Theoretical Framework for Computational Story Blending: From a Cognitive System Perspective

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Abstract

The objective of this study is to design a general computational model of story creativity as the fundamental component of a cognitive system. In this paper, a theoretical framework for computational *story blending* is presented. This framework is inspired by cognitive and computational models of conceptual blending. Story blending, which is defined as composing a novel story by combining two input stories, is a fundamental principle of story creativity. Although the idea proposed in this paper has not been implemented yet, this study provides a theoretical basis for a computational modeling of story blending.

Introduction

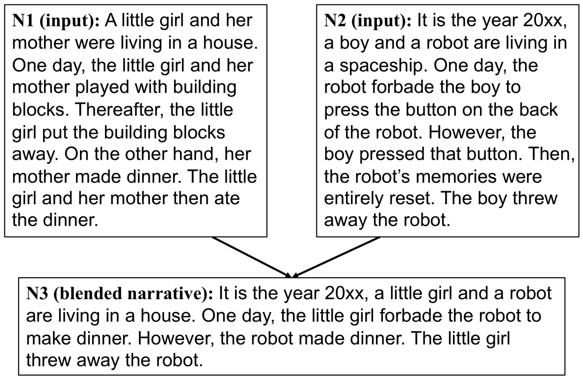
Story creativity is the foundation of autonomous integrative artificial intelligence that can generate a contextual structure of the present situation, episodic memories, future goals and plans, the imaginations of the mental states of other persons, and hypothetical or fictional worlds. Meanwhile, conceptual blending theory, as proposed by Fauconnier and Turner (2002), characterizes the fundamental mechanism of human creative (but ordinary) thinking as the production of a novel concept by combining different familiar concepts. This cognitive theory has been applied to computational creativity studies, such as Eppe et al. (2018), Goguen and Harrell (2010), and Schorlemmer et al. (2014). This study seeks a general model of generative narrative cognition from a cognitive system perspective, whereby cognitive and computational models of conceptual blending are informative.

In this paper, a theoretical framework for computational *story blending* is proposed toward a general computational model of story creativity. Story blending is defined as composing a novel story by combining two input stories. In this context, a “story” refers to a mental representation of a narrative, whereas a “narrative” generally refers to information that is expressed in a communicational context.

Although the idea proposed in this paper has not been implemented yet, this study provides a theoretical basis for the computational modeling of story blending. A more detailed design and implementation will be presented in a future paper.

To illustrate the notion of story blending, Figure 1 shows an example of “narrative” blending by a non-expert human (a university student). A blended narrative (N3) was created by combining two given narratives (N1 and N2). This simple example contains various blending forms, e.g., merging temporal–spatial setting, replacing characters and their roles, and reconnecting the reason for a character’s action. Moreover, these operations are done in an integrated manner. Story blending refers to the cognitive process underlying this type of ability.

The rest of this paper is organized into five parts. First, previous related studies of narrative intelligence and conceptual blending are reviewed. Second, the significance of story blending is described. Third, several fundamental issues in computational modeling of story blending are discussed in three sections. Fourth, an architectural design of computational story blending is described. Finally, a conclusion and future prospective studies are presented.



N1 (input): A little girl and her mother were living in a house. One day, the little girl and her mother played with building blocks. Thereafter, the little girl put the building blocks away. On the other hand, her mother made dinner. The little girl and her mother then ate the dinner.

N2 (input): It is the year 20xx, a boy and a robot are living in a spaceship. One day, the robot forbade the boy to press the button on the back of the robot. However, the boy pressed that button. Then, the robot’s memories were entirely reset. The boy threw away the robot.

N3 (blended narrative): It is the year 20xx, a little girl and a robot are living in a house. One day, the little girl forbade the robot to make dinner. However, the robot made dinner. The little girl threw away the robot.

Figure 1. Example of “narrative” blending by a human subject.

Background

This section presents a review of previous related studies.

