Comme il Faut: A System for Authoring Playable Social Models

Josh McCoy, Mike Treanor, Ben Samuel, Noah Wardrip-Fruin, and Michael Mateas

Expressive Intelligence Studio

Center for Games and Playable Media

University of California, Santa Cruz

{mccoyjo, mtreanor, bsamuel, nwf, michaelm}@soe.ucsc.edu

Abstract

Authoring interactive stories where the player is afforded a wide range of social interactions results in a very large space of possible social and story situations. The amount of effort required to individually author for each of these circumstances can quickly become intractable. The social AI system Comme il Faut (*CiF*) aims to reduce the burden on the author by providing a playable model of social interaction where the author provides reusable and recombinable representations of social norms and social interactions. Motivated through examples from an in-development video game, Prom Week, this paper provides a detailed description of the structures with which CiF represents social knowledge and how this knowledge is employed to simulate social interactions between characters.

Introduction

Authoring for interactive storytelling requires authoring a space of possible stories, while playing an interactive story is exploring one distinct story of the many possible stories that could be experienced. To make the space of stories as compelling as possible, the player should have a number of interaction options available that are consistent with the state of the story world. As each decision has impact on the story, each time the player interacts with the world the effects of past player choices need to be accounted for. Accounting for past impacts on the story as the story unfolds leads, if handled naively, to an exponential explosion of authoring that needs to be performed. At worst every possible choice of interaction the player is presented with has to distinctly account for every possible action that could have previous taken place. If each one of these possible states of player consequence is to be explicitly detailed by an author, the burden on the authors becomes very heavy in most story worlds. The alternative, of limiting the number of choices and segregating sets of choices, makes player choice and impact feel artificially constrained. This can be clearly seen in even the best story-focused games today, such as *Mass Effect 2* (Bioware, 2010), where the large number of hand-authored dialogue trees are both burdensome to produce and artificially constrained (e.g., party member relationships can only develop on the ship).

One way to help overcome these authorial challenges is building a social artificial intelligence (AI) system that computationally models social space and social interaction. This would make building social play experiences more tractable by allowing the system to manage the mechanics of social interactions, which would result in reducing the volume of story space to be explicitly authored and increasing the amount available for player exploration.

Comme il Faut (*CiF*) (McCoy et al. 2010) is an AI system that uses these techniques to enable an interactive, authorable model of social interaction for autonomous agents. Social exchanges are the primary structure of representing social interactions in *CiF*. Social exchanges are defined as multi-character social interactions whose function is to modify the social state existing within and across the participants.

Copyright © 2011, Association for the Advancement of Artificial Intelligence (www.aaai.org). All rights reserved.

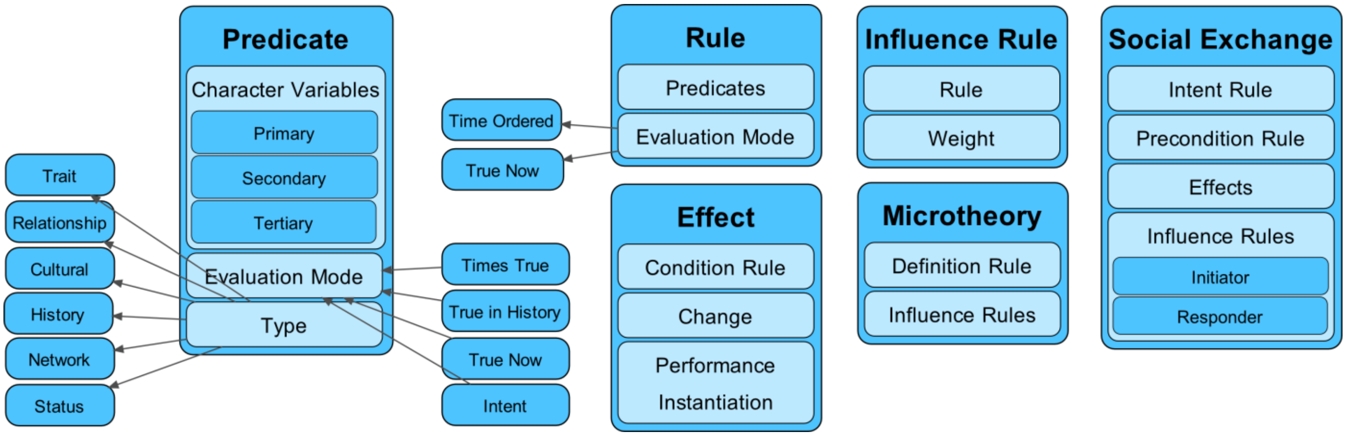

Figure 1: This diagram shows the basic data structures used by *Comme il Faut* to represent knowledge of playable patterns of social interaction as well as encode the social norms of a story world.

