which is selected as the next event in the tale. The systems reincorporates the character Jaguar Knight to keep the coherence of the story. Actions at time = 0 and at time = 2 run smoothly together: the princess heals the knight and then she falls in love with him. But action at time = 1 does not fit with the rest of the story produced so far. The tension of the story is still zero, i.e. so far nothing interesting is occurring in the text.

Employing the new character’s context MEXICA matches another atom which is 18% alike character’s context. This atom has associated the action Eagle knight was in love with the princess which is selected as the next event in the tale. In the action at time = 3 the systems reincorporates the character Eagle Knight. But again, this action does not increment the tension in the story. Actions at time = 1 and at time = 3 run smoothly together: the knight’s feelings towards the princess grow over time; however, this couple of actions do not fit with the rest of the story.

After generating the first three actions MEXICA switches to reflection to continue the story; the engagement–reflection cycle produces the following sequence:

***NEW STORY:***

**Time = 4:** The character jaguar knight is introduced in the story.

**Time = 5:** The character princess is introduced in the story.

**Time = 7:** The character lady is introduced in the story.

**Time = 8:** Jaguar knight kidnapped the lady and took her to the forest.

**Time = 6:** Lady took a war lance and hurt seriously jaguar knight.

**Time = 13:** Jaguar knight was dying and nobody knew about it.

**Time = 9:** In the morning princess went to Chapultepec forest.

**Time = 10:** Princess realised that lady hurt jaguar knight.

**Time = 11:** Princess felt a special affection for jaguar knight.

**Time = 12:** Princes was in love with the warrior.

As a result of employing a low value for the ACAS-Constant the dynamic of the system is altered (cf. with the story The princess who cured the Jaguar Knight): 10 actions are generated during reflection (actions in italics) and only three actions are generated during engagement. Fig. 16a shows the engagement–reflection map of this story. The first part of the story – from the actions that introduce the characters in the narrative until the action where the princess heals the knight – is generated during reflection and shows a strong coherence; however, MEXICA is not capable of keeping that coherence in the second part of the story where the actions generated during engagement are included. The second part neither leads the story towards a problem that requires to be solved nor works out a problem previously established. That is why the tension in the story never decreases as is illustrated in Fig. 17a.

When the ACAS-Constant has a high value (80%). During the first engagement cycle the system generates the following sequences of actions:

**Time = 0:** Princess healed jaguar knight

**Time = 1:** Jaguar knight had a serious accident 100% (20)

**Time = 2:** Princess decided not to cure jaguar knight 100% (60)

**Time = 3:** Princess returned to Tenochtitlan City 100% (40)

The initial character’s context is employed as cue to probe memory and the system matches an atom which is 100% alike the context; this atom has associated the action
Jaguar knight had a serious accident which is selected as the next event in the tale. MEXICA repeats the same process and matches an atom which is 100% alike character’s context and retrieves action at time = 2; then, once more it matches an atom which is 100% alike character’s context and retrieves actions at time = 3. In this case, MEXICA is generating a sequence of actions identical to a sequence present in one of the previous stories. Table 3 compares the story in progress and that part of the previous story. Thus, the material produced during engagement is very predictable: the system duplicates material found in its knowledge base.

After generating the first three actions MEXICA switches to reflection to continue the story; the engagement–reflection cycle produces the following sequence:

***NEW STORY:

Time = 4: The character jaguar knight is introduced in the story.
Time = 5: The character princess is introduced in the story.
Time = 7: The character lady is introduced in the story.
Time = 8: Lady hated jaguar knight.
Time = 6: Lady wounded jaguar knight.
Time = 11: Princess took the decision of healing jaguar knight.
Time = 0: Princess healed jaguar knight.

Fig. 16. The engagement–reflection maps of the stories developed by MEXICA when (a) the ACAS-Constant is set to 10% and (b) the ACAS-Constant is set to 80%.

Fig. 17. The Tensional Representation of the stories developed by MEXICA when (a) the ACAS-Constant is set to 10% and (b) the ACAS-Constant is set to 80%.

Jaguar knight had a serious accident which is selected as the next event in the tale. MEXICA repeats the same process and matches an atom which is 100% alike character’s context and retrieves action at time = 2; then, once more it matches an atom which is 100% alike character’s context and retrieves actions at time = 3. In this case, MEXICA is generating a sequence of actions identical to a sequence present in one of the previous stories. Table 3 compares the story in progress and that part of the previous story. Thus, the material produced during engagement is very predictable: the system duplicates material found in its knowledge base.