Computational Story Generation

Narrative generation is a challenging issue in artificial intelligence. In this context, the term "story" generation refers to the process of generating a content-level structure of a narrative, rather than an expression-level processes [in narratological terminology, a story or fabula refers to the content plane of a narrative, whereas a discourse or syuzhet refers to the expression plane (Prince 2003)].

There are several different but interrelated approaches to computational story generation. Some of the major approaches include the following:

- Planning-based approaches that model story generation as a simulation of the characters' goal-directed actions in a specific world model (Meehan 1980; Riedl and Young 2010).
- Schematic approaches that formalize the generative structural knowledge of stories in the forms of story grammar (Pemberton 1989) and thematic structure (Bringsjord and Ferrucci 1999), among other forms.
- Case-based approaches that model story generation as the reconstruction of existing stories in various ways, including case-based reasoning (Turner 1994), retrieving possible next actions (Pérez y Pérez and Sharples 2001), and analogical reasoning (Riedl and León 2009; Ontañón and Zhu 2011).

Story blending can be regarded as a case-based approach.

Story in Cognitive Systems

Studies on cognitive systems or cognitive architecture are aimed at developing not only specific intellectual functionalities, but also general computational theories, models, frameworks, and systems for developing integrative intelligence. From a cognitive system perspective, a story or narrative can be considered as a universal form of knowledge, memory, or a mental representation of a subjective world.

Since the early years of artificial intelligence, researchers have focused on the roles of stories in a human intelligence. Their studies have led to several computational theories, including script (Schank and Abelson 1977) and dynamic memory based on memory organization packets (Schank 1982).

Recent studies have investigated the importance and universality of stories or narratives. For example, León (2016) proposed an architecture of narrative memory that focused on knowledge representation of episodic and procedural memories and narrative communication based on these memories. Samsonovich and Aha (2015) proposed a computational theory of goal reasoning based on a multilayered narrative structure and the notion of character. Akimoto (2018a) described the structures and functions of stories as attributes of an agent's subjective world from four perspectives: a) constructing the contextual structure of the present situation; b) associating the past, future, and fiction with the present situation; c) imagining stories about others; and d) distinguishing between facts and fiction as metastory information.

For the above-mentioned reasons, an essential issue for cognitive systems is to achieve a general model of story creativity.

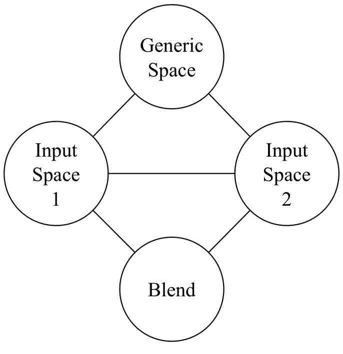


Figure 2. Simple illustration of conceptual blending.

Computational Conceptual Blending

Conceptual blending theory (Fauconnier and Turner 2002) explains the fundamental mechanism of human creative thinking as the production of a novel concept by combining different familiar concepts. Figure 2 shows a simple illustration of conceptual blending. An *input space* (or an input mental space) refers to a small conceptual packet that provides source information for composing a *blend* (or a blended mental space). A blend is a new space produced by the combination of two or more input spaces. Here, a shared structure between input spaces, based on the cross-space mapping and counterpart connections, is captured into a *generic space*. This shared structure becomes part of the blend. However, the blend also contains other specific structures, including an emergent structure that is not directly projected from the input spaces.

Although conceptual blending was originally developed as a cognitive theory, several researchers have proposed computational models of conceptual blending. For example, Goguen and Harrell (2010) formalized conceptual blending by using algebraic semiotics as the basis for poetry narrative generation. In the COINVENT project (Schorlemmer et al. 2014; Eppe et al. 2018), the amalgam theory in case-based reasoning (Ontañón and Plaza 2010) was adapted into the core process of conceptual blending. Computational modeling of conceptual blending involves various subproblems.

