Shared Mental Models in Improvisational Performance

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ABSTRACT

This paper describes the mental structures called *shared mental models*, which are heavily related to group problem solving and cognition, and reports how they are related to theatrical improvisation based on our empirical findings. We have conducted a series of studies on real life improvisers aimed at uncovering the underlying cognition involved in improvisation, with the end goal of having a clear understanding of how to build improvisational synthetic characters. We describe *cognitive divergence*, when improvisers have conflicting mental models of what is occurring on stage, and *cognitive convergence*, which is the process of resolving such conflicts within the performance. These findings are supported by examples from our study and are used to make conclusions about improvisational synthetic character design.

Categories and Subject Descriptors

I.2.1 [Artificial Intelligence: Applications and Expert Systems]; J.5 [Arts and the Humanities]

General Terms

Algorithms, Design

Keywords

Improvisation, cognitive science, intelligent agents, narrative

1. INTRODUCTION

> "Hence, mental models serve three crucial purposes: They help people to describe, explain, and predict events in their environment."
>
> - Mathieu, Heffner, Goodwin, & Cannon-Bowers [12]

There has been interest in the believable agents community in creating *improvisational agents* that could interact with a user or other agents in a dramatic, free flowing, and coherent manner. Improv agents can be used in game-based environments to respond to unplanned user inputs, like in interactive narratives, virtual worlds, or as pedagogical agents in digital game-based education. Previous approaches [6,17] have been based primarily on canonical improv texts, such as Johnstone's [9] or Spolin's [19]. These works tend to focus on a single aspect of improvisation, such as *character status* (i.e. the relative dominance a character has compared to others on the stage), and have produced characters that rely on declarative knowledge of what people are taught about improvisation, not about what they actually do nor about what cognitive mechanisms elicit their behavior. While useful case studies, these projects have not helped us reach an understanding about how to create improvisational characters mainly because we do not adequately understand what it is improvisers *do*.

Our ongoing multi-year effort to understand the cognition involved in theatrical improvisation, attempts to reach a broader and deeper understanding of improvisation as it relates to artificial intelligence. We collect data on real life improvisers by having them perform in our study space and then reflect on each performance in recorded individual retrospective protocol collections and group interviews. Our goals have been to a) define a methodology for studying this little understood domain of human creativity, b) develop a better theoretical understanding of cognition and creativity in an improvisational setting by studying real world improvisers, and c) develop synthetic characters that employ a computational representation of our findings.

We focus on cognitive phenomena that seem tractable and relevant to the creation of synthetic characters for computer games, virtual worlds, or interactive narratives in an attempt to keep the work tractable and relevant. We have four major categories describing our current findings: basic cognition, narrative development, referent use, and shared mental models (see [10] for a discussion of our general findings and experimental details). Our current findings on shared mental models seem to show them fundamental to the improvisational process in a group performance. Previous representations of improvisation have focused on either the aforementioned examples of improvisational teachings or have focused on postulations of core algorithms for decision-making [8]. Neither of these approaches has focused on a fundamental aspect of improvisational theatre and performance: group dynamics. We selected improvisational theatre as our domain of study in part because it had a unique feature that made it different from most other forms of improvisation: improvisers must always coordinate with each other *implicitly* as opposed to *explicitly*. Whereas jazz performers can use body language, verbal communication, eye contact, etc. to indicate intention, theatrical improvisers have everything that is done on stage interpreted as part of the performance of their characters. For instance, they cannot explicitly say "let's take the story in this direction" or "you be this character," they must implicitly

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communicate, negotiate, and agree on scene elements through their performative acts.