After generating the first three actions MEXICA switches to reflection to continue the story; the engagement–reflection cycle produces the following sequence:

***NEW STORY:

Time = 4: The character jaguar knight is introduced in the story.
Time = 5: The character princess is introduced in the story.
Time = 7: The character lady is introduced in the story.
Time = 8: Lady hated jaguar knight.
Time = 6: Lady wounded jaguar knight.
Time = 11: Princess took the decision of healing jaguar knight.
Time = 0: Princess healed jaguar knight.

Table 3
A comparison between a story generated by MEXICA when the ACAS-Constant is set to 80% and one of the previous stories

<table>
<thead>
<tr>
<th>Story developed with the ACAS-Constant = 80%</th>
<th>Previous story</th>
</tr>
</thead>
<tbody>
<tr>
<td>Princess healed jaguar knight</td>
<td>Tlatoani was the proud father of the prince</td>
</tr>
<tr>
<td>Jaguar knight had a serious accident</td>
<td>Tlatoani had a serious accident</td>
</tr>
<tr>
<td>Princess decided not to cure jaguar knight</td>
<td>Prince decided not to cure Tlatoani</td>
</tr>
<tr>
<td>Princess returned to Tenochtitlan City</td>
<td>Prince returned to Tenochtitlan City</td>
</tr>
</tbody>
</table>
As in the previous example (when the ACAS-Constant is set to 10%), only three actions are generated during engagement; the rest of the events in the tale are generated during reflection. Fig. 16b shows the engagement–reflection map of the story. This situation occurs because, although the three initial actions are equal to one of the previous stories, the actions inserted during reflection to satisfy preconditions generates a new context that cannot be matched with any atom in memory when the ACAS-Constant has a value of 80%. This generates an unbreakable impasse. Nevertheless, in this case reflection helps the system to generate a novel tale and prevents it for copying the whole previous story. Thus, when the ACAS-Constant is set with a high value MEXICA requires to generate tales that resemble the previous stories, otherwise the system is unable to match atoms during engagement and an impasse that the system cannot break might be declared. The story generated with the ACAS-Constant = 80% is coherent and interesting: Fig. 17b shows how the tension grows, reaches a climax and then decreases.

The results of the comparison of MEXICA’s performance for different values of the ACAS-Constant suggest that:

- If the user sets the ACAS-Constant to a high value then the system tends to produce actions which fit well in the story but which are very predictable. At the same time, if the system generates a novel context, the possibilities of matching atoms during engagement and therefore of continuing the story employing the full engagement–reflection cycle decrease. However, the system is able to generate coherent and interesting stories.
- If the user sets the ACAS-Constant to a medium value MEXICA tends to produce novel situations but it might need to insert (some times complex) sequences of actions to maintain story coherence. This characteristic provides the system with flexibility during plot generation to generate novel, coherent and interesting stories.
- If the system matches atoms which are very unalike characters’ context it tends to generate novel situations which are unrelated to the story in progress; as a consequence, MEXICA struggles to keep the story coherent.

- All the previous stories satisfy requirements of interestingness: at the beginning of each previous story the tension increases, reaches a maximum value and then decreases (see Fig. 8). This information is encoded in the atoms (knowledge structures are built from previous stories). Thus, when MEXICA starts to develop a new tale the tension must grow (like in all previous stories). In the previous examples, when the ACAS-Constant has a medium or high value the system produces sequences of actions that increases the tension in the story during the first engagement cycle. However, when the ACAS-Constant has a low value the tension does not grow. This result suggests a correlation between the value of the ACAS-Constant and the behaviour of the tension during engagement.
- As this analysis shows, to modify the value of the ACAS-Constant does not just imply that a group of actions are not available anymore. Its major consequence is that the whole dynamic of the system is modified. This situation can be observed in the engagement–reflection maps in Fig. 16.

7. Conclusion

Emotions are the core elements in MEXICA:

- All operators’ preconditions and postconditions are described in terms of emotional links and tensions between characters.
- All knowledge structures in memory are comprised by clusters of emotional links and tensions between characters.
- A story is represented as a cluster of emotional links and tensions that evolve over time.
- Tension is used to evaluate the interestingness of the story produced by MEXICA.
- During reflection MEXICA employs preconditions and postconditions to evaluate and modify the story in progress.
- During engagement MEXICA employs clusters of emotional links and tensions (atoms) to progress the story.