Because conceptual blending generally has a huge solution space (i.e., possible combinations), it is necessary to formalize metrics for identifying "good" blends to prune the solution space. Eppe et al. (2018) introduced metrics for evaluating blends in terms of the amount of information, compression of structure, and balance of information. These metrics were defined based on the optimality principles of conceptual blending that were conceptually described by Fauconnier and Turner (2002). On the other hand, Confalonieri et al. (2018) introduced domain-specific values from the perspective of audiences into the process of conceptual blending.

Constructing an adequate generic space is regarded as a key aspect of generating a consistent blend. As described by Besold (2018), analogical reasoning is a foundation of this process. From another perspective, Hedblom et al. (2016) adapted image schemas into the process of generalization or cross-space mapping as a representation of the abstract qualitative meaning of concepts.

The above-mentioned ideas and computational formulations of conceptual blending are applicable to story blending. However, story blending must deal with the content-level structures of stories, whereas computational conceptual blending treats the structures of general concepts. Goguen (2010) introduced a process called structural blending into poetry generation; this process focuses on composing a text-level structure. Computational conceptual blending also provides a basis for story creativity in inventing ideas of a unique character and an imaginative world setting. However, the primary focus of story blending is on manipulating an integrative and temporal structure that consists of concrete events and entities. This issue is a difficult aspect of story blending.

Story Blending in a Cognitive System

Story blending is a reasonable approach to a general model of story creativity for two reasons. First, producing new information and knowledge based on memory is an essential attribute of true autonomous intelligence. Second, stories can be regarded as integrative knowledge for composing a new story.

As described previously, story creativity is the common foundation for generating past memories; future expectations, predictions, goals, and plans; the contextual structure of the present situation; the imaginations of the mental states (i.e., theory of mind) of other persons; and hypothetical or fictional worlds. These aspects are necessary for an agent that autonomously interacts with its environment. In this context, the environment potentially includes all sorts of social and physical situations that an agent faces. Thus, interaction with the environment includes, for example, exploring a mountain, eating at a restaurant, communicating or cooperating with other persons (or agents) toward a goal, and creating an artistic work within the constraint of a specific genre.

Regarding the relationship to the environment, creative story generation can be classified as two types:

- *Adaptive* story generation: adaptation to an unfamiliar environment (e.g., the ability to generate a canonical story in a specific genre or to generate a story for acting appropriately at a restaurant).
- *Innovative* story generation: the challenge of making a change in the environment by producing a novel and valuable story or narrative (e.g., to generate a new style of story in or beyond a specific genre or to invent a new system of a restaurant).

Story blending aligns with both adaptive and innovative story generation. From the perspective of cognitive development, agents must adapt to new environments by using their own knowledge accumulated through previous experiences. The similarity between creativity and cognitive development is also described by Aguilar and Pérez y Pérez (2015). On the other hand, from the perspective of cultural development, an innovative story or narrative is essentially produced from the prior accumulation of social knowledge or narratives.

The next three sections discuss three fundamental issues for computational story blending: how to represent a story, how to deal with the structural complexity of a story, and what directs story generation.

Representation of a Story

From a cognitive system perspective, it is important to seek a general representational framework for a story as a uniform mental representation. However, this issue should be comprehensively addressed by considering various aspects of story cognition, including generation, understanding, analogy, blending, memory retrieval, embodiment or multimodality, and action–perception cycle. Hence, this study undertakes an exploratory design of a representation framework of a story from the perspective of story blending.

Stories and General Knowledge

To begin, it is important to distinguish between stories and general knowledge underlying stories (see Figure 3). The role of general knowledge here is to provide a common basis among different stories, even though every story is a unique item of information containing concrete events and entities arising at a time and a place. Narrative cognition generally requires various kinds knowledge, including common sense knowledge. In story blending, categorical or attributive knowledge of words and relationships are especially required for structural comparison and manipulation of and between stories.