Through the use of social exchanges along with additional encoded social context, *CiF* lowers the authoring burden needed to create the social aspects of an interactive story by allowing the author to specify the rules and general patterns of how social interaction should take place. With the separation of patterns of social behavior from the norms that govern their use, authors can explicitly encode the reasoning of domains of social norms which can be reused across all social behaviors. The encoding of social norms is comprised of individual rules each of which encompass a social consideration. Because of this rules-based encoding, additional domain knowledge can be easily added to the existing base of rules and be immediately used by *CiF*. When the rules are used in conjunction with social exchanges, the character behaviors generated by *CiF* are rich and surprising.

In this paper, we contribute a detailed description of the structures with which *CiF* represents social knowledge and how this knowledge is employed to simulate social interactions between characters in a story world. Situations from an in-development video game, *Prom Week*, provides concrete examples of how *CiF* can be used to enable social behavior in characters for interactive storytelling in a way that is tractable to author and flexible for the player.

Related Work

There are many systems in the domain of modeling interactions between characters or virtual humans based on cognitive or psychological models that reason over competing capacities of a prescribed set of desires (Aylett, Louchart, Dias, Paiva, & Vala, 2005; Marsella & Gratch, 2009; Si, Marsella, & Pynadath, 2009). *CiF* is an implementation of an alternate, norms-based vision of modeling what characters should be doing. This approach gives characters the affordance to reason over what desires are appropriate for the situation and then to negotiate between those relevant desires (Evans, 2009). Through modeling normal patterns of social behavior with a context of general social norms, the amount of story space covered by each authoring effort is increased over that of authoring for a single social state.

Narrative generation systems (Lebowitz, 1984; Meehan, 1976; Turner, 1994) model enough of a story world to create stories. In comparison, *CiF* does not attempt to model an entire story world. Instead it deeply models the myriad of considerations necessary for a character to follow norms during social interactions. As such, *CiF* is meant to be the social reasoning component encompassed by a narrative generation system.

CiF represents a different take on computational social behavior by focusing on deeper models of interpersonal behavior. This stands in contrast to the more common agent-based approaches that rely on computational economics or artificial life (Langton, 1995). Instead of starting with a foundation similar to agent-based approaches, *CiF* is based on dramaturgical analysis (Goffman, 1959) and models character behavior primarily through socially normative pressures found in everyday life.

In comparison to hierarchical task networks (Erol, Hendler, & Nau, 1995) and behavior trees (Isla, 2005), the operators, or patterns of social behavior, in *CiF* make use of larger sets of domain knowledge to judge their appropriateness for the current context. Instead of encapsulating domain knowledge implicitly in hierarchically layered operators or behaviors using a small number of (possibly procedural) pre or post conditions, *CiF* chooses characters' behaviors based on all applicable rules in a large rulebase that encodes normal social behavior authored for a particular story world.

The Sims 3 is an example of a culturally influential and commercially successful video game that has a highly dynamic social space (Electronic Arts, 2009). Its characters, known as Sims, have traits and desires that inform the social practices (social norms and cluster of expectations) they perform (Evans, 2008). Two major differences between the systems are in the complexity of the statements of social norms and the use of history in those statements. *CiF* provides a level of complexity similar to first order logic in that parties outside of the social exchange can be referenced (*x* is cheating on *y* if *x* and *y* are dating and there is a character *z* also dating *x*) where *The Sims 3* can only reference the two characters in an interaction. *CiF* also allows for both back story (history of the story world before the player is involved) and play history to be used in reasoning and social exchange performance, a feature completely missing from *The Sims 3*. These richer rules found in *CiF* allow for each individual authoring effort to be more potent while enabling an entire new set of social reasoning to the characters.

Social Knowledge Representation in CiF

CiF consists of authored content and processes to use that knowledge. *CiF* is a general system for facilitating character performance in any encoded set of social dynamics. Social exchanges are the primary form of encoding social performances for characters and are constructed from the metaphor of drama present in dramaturgical analysis (McCoy & Mateas, 2009).