MEXICA encodes the core features of the whole story in progress within characters’ contexts, i.e. clusters of emotional links and tensions between characters. Because characters’ contexts are employed as cues to probe memory and transform clusters, they work as dynamic scaffolds that drive the construction of a coherent story. By contrast, previous computer models of writing employ rigid predefined story-structures to conduct the development of stories (for an analysis of how predefined structures affect computer-creativity, see Pérez y Pérez & Sharples, 2004). It is interesting how MEXICA avoids the use of explicit goals during plot generation. Although a story produced by MEXICA might seem a goal oriented product, the system never employs explicit characters’
goals during the engagement–reflection cycle. This characteristic is relevant because many works in AI and creativity represent the creative process exclusively in terms of detailed initial and final states (e.g. Gervás, Díaz-Agudo, Peinado, & Hervás, 2005; Meehan, 1981; Turner, 1994). In this way, this work suggests that, although the generation of some creative products might be understood and explained in terms of explicit goals, they do not necessarily are exclusively the result of an explicit goal-oriented activity.

Tensions can be employed not only to generate stories but also to evaluate its interestingness (tensional representation). As far as this author know, this is the only model of story writing that assesses the interestingness of its output. Although it is clear that a judgment of the quality of a plot includes more than analysing the dramatic tension in the story, the tensional representation seems to be a good starting point for producing automatic evaluators.

MEXICA has only been tested with two types of emotional links and 10 types of tensions. The prototype requires to include more complex combinations of emotions and tensions. However, it is intriguing how this limited number of elements allows developing interesting plots. Clusters of emotional links and tensions are useful to provide automatic storytellers with the common sense necessary to develop narratives (see Pérez y Pérez & Aliseda, 2006). This might be helpful for interactive storytellers based on believable autonomous agents. This type of systems have of a conflict between agents searching how to approach their own goals and system’s necessity of moving a whole story forward:

Knowing which action to take at any given time depends not just on the private internal state of the agent plus current world state, but also on the current story state. And the current story state includes information about all the characters involved in the story, plus the entire past history of the interaction considered as a story, that is, as a sequence of actions building on each other and moving towards some end. The global nature of story state is inconsistent with the notion of an autonomous character that makes decisions based only on private goal and emotion state and local sensing of the environment (Mateas & Stern, 2000).

As it has been illustrated in this work, clusters of emotional links and tensions between characters provide a representation of a “story state”. Each character in MEXICA has its own context and therefore its own representation of the story-world (which might be different to the other persona’s context); during engagement, each character contributes with a set of options to progress the plot in a coherent way. One can think of characters in MEXICA as agents. Thus, it might be possible to employ emotional links and tensions to complement the local representation of autonomous characters in interactive storytellers and in this way help to produce adequate plots.

MEXICA exemplifies a computer model where structures representing emotions and tensions between characters drive the creative process. Nevertheless, its output is far from having the quality of human writing. It has been argued that it is necessary to be an embodied human being – to recount authentic human experience – to successfully carry out this type of creative process. For example, the words written by Hofstadter in 1979 where he speculated about computerised music-composers clearly illustrates this position:

Music is a language of emotions, and until programs have emotions as complex as ours, there is no way a program will write anything beautiful. . . A “ program” which could produce music as [Chopin or Bach] did would have to wander around the world on its own, fighting its way through the maze of life and feeling every moment of it. It would have to understand the joy and loneliness of a chilly night wind, the longing for a cherished hand, the inaccessibility of a distant town, the heartbreak and regeneration after human death. It would have to known resignation and world-weariness, grief and despair, determination and victory, piety and awe. . . Therein, and therein only, lie the sources of meaning in music (Hofstadter, 1979; cited in Hofstadter, 2002).

However, in 2002 Hofstadter instead wrote the following lines after playing on the piano a mazurka in a Chopin style composed by a computer program:

I was impressed, for the piece seemed to express something. If I had been told it had been written by a human, I would have had no doubts about its expressiveness. . . It was slightly nostalgic, had a bit of Polish feeling in it, and it did not seem in any way plagiarized. It was new, it was unmistakably Chopin-like in spirit, and it was not emotionally empty. I was truly shaken. How could emotional music be coming out of a program that had never heard a note, never lived a moment of life, never had any emotions whatsoever? (Hofstadter, 2002, p. 72).

Computer models of emotions might help us to answer this kind of questions and to reconsider our ideas about the creative process. Nevertheless, even if it were possible to simulate the effects of recounted experience, we are far from being able to produce a complete computational account of emotion. Much more work is required in this area.

The engagement–reflection architecture provides a frame to explore the role of emotions during the creative process in computers. MEXICA is only a first step towards computer models of creativity where emotions are an integral part of the model. Maybe this work will encourage research in this area.
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References