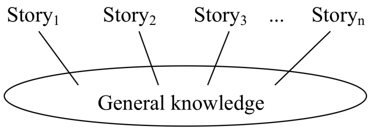


Figure 3. Stories and general knowledge.

Hierarchy of a Story

The fundamental structural units that form a story can be classified into four types, as follows:

- **Entity:** A character or object appearing in a story.
- **Event or State:** A character’s action or stative information.
- **Relation:** A relationship between two entities or two events or states.
- **Time and place:** A temporal and spatial setting of a story or part of a story.

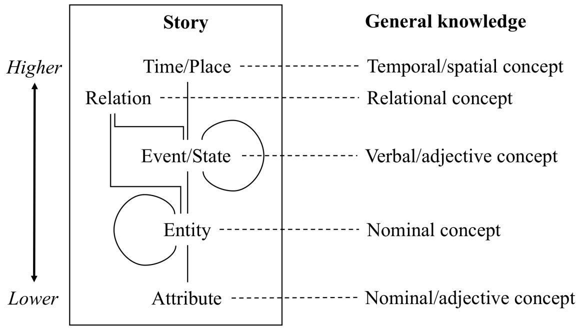


Figure 4. Hierarchy in a story and correspondence to general knowledge.

Thus, a story *S* is represented as a tuple <*N*, *V*, *R*, *T*, *P*> that consists of entities (*N*), events or states (*V*), relations (*R*), times (*T*), and places (*P*).

The relationships among these structural units can be interpreted as a hierarchical organization, as shown in Figure 4. In this hierarchy, the higher unit *contains* the lower unit. In particular, an entity contains attributes, an event or state contains entities as its arguments, a relation forms an integrative structure by containing two events or states or entities, and a time or place gives temporal or spatial setting, respectively, to the contained parts (events or states). The temporal order of events is also represented by anteroposterior relations. In addition, an aggregative event or state and entity is formed by containing two or more subevents or substates and subentities, respectively. For example, a "shortcake" can be seen as an aggregative entity containing "strawberry," "whip cream," and "sponge." Similarly, the event "Lisa eats a steak in a restaurant" can be decomposed into several subevents.

Figure 4 also shows the corresponding general knowledge for each level of story element. Here, every story element is positioned as a unique instance of the corresponding concept.

Description Format

Because a story is composed of different types of structural units, designing a unified representation format for these units is a key issue in reducing the algorithmic complexity of story blending. Based on the hierarchy of a story, each unit can be represented by the same list format that consists of symbols for a head *h* and contained units c_i: (h, c_1, …, c_n). Figure 5 shows an example of a simple representation of a story that is manually produced based on N2 in Figure 1.

How to Deal with the Structural Complexity of a Story

A story has a complex structure in which various representational elements are organized. In addition, story blending requires various semantic and structural processing. Hence, handling structural complexity is a difficult problem in computational story blending. Two approaches are introduced for addressing this problem: multiple abstraction and blend-centered perspective.

```
(n1:boy (name Jiro) (body small))
(n2:robot (sub n3 n4))
(n3:memory)
(n4:button (cause (reset memory)))
(v1:live (agent n1 n2) (location p1))
(v2:forbid (agent n2) (counter-agent n1)
   (object (press n4)))
(v3:press (agent n1) (object n4))
(v4:reset (object n3))
(v5:throw_away (agent n1) (counter-agent n2))
(r1:then v1 v2)
(r2:then v2 v3)
(r3:then v3 v4)
(r4:then v4 v5)
(r5:violation v3 v2)
(r6:cause v3 v4)
(r7:reason v4 v5)
(r8:partner n1 n2)
(p1:spaceship v1 v2 v3 v4 v5)
(t1:20xx v1 v2 v3 v4 v5)
```

Figure 5. Example of story based on N2 in Figure 1.