CiF uses rules to reason over the social world when making decisions about social exchanges. To calculate a character's will, or volition, to perform social exchanges, some rules are given a weight to aid in comparing social concerns. Below is a discussion of rules, the predicates that form these rules, and several ways in which they are used in and with social exchanges (see Figure 1). The examples come from authored content in *Prom Week*. Unless otherwise specified, *x*, *y*, and *z* stand for distinct characters in the social space.

Predicates

Predicates are the binding between the current social state as modeled by *CiF* and the authoring in social interaction patterns and social norms. They are representational primitives that can be evaluated for truth in a specific social state. Predicates have 3 major elements. First is a set of up to 3 characters or character variables that will bind to characters during evaluation. Next is a predicate type corresponding to aspects of the social environment modeled by *CiF* consisting of character traits, relationships, statuses, social network values, history in the social facts database (SFDB), and cultural items in world found in the cultural knowledgebase (CKB), which are described in detail in previous publications (McCoy et al., 2010).

Rules

Most story-heavy games model the world as a set of linear progressions (for quests/missions), directed graphs (for conversations), and simple variables (for character development, etc). For the purposes of a world with the dynamism we desire, these are both too inflexible as representations and too elaboration-intolerant for authoring. Instead, *CiF* reasons over the state of the world through rules and conditions. Conditions, and the left hand side of rules, are composed of predicates. These predicates can be evaluated for truth and assertions may be made on them to determine adjustments to the social space. Currently, the social world modeled in *Prom Week* consists of nearly 4900 rules comprised of over 40000 individual predicates.

Influence Rule Sets

Most story-focused games model a character's willingness to engage in a behavior with a simple story progression point or characteristic threshold value. To enable greater dynamism, CiF employs influence rule sets (IRSs) — sets of rules that influence the desires of the agents to engage in social exchanges. The right-hand-side of every rule inside of an IRS is a weight that represents how important the rule is in determining intents, where an intent is the intended change in social state after performing a social exchange (e.g. have two characters start to date). Every social exchange has two influence rule sets, one for the initiator, *i*, of the social exchange and one for the responder, *r*. Though structurally equivalent, the two IRSs have contextual differences. Weights in the initiator IRS determine both which social exchanges *i* is interested in playing and who to perform them with. All rules, both in all initiator IRSs and in all microtheories (discussed below) are considered and their weights tallied—the social exchanges with the highest scored weights represent the social exchanges *i* wants to perform most. A similar scoring mechanism is used for *r*, with one small caveat; *r* need only decide whether to accept or reject the proposed social exchange's intent (discussed below).

Microtheories

The power of influence rule sets is great, but if each set of rules contains repetitions of influence considerations that also apply in other situations, we have found that rule sets can become unwieldy and difficult to maintain during revisions. To address this, we have introduced the concept of *microtheories* in CiF to capture knowledge about social dynamics that apply across multiple social exchanges. The microtheory library constitutes a large repository of rules, split between dozens of microtheories. A microtheory consists of a definition and a pair of influence rule sets. The definition of a microtheory is a condition, often times consisting solely of one predicate, for example, *relation-*

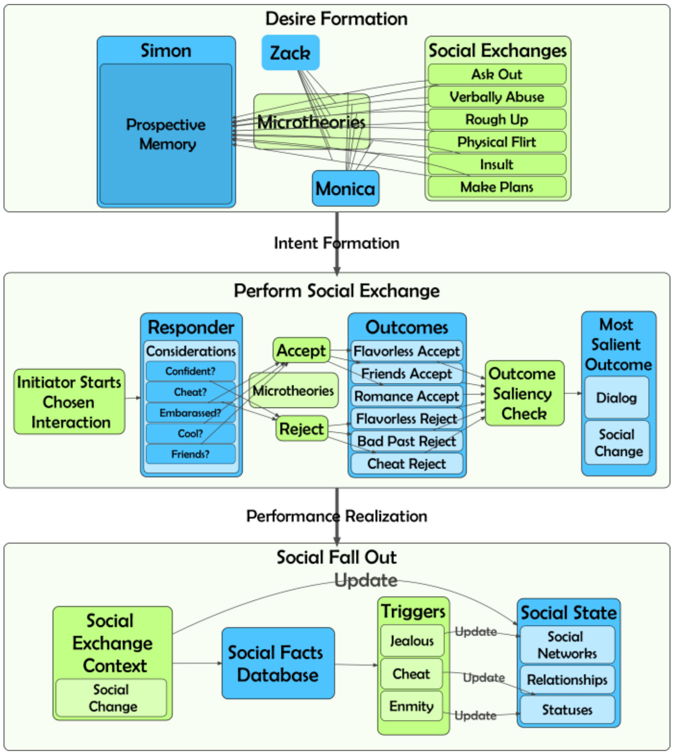

Figure 2: The interaction between representations and the procedures in CiF are shown in this figure. Desire Formation determines the volition of each character to perform a social exchange with each other character. Perform Social Exchange determines the outcome of the social exchange. Social Fall Out updates the exchange and determines the cascading consequences of the social state change.