The term *shared mental models* specifically refers to the common framework of knowledge (i.e. *mental models*) shared among the members of a group [4,16]. Each group member possesses a collection of assumptions, or mental models. Mental models are internal constructs that people use to understand and anticipate the world around them. In a group environment, these mental models (collections of assumptions) do not necessarily all coincide. When individual mental models conflict (that is, when they diverge), *cognitive divergence* occurs. While cognitive divergence persists, the shared mental model of the group is incomplete. Some mental models might be shared among the group, but divergence on one or more issues prevents complete *cognitive consensus* (agreement of mental models) among all members. Divergence must be corrected actively and intentionally on the part of one or more members of the group through the process of *cognitive convergence*. If cognitive convergence never occurs, cognitive divergence will continue and the shared mental model of the group will be incomplete.

Based on the findings we report below, shared mental models appear to be a very fundamental feature of improvisational theatre. Improvisers continuously make decisions based on their estimation of what the other improvisers are trying to accomplish and this implicitly shared agreement to reach an agreed upon state during a performance. Understanding how shared mental models are used by improvisers on stage can inform us how to build better improvisational agents, which is also discussed below.

2. RELATED RESEARCH

Several studies in psychology have helped us reach a general understanding of shared mental models. For example, Mathieu et al. examined shared mental models in the context of team performance [12]. The study examined two-person teams working together in computer flight-combat simulations, "…show[ing] that the similarity of knowledge structures between two team members can predict the quality of team processes and performance." Stout et al. outlines another experimental study that focused on the relationship between shared mental models and team planning [20]. In the experiment, teams of two, randomly assigned as "mission commander" and "second in command," were given a series of tasks to accomplish for a strategic mission in a helicopter simulation. The study reveals, among other things, that the quality of team planning positively influences the formation shared mental models.

Cannon-Bowers et al. provide a comprehensive look at the idea of shared mental models [4]. Drawing on earlier research by Cannon-Bowers and Salas [3], it presents shared mental models as a tool for understanding team performance and team decision-making. They provide a definition of shared mental models as "...knowledge structures held by members of a team that enable them to form accurate explanations and expectations for the task, and, in turn, to coordinate their actions and adapt their behavior to demands of the task and other team members." Orasanu & Salas provide a simpler definition, describing shared mental models as "organized knowledge that is shared by team members" [16].

In the context of improvisational theatre, shared mental models are especially useful for understanding the dynamics of the stage. Shared mental models are the mechanism that allows improvisers to improvise "on the same page." Likewise, the absence of shared mental models explains failures of performances to "make sense": since the improvisers themselves have not made sense with each other. Once this mechanism is understood, it is possible to proceed to understand how it is created.

There are several concepts relevant to shared mental models, the most important of which is *cognitive consensus* [14,15]. Mohammed & Ringseis define cognitive consensus as "similarity among group members regarding how key matters are conceptualized." and "...shared assumptions underlying decision issues" [15]. Mohammed, in a different essay, defines cognitive consensus as "a common conception of the assumptions underlying the issues of importance" and the "internalization of the group's viewpoints" [14]. All of these definitions relate very directly to the definitions of shared mental models, especially Klimowski & Mohammed's definition and the common idea of "underlying assumptions" [10]

Cognitive consensus is distinguishable from shared mental models in that it is a state that a group can reach whereas shared mental models refers to the cognitive structures involved in reaching that state. Therefore, cognitive consensus is a prerequisite for the existence of shared mental models. Because of the aforementioned research on the positive effects of shared mental models, it naturally follows that cognitive consensus is desirable for groups seeking to create stronger shared mental models and the benefits it brings. Cognitive consensus' desirability makes it the goal-state of our coding scheme, with all other analyses focusing on how it is created.

Another relevant concept is "grounding," the communication theory term used to describe the process of establishing mutual understanding (i.e. common *ground*) [5,21]. This idea of establishing common ground is very similar to that of establishing cognitive consensus. Thus, grounding proves a useful counterpart to of cognitive consensus. Also, it describes a more functional level of Cognitive Consensus, mentioning the specific techniques or types of phrases people use to communicate. Because of this low-level specificity, grounding provides the necessary vocabulary for describing the tools improvisers use to communicate and navigate their divergences. This vocabulary includes *presentation*, *repair*, *repair request*, *verification*, *acknowledgment, acknowledgment request*, *acceptance*, and *rejection* [5,21]. However, these terms were not completely adequate for describing our data, so we extrapolated a several more terms: *observation*, *deferment*, *clarification request*, and *blind offer*. The next section of this paper describes these terms in more detail.