Multiple Abstraction

Abstraction is considered as a general issue in dealing with a complex problem or object in a computational system. According to Saitta and Zucker (2013), abstraction is an essential aspect of intelligence relevant to various cognitive activities, including problem solving, perception, analogy, categorization, language, and learning. Although the term "abstraction" has various meanings in various disciplines, the basic issues in abstraction can be organized into the following seven aspects: *simplicity*, *relevance*, *granularity*, *abstract or concrete status*, *naming*, *reformulation*, and *information content* (Saitta and Zucker 2013). Considering the first two aspects, simplicity means there is a general agreement that abstraction should reduce the complexity of tasks, and relevance means that abstraction is mainly supposed to capture the relevant aspects of problems, objects, or perceptions.

In story blending, abstraction can be regarded as the process of extracting manipulable partial information from a story from a *restrictive perspective*. This process is clearly different from generalization, which constructs a generic structure from input stories. The following are the various conceivable perspectives for story abstraction: "story-line" extracts the relational structure of events, excluding information on the entities; "story-world" extracts the relational structure of entities, excluding information on the events; "character perspective" extracts events and entities that are relevant to a specific character; and "temporal or spatial setting" extracts times or places from a story.

Based on the hierarchy of a story structure, abstraction can be defined as a top-down restriction or filtering of information to be extracted. In this process, the detailed contents of the extracted units may be parameterized as a variable or a category in general knowledge. Figure 6 shows an example of an abstraction (by hand) of the story in Figure 5 from the "story-line" perspective.

```
(v1:live (agent human#1 robot#1) (location
   vehicle#1))
(v2:forbid (agent robot#1) (counter-agent
   human#1) (object action#1))
(v3:press (agent human#1) (object button#1))
(v4:reset (object memory#1))
(v5:throw_away (agent human#1) (counter-agent
   robot#1))
(r1:then v1 v2)
(r2:then v2 v3)
(r3:then v3 v4)
(r4:then v4 v5)
(r5:violation v3 v2)
(r6:cause v3 v4)
(r7:reason v4 v5)
```

Figure 6. Example of abstraction (by hand) of the story in Figure 5, from a "story-line" perspective.

Abstraction of stories precedes most processes in story blending, including comparison between stories, generalization of stories, and combinational integration of parts of stories. Moreover, story blending requires the combination of different abstractions from multiple perspectives.

Blend-centered Perspective

In previous studies on computational story generation, the generative process is generally modeled in the form of centrally controlled symbolic processing. However, from a long-term perspective, an emergentist approach is necessary for modeling complex cognitive processes, including story generation.

This approach is rooted in the work of Minsky (1986) that explains the mind as a type of distributed multi-agent system based on the collaborative activities of diverse simple agents. Inspired by this theory, Kokinov (1994) developed the DUAL cognitive architecture based on a distributed multi-agent system, whereby an agent refers to a small representational and procedural unit in a cognitive system. Akimoto (2018b) showed a conceptual-level theory of generative narrative cognition from an emergentist perspective. This theory posits that stories are fundamental agents that form a mind, and each story and its partial structures involve a power of self-organization.

Although implementing a fully distributed model of a generative story is still a distant goal, this study partially introduces an emergentist perspective. In particular, story blending is modeled as an internal process of the blended story to be generated. In other words, a blended story is an agent that generates its own structure.

Conceptual Diagram of Story Blending

By combining the above-mentioned approaches (multiple abstraction and blend-centered perspective), the diagram of conceptual blending (Figure 2) can be enhanced, as shown in Figure 7. Here, the blended story (S_b) composes its own structure by extracting information from two input stories (S_l and S_r).

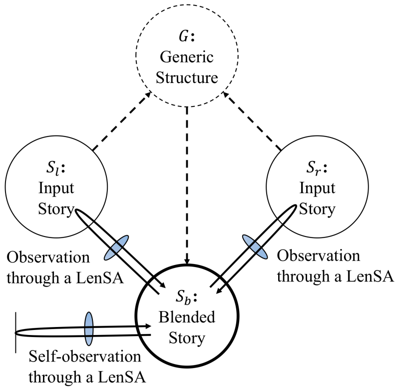


Figure 7. Conceptual diagram of story blending.