ship(*friends*,*x*,*y*) is the definition of the Friends microtheory. Only microtheories whose definitions evaluate to true in the current context are considered when calculating volitions. The rule set then provides a general understanding of what it means to be friends; the first set applies to *i*'s considerations, the second to *r's*. For example, friends are more likely to get along, and less likely to become enemies, than strangers.

Rules in microtheories are essentially shared by all social exchanges. This abstraction permits the initiator and responder IRSs associated with specific exchanges to focus on capturing the nuances which differentiate social exchanges from one another. For example, *status*(*feelsSuperiorTowards*,*x*,*y*) would generally negatively impact *x*'s desire to befriend *y*, which is reflected its own microtheory. However, when taken in the context of the social exchange "Give Advice", it is reasonable that *x* would want to give advice to *y*, a social exchange that—given the right context—can lead two characters to friendship.

Social Exchanges

Social exchanges define the space of possible social interactions between characters in CiF. They have been developed with an emphasis on maximum flexibility (in when they occur, between which characters, and in what sequences) and maximum specificity (so they feel grounded in particular characters and histories, the strength of today's story-focused games). Social exchanges make use of the abstractions of rules and IRSs. Every social exchange has an initiator *i*, a responder *r*, and an optional third agent referred to as the other, *o*. Social exchanges are comprised of an intent, a set of preconditions, influence rule sets for *i* and *r*, a set of effects, and a set of instantiations. As mentioned above, the intent of the social exchange is a condition, typically of only a single predicate, which embodies the change *i* wants to make on the social state. For example, the intent of the social exchange "Ask on a Date" is *relationship*(*dating*,*i*,*r*). Preconditions are conditions which must hold true for the social exchange to be considered playable. The social exchange "Break Up" has a precondition of *relationship*(*dating*,*i*,*r*); before *i* can breakup with *r*, *i* and *r* must be dating.

Next, a social exchange has a set of effects, where an effect is made up of a pair of rules called the effect conditions and the social changes, and a label marking the effect as either 'accepted' or 'rejected.' The effect conditions dictate what must be true for this effect to take place, and the effect changes outline how the social state of the world is affected based on this particular effect playing out. At a high level, an effect represents one possible trace through a social exchange. At minimum, a social exchange should have two effects—a generic effect for the case in which the exchange is accepted (the sum of all of the rules factoring into *r*'s considerations was positive) and another for rejection (the sum was negative). However, through the use of effect conditions, additional considerations can be taken into account which may impact the social space in additional ways. For example, given *trait*(*cold*,*i*), "Break Up" may not only lead to *relationship*(~*dating*(*i*,*r*)), but could have more serious repercussions as well, such as *relationship*(~*friends*(*i*,*r*)). If multiple effects have conditions which evaluate as true, the most salient effect is chosen.

The final component to a social exchange is a set of instantiations. An instantiation is a set of lines of dialogue, each tagged with animations that communicate state change and the justifications for the state change using natural language generation templates. Every instantiation is linked to a specific effect, thus the performance realization of the aforementioned "Cold Break Up" example would be different than either the generic accept or reject of the same exchange.

Examples of Representation

The following example will illustrate the structures described above, and will be used again to demonstrate the algorithms. The example is from *Prom Week*, *CiF's* inaugural application, which is set in a high school in the week leading up to the prom.

Simon is a character with the traits of being a weakling and witty. Naomi is another character with the trait of attractive. Simon has the status of having a crush on Naomi, and Naomi has the status of popular. Naomi and Simon have the relationship of being friends. Simon has high romance network values toward Naomi and she has very low romance scores toward him. Naomi also has low cool network values toward Simon. All other network values are neutral. The cultural knowledge base states that Simon likes objects labeled as "lame," such as scientific calculators, and Naomi likes things that are "cool," such as footballs. In the social fact database is an entry marked as something embarrassing that Simon has done toward Naomi. It is described as "Simon misunderstood Naomi asking for help on homework as a romantic advance."