A final relevant concept is Janis' idea of *groupthink* [7]. Groupthink is a phenomenon that he describes as "a mode of thinking that people engage in when they are deeply involved in a cohesive in-group, when the members' strivings for unanimity override their motivation to realistically appraise alternative courses of action." Baron makes the relation of this phenomenon to cognitive consensus all the clearer, defining groupthink as "the illusion of consensus" [1]. Thus, groupthink is a poorly executed and failed attempt at achieving cognitive consensus.

3. CURRENT FINDINGS

So what relevance do shared mental models have to understanding improvisational (improv) theatre? Misunderstandings and miscommunications are common in improv because coordination between improvisers is not an explicit act (i.e. improvisers do not directly communicate their intentions in a scene outside of what

occurs in the performance on stage). Improvisers do not necessarily share the same knowledge related to a scene from the very beginning. Therefore, it is up to them to implicitly communicate with each other onstage (through the actions of their characters) and establish cognitive consensus during a scene. The free-flowing, unscripted nature of improv makes all the more transparent the process of recognizing and resolving divergences in mental models in order to achieve cognitive consensus and create shared mental models among the improvisers.

- Cognitive Divergence:
  - Diegetic:
    - Character
    - Environment
    - Future-oriented
  - Nondiegetic:
    - Actor
    - Audience
    - Methodological
    - Theoretical
    - Interpersonal
    - Moral
    - External Knowledge
- Cognitive Convergence:
  - Observation
  - Repair:
    - Self-Oriented:
      - Deferment
      - Repair Request:
        - Clarification Request
        - Verification
        - Blind Offer
    - Other-Oriented:
      - Presentation
      - Clarification:
        - Actor Clarification
        - Audience Clarification
      - Acknowledgment Request
  - Acceptance:
    - Perceived Cognitive Consensus
    - True Cognitive Consensus
    - Acknowledgment
    - Groupthink
    - Rejection

Fig. 1. This figure depicts the shared mental models process, divided into *cognitive divergence* on the left and *cognitive convergence* on the right. This structure represents all possible steps taken in the attempted creation of shared mental models.

Some improv "games" (i.e. scenes that have specific rules for the improvisers to follow), such as "Party Quirks," even have this mechanic (which we call "knowledge disparity") built into the structure of their performance. In Party Quirks, one improviser plays the part of a party host to three other improvisers, all of whom are given specific character quirks known to everyone except the host. It is the goal of the host to infer the quirks of all three other improvisers from their behavior and interactions on stage. In other words, the host must deliberately seek out cognitive consensus with his fellow improvisers. However, it is important to realize that even improv games that do not deliberately disrupt cognitive consensus can bring about divergences between improvisers. For instance, three improvisers in a narrative-focused scene were instructed to act out a dinner scene according to a very specific plot. During our group interview afterwards, it became clear that each improviser had a very different idea about the role and gender of each of the other characters throughout the entire scene.

After studying several performances of similar improv games, we have developed an induced theory for how to describe the data related to shared mental models in our study. This theory is based on the mixed top-down and bottom-up process described earlier, using our data to help indicate what kind of phenomena is present and current theories in related domains, such as organizational psychology, to provide terminology for describing what we are finding. This theory is subsequently being used as our coding scheme for annotating video data, which will eventually lead to more fine-grained analyses of our study data.

Fig. 1 outlines our current theory of shared mental models and improvisation. The rest of this paper provides an overview of the relevant elements in this outline and how they map to our study data.