In this process, the blended story observes the inputs from a restrictive perspective. The term *lens of story abstraction* (*LenSA*) is introduced to refer to "observation equipment" for extracting an abstract structure from a story. More precisely, a LenSA corresponds to a function that extracts partial information from a story. The blended story uses LenSAs for gathering information from the input stories to generate its own structure. The blended story also observes its own structure through a LenSA to manage and direct the generative process.

The generic structure (G) refers to a common structure (which includes cross-story mapping) that emerges behind the two stories observed through a LenSA. Different generic structures can be constructed depending on the type of LenSA. In this case, because each story consists of unique instances, the commonality between stories is identified by categorical matching based on general knowledge.

Although the retrieval or recollection of input stories from memory is also an important issue, this topic is not included in this study, but will be addressed in future research.

What Directs Story Generation

Because the value of a story is highly dependent on the environmental context in which the story is used, defining absolute measures for identifying "good" stories seems inadequate when dealing with a general model of story creativity. Hence, this study takes a *relativistic* perspective by classifying criteria for directing story blending into *external* criteria based on the relationship with an environment and *internal* criteria based on the internal structure of a cognitive system. These criteria are described next.

External Criteria

External criteria for a story are defined based on values for oneself (the agent that produces the story), others (the receivers or users of the produced story or narrative), and societies in an environmental context. Although there are environmental dependencies, the basic types of external criteria can be classified along with the aforementioned notions of adaptive and innovative story generation, as follows:

- *Fitness* to an environment is determined from positive and negative feedback from that environment. Adaptive story generation needs to be modeled as an interactive system coupled with an environment and is primarily directed by fitness to that environment.
- *Effect* on an environment is determined based on a change in that environment (e.g., the effect on an audience's knowledge or worldview, creation of a new style or genre, and changes in cultural values). An effect on an environment is the essential condition for innovative story generation. However, the computational modeling of this criterion is a difficult problem.

Internal Criteria

Internal criteria provide only general conditions or driving forces for story generation. These criteria, which are independent of the environment, constitute the foundation of both adaptive and innovative story generation.

Producing *novelty* in story creation is assumed to be an essential condition of both adaptive and innovative story generation. The fundamental driving force for producing novelty can be formalized based on *difference* and *similarity* to the input or pre-existing stories in a cognitive system.

The agent and the environment may be viewed as developmental cognitive and social systems, respectively. A social system refers to a space of communication among two or more individuals under some form of constraints (e.g., a dialog between individuals, a communication within a team, or an artistic genre). Then, the notions of adaptive and innovative story generation can be reinterpreted. Adaptive generation is a trigger for a developmental change in the cognitive system itself. Similarly, innovative generation is a trigger for a developmental change in the environmental social system.

In both cases, difference is generally accepted as an essential condition of novelty. However, similarity is also necessary for organizing or anchoring new information (a story or narrative) into the relationship with pre-existing information. In other words, similarity is a constraint for continual development of both sides of the cognitive and social systems.

In the case of innovative story generation, difference and similarity to pre-existing information are determined not in a cognitive system, but in a social (environmental) system. However, if a cognitive system has acquired proficiency in that environment, a story's difference and similarity may be approximately simulated inside the cognitive system. For example, a cognitive system that has rich knowledge of a specific narrative genre will be able to compute the difference and similarity of a new idea based on its own memory.

In addition to difference and similarity, a fundamental condition for the internal structure of a story itself is also required. In particular, because a story is assumed to be an integrative structure that forms a mental world, the story must have *structural unity* or the coherence in the structure of the story. This attribute is the basis for composing the structure of the whole story.

In summary, the three internal criteria for directing story blending are presented as follows:

- **Difference and similarity:** A blended story must have both differences and similarities to the input stories. These criteria provide the driving force and constraint for achieving novelty.
- **Unity:** A blended story must have structural unity as the basic condition for the structure of the story.