This situation describes how *CiF* represents the unfortunate situation where a nerdy character has unrealistic hopes of having a relationship with someone "out of his league."

Algorithms in *CiF*

CiF operates by looping through a set of processes (as seen in Figure 2) that leverage the authored social knowledge detailed in the previous section. The first process is desire formation, which determines a character's volition (or will) to perform a social exchange with roles bound to specific characters. Volition is scored by counting the weight of the true influence rules in both the microtheories with true definitions and social exchange's initiator IRS. Next, a social exchange (with the characters bound to roles) is selected to perform. When intent is selected (discussed below), *CiF* determines how the responder chooses to either accept or reject to the social exchange chosen. This process is very similar to scoring volition in the intent formation process: the sum of true rules in both the active microtheories and the social exchange's responder influence rules set is found. If the sum is 0 or greater, the exchange is accepted. Otherwise it is rejected. Next, the process finds the most salient of the social exchanges effects to enact. Each social exchange effect contains a condition rule and assertions for changing the social state. The chosen effect's change is then asserted. This includes placing an entry into the SFDB to account for the performed exchange. The last step is running the trigger rules, which are rules that encode the cascading effects of social state change. Triggers are similar to effects in that they have a condition rule and assertions for social change when the condition rule is true.

Desire Formation

The following example will demonstrate the details of why Simon wants to perform an action that would raise Naomi's sense of romance for him (the romance network) and why Naomi rejects him so soundly. In the text below, *x*, *y* and *z* are variables that characters can be bound to.

As mentioned above, Simon and Naomi have the relationship of friends and Simon possesses the status of having a crush on Naomi. Together, these two facts activate the microtheories *relationship*(*friends, x, y*) and *status*(*has a crush on, x, y*). *T*he "friends" microtheory contains an influence rule that would detract from a character's desire to be romantic with the person he or she is friends with. However, the "has a crush on" microtheory contains an influence rule with a positive weight greater than the negative weight of the friend microtheory's rule. Furthermore, additional microtheory rules for Simon's high romance network value toward Naomi would contribute to this desire. When the weights from all true rules across all applicable microtheories are summed, the net result is that Simon wants to perform a social exchange that has the intent to raise Naomi's romantic feelings toward him (*intent*(*Simon, romanceNetwork*(*+, Naomi, Simon*))).

Though there could be many social exchanges defined with this intent, the two considered here will be a physical flirt and a conversational flirt. These two social exchanges are similar by intent, but different because their preconditions, influence rule sets and effects differ drastically. Simon's desire to perform one over the other will be determined by the two social exchanges' initiator influence rule sets in a process very similar to the microtheory's. For example, because Simon has the trait of weakling (*trait*(*weakling, Simon*)), and there is a rule with negative weight pertaining to that trait in physical flirt, he would be less likely to want to perform that exchange. For each social exchange, the net value of the weights of the true initiator influence rules add to the value of all true initiator influence rules from the microtheories to form the total desire to perform each exchange.

Intent Selection

Once Simon's desires are formed, the intent selection process determines exactly what he chooses to do. Intent selection is a natural place to allow for interaction. In the case of *Prom Week*, the players choose among each character's top desires.

Perform Social Exchange

The next step is to determine how Naomi will respond. The same *relationship*(*friends, x, y*) microtheory rule that detracted from Simon's desire to perform an exchange that would increase Naomi's romance network toward Simon, also affects the responder's desire to accept or reject the intent of the exchange. Additionally, another microtheory is brought into play by the fact that Naomi is friends with Cassie who has a crush on Simon (the microtheory with the definition of (*relationship*(*friends, x, z*) ^ *status*(*has a crush on, z, y*)). In this microtheory is a rule that detracts from a character's desire to accept an exchange that would increase romance with the character that a friend has a crush on. Even worse for Simon, Naomi has the status of popular and Simon does not (*status, popular, x*) ^ ~*status*(*popular, y*)). This also will detract from Naomi's desire to accept the intent of the exchange.

The previous influence rules pertained to Naomi's desire to accept or reject Simon's intention to raise her feelings of romance toward him in general. The responder influence rule set and the effect conditions of the "Conversational Flirt" exchange will determine exactly how she responds. For example, "Conversational Flirt" has a negatively weighted responder influence rule for if Simon likes something that is labeled as lame that Naomi doesn't like from the cultural knowledge base. As detailed above, Simon likes scientific calculators and Naomi does not.