Architectural Design of Story Blending

Based on the above-mentioned considerations, this section presents an architectural design for computational story blending. The objective of the proposed design from the three perspectives are presented next.

First, the proposed design focuses only on the process of blending the two given stories, without considering the process of retrieving stories from the memory.

Second, this study intends to present a fundamental principle of story creativity, instead of a specific application such as entertainment content generation. Hence, the proposed design of story blending aims at achieving environment-independence. From this stand point, the design focuses only on the aforementioned internal criteria and does not consider external criteria. Thus, the basic design objective is to develop a computational model that composes a blended story with structural unity and differences from or similarities to the given input stories.

Third, computational story blending involves various subproblems, including knowledge representation, abstraction, generalization, combination, similarity, difference, and unity. In each subproblem, there are various potential methods for implementing story blending. Hence, the proposed design aims at achieving an abstract theoretical framework for story blending by defining the basic representational and procedural elements and their relationships.

Structural Formulation

Basic representational elements of story blending, and their relationships, are illustrated by a hexangular diagram, as shown in Figure 8. These elements are defined as follows:

- S_l, S_r: Given (or retrieved) input stories.
- S_b: The blended story to be generated.
- A_l, A_r, A_b: Abstract structures extracted through a LenSA from S_l, S_r, and S_b, respectively.
- G_{lr}, G_{bl}, G_{br}: Generic structures constructed from A_l–A_r, A_b–A_l, and A_b–A_r, respectively. (G_{bl} and G_{br} have no counterpart in the original diagram of conceptual blending shown in Figure 2. These structures are used for calculating the differences and similarities between the blended and input stories.)
- dif_{lr}, dif_{bl}, dif_{br}: Numerical values representing the differences between each pair of stories observed through a LenSA, i.e., A_l–A_r, A_b–A_l, and A_b–A_r, respectively.
- sim_{lr}, sim_{bl}, sim_{br}: Numerical values representing the

similarities between each pair of stories observed through a LenSA, i.e., A_l–A_r, A_b–A_l, and A_b–A_r, respectively.

- $unity_b$: A numerical value representing the structural unity of S_b.

These elements, excluding input stories, are dynamically generated and rewritten through the generative process.

Procedural Formulation

Figure 9 illustrates the procedural framework of story blending. From a blend-centered perspective, the procedure of story blending is designed based on the internal processes of a blended story. However, the LenSAs, generalization, and combination can be considered as automatic processes that generate abstract, generic, and combinational structures, respectively. Hence, these elements are positioned as external processes. Overall, a blended story generates its own structure (S_b) from two input stories (S_l and S_r) with general knowledge by using functions of the LenSAs, generalization, and combination.

Basic Functions

In the framework shown in Figure 9, the following procedural elements are defined as functions:

- LenSA(X, S_P): Extracting an abstract structure A_P from a story. Here, the type of LenSA (e.g., story-line or story-world) is specified by *X*, which is determined by the self-manager part as described later.
- generalization(A_P, A_Q): Constructing a generic structure G_{PQ}, including cross-space mapping between structural units, from two abstract structures.
- combination(A_P, A_Q, G_{PQ}): Generating a set of candidate combinational structures $C = \{c_1, \ldots, c_n\}$ of two abstract structures. A combinational structure is also a partial structure of a story that is constructed by selective integration of two abstract structures.
- difference(A_P, A_Q, G_{PQ}): Calculating dif_{PQ}.
- similarity(A_P, A_Q, G_{PQ}): Calculating sim_{PQ}.
- unity(S_P): Calculating $unity_P$.

Self-Manager

The self-manager controls its own generative process. This iterative sequence of processes involves extracting abstract structures from the input stories, combining the abstract structures, and integrating a combinational structure into the blended story until the blending is completed. Although the detailed design will be performed in future work, a tentative framework of the blending process is presented as follows:

Step 1: Selection of a LenSA. The self-manager chooses a LenSA based on similarities and differences. Various selection strategies are conceivable, such as a similar aspect between inputs (higher sim_{lr}), a different aspect between inputs (higher dif_{lr}), and lack of information in the current blend structure (higher dif_{bl} and dif_{br}). When a LenSA is chosen, abstract structures (A_l and A_r), a generic structure (G_{lr}), and a set of combinational structures (C) are automatically generated.

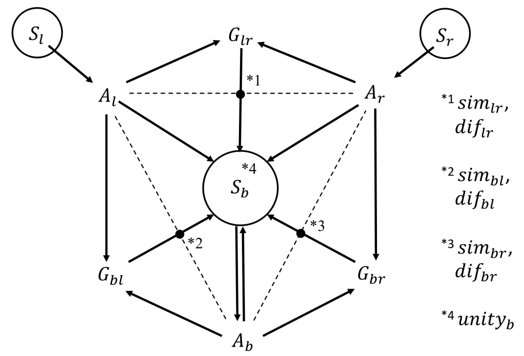


Figure 8. Diagram of story blending.

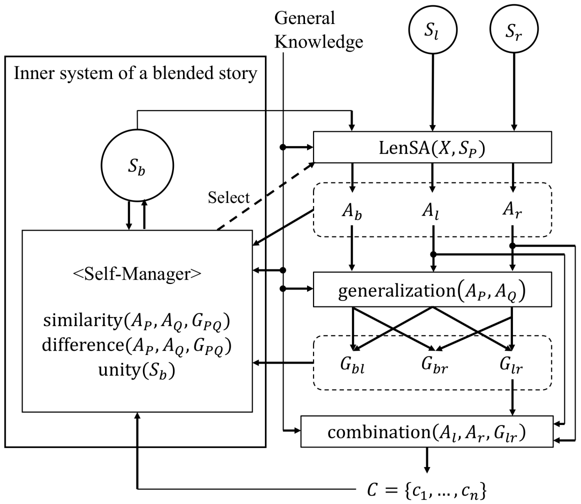


Figure 9. Procedural framework of story blending.

Step 2: Selection of a combinational structure. By assuming each combinational structure (c_i) as the abstract structure (A_b) of the blend, the self-manager chooses a combinational structure that has *higher* and *balanced* values of sim_{bl}, sim_{br}, dif_{bl}, and dif_{br}, in total.

Step 3: Integration. The self-manager integrates the selected combinational structure into the blended story. Structural adjustment will also be required here.

Step 4: Completion judgment. The self-manager observes the blended structure and judges whether to capture additional information from the input stories (i.e., return to Step 1) or to proceed to the final adjustment process (Step 5).

Step 5: Final adjustment. The self-manager completes the blended structure and content to increase $unity_b$.

Concluding Remarks

In this study, story blending was presented as a fundamental principle of story creativity in a cognitive system. From this perspective, three basic issues were discussed. First, a representational framework of a hierarchical story structure was presented. Second, two approaches for managing structural complexity in a story (i.e., multiple abstraction and blend-centered perspective) were introduced. Third, the criteria of directing story generation were classified into external criteria (based on the relationship with an environment) and internal criteria (based on the internal structure of a cognitive system). This study especially focused on the latter and stated three essential internal criteria: differences and similarities to existing (input) stories and structural unity of the blended story. Based on these concepts, an architectural design of computational story blending was presented.

The next stage of this study will create algorithms of the system elements, including abstraction, generalization, combination, and calculations of difference, similarity, and unity. Particularly, there are two primary challenges in the future. The first one is to formulate the mechanism of abstracting a story through multiple structural perspectives. This mechanism will be a basis for not only story blending, but also broad aspects of story cognition. The second challenge is to develop a general model for combining two (abstracted) stories via their generalization.

Acknowledgments

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