By the microtheory and responder influence rules, it is determined that Naomi will reject Simon's advances. But the way in which she rejects him is determined by the most salient effect condition. In this case, this is an effect condition that matches the responder rule about the cultural knowledge base. The social change tied to that effect condition makes Naomi's cool network towards Simon decrease and the interaction is labeled in the social fact database as something embarrassing that Simon did to Naomi (*coolNetwork*(*-20, Naomi, Simon*) ^ *SFDB*(*embarrassing, Simon, Naomi*)). In *Prom Week*, effects are tied to comic book like performance instantiations where characters engage in authored dialogue pertaining to effect conditions.

Social Fall Out

After the social exchange outcome is established and the social state is change, the consequences of the outcome are simulated. Running the triggers over the entire cast comprise the bulk of this process by detecting change outside of the venue of the social exchange that was just enacted. Some examples are: if Naomi just acquired her third friend then she gains the status of popular or if Simon started dating Monica while already dating Cassie, he becomes a cheater and Cassie become heartbroken. The final responsibility of this procedure is to record the outcome of the social exchange and true triggers in *CiF*'s social history, allowing these social consequences to be reasoned over in future social exchanges.

Conclusion

This paper contributes a description of the structures representing social knowledge and how this knowledge is employed to simulate social interactions between characters in *CiF*. Additionally, how *CiF* can be used to enable social behavior in a way that authoring can be done tractably and flexibly was explored. Through authoring reusable patterns and spaces of social norms, authors gain more capabilities and leverage when creating interactive stories.

A side effect of using rules is tuning the large number of rules in an authored story is difficult. *Prom Week* contains over 4,900 unique influence rules, nearly 100 microtheories, 30 social exchanges (with around 60 planned for *Prom Week*'s release) each with over twenty rules that contribute to the characters desire and responses, a cast of 18 characters, and a combined total of over 40,000 predicates. As we author experiences with *CiF*, rule sets have been successfully managed with manual tuning guided by play testing and metrics over large sets of rules. Future work includes using machine learning techniques to diagnose misbalanced rules that lead to behavior outside of the social norms of the story world.

References

Aylett, R. S., Louchart, S., Dias, J., Paiva, A., & Vala, M.2005. Fearnot!: an experiment in emergent narrative. *Proceedings of Intelligent Virtual Agents (IVA05)* (p. 305).

Bioware.2010. Mass Effect 2.

Electronic Arts.2009. The Sims 3.

Erol, K., Hendler, J., & Nau, D. S.1995. Semantics for Hierarchical Task-Network Planning.

Evans, R.2008. Re-Expressing Normative Pragmatism in the Medium of Computation. *Proc. of Collective Intentionality VI*.

Evans, R.2009. The Logical Form of Status-Function Declarations. *Etica & Politica*, *11*(1), 203–259.

Goffman, E.1959. *The Presentation of Self in Everyday Life*..

Isla, D.2005. Handling Complexity in the Halo 2 AI. *Game Developers Conference*, 12.

Langton, C. G.1995. Artificial Life: An Overview.

Lebowitz, M.1984. Creating characters in a story-telling universe. *Poetics*, *13*(3), 171-194.

Marsella, S., & Gratch, J.2009. EMA: A process model of appraisal dynamics. *Cognitive Systems Research*, *10*(1). Elsevier.

McCoy, J., & Mateas, M.2009. The Computation of Self in Everyday Life : A Dramaturgical Approach for Socially Competent Agents. *Proceedings of the AAAI Intelligent Narrative Technologies 2 Symposium (AAAI-INT2 2009)*. Stanford, CA.

McCoy, J., Treanor, M., Samuel, B., Tearse, B., Mateas, M., & Wardrip-fruin, N.2010. Comme il Faut 2 : A fully realized model for socially-oriented gameplay. *Proceedings of Foundations of Digital Games (FDG 2010) Intelligent Narrative Technologies III Workshop (INT3)*. Monterey, California.

Meehan, J.1976. *The metanovel : writing stories by computer*. [New Haven]: Yale University Department of Computer Science.

Si, M., Marsella, S., & Pynadath, D. V.2009. Modeling appraisal in theory of mind reasoning. *Autonomous Agents and Multi-Agent Systems*, *20*(1), 14-31.

Turner, S.1994. *The Creative Process: A Computer Model of Storytelling and Creativity*. Psychology Press.