3.1 Overview

The two main processes involved in reaching cognitive consensus are *cognitive divergence* and *cognitive convergence*. Cognitive divergence is when the assumptions of two or more improvisers do not match. For example, one improviser thought that a particular scene was in an office while another improviser thought it was in a coffee shop. Since we are interested in understanding how improvisers achieve cognitive consensus, it is important to begin by recognizing when it does not exist. The second process is cognitive convergence, or the process of achieving consensus. The terms themselves are derived from the concept of cognitive consensus and describe whether the mental models of one or more improvisers are moving towards (converging) or away from (diverging) that goal.

3.2 Cognitive Divergence

Shared mental models are based on shared assumptions between improvisers [4,16]. Therefore, cognitive divergence manifests itself as the types of assumptions that can conflict between improvisers. This divergence is not caused merely by the existence of these assumptions but by difference between the assumptions of two or more improvisers. Since we are studying a narrative form, terms specific to narrative theory can help us organize these assumptions into *diegetic* and *non-diegetic* categories.

Diegetic assumptions relate to the story-world of a scene. The types of diegetic assumptions, which are based both on related work [13] and our own findings, are *character*, *environmental*, and *future-oriented*. Character assumptions are about character relationships, goals, history, and attributes. For example: "Oh, I

didn't realize you were a woman." Environmental assumptions are about objects, locations, and their attributes. An example of this would be the office/coffee shop confusion from earlier. Future-oriented assumptions are about the direction of the development of the story.

Non-diegetic assumptions include everything that does not directly concern the story-world of a scene. The types of non-diegetic assumptions, which are based both on related work [13] and our own findings, are *actor*, *audience*, *methodological*, *theoretical*, *interpersonal*, *moral*, and *external knowledge*. Actor assumptions are assumptions about another actor's assumptions (similar to the idea of metacognition). This is usually characterized by thoughts about another improviser's thoughts, such as one improviser's comment that "...I thought you knew who she was." Audience assumptions are concerned with what the audience is thinking. Methodological assumptions are about the methods and procedures of a specific improv game (also called *referents* [18]). Theoretical assumptions are about the broad nature of improvisational theatre and its practice. For instance, one improviser put arbitrary restrictions on his performance because of his theoretical assumptions, commenting later that "… in short form traditionally…once you're in you're in, once you're out you're out…later on it was like…'I could have been in there the whole time.' It's like side-support. I didn't know we were supposed—we could do side-support." Interpersonal assumptions are about one's relationship with the other improvisers and appropriate ways to interact with them. As one improviser explains, "you need to be comfortable taking a risk and touching your teammate." Trust and respect are very relevant to interpersonal assumptions because they dictate how improvisers interact with each other. Moral assumptions are about what is appropriate for a public performance (e.g. swearing, taboo topics, etc.). Finally, external knowledge assumptions are about real-world facts (such as a reference to the current president or a classic literary author). For example, one improviser was confused by his fellow improvisers' references to external knowledge, saying, "What the heck is queso? I don't know what queso is! I'm thinking 'What is queso?'"

3.3 Cognitive Convergence

As already mentioned, cognitive convergence is the process of establishing cognitive consensus, which is a state of agreement of assumptions between two or more people and is necessary for shared mental models to exist. Cognitive convergence takes place in three phases: *observation*, *repair*, and *acceptance* [5,21].

Observation. *Observation* is the internal recognition of a divergence by an improviser. It occurs for each new divergence that is recognized (that is, each divergence that occurs after a change in an improviser's mental model). Even though an observation might be inaccurate, it still exists from the perspective of the improviser., Observation is not necessarily a prerequisite for the other phases of convergence, even though it usually precedes them. For instance, in the Party Quirks improv game mentioned earlier, divergence is implicit so improvisers will begin the scene with the specific knowledge of a) knowing divergence exists and b) trying to fix it.

Repair. The next phase of convergence is *repair*, which is an active (external/intentional) attempt to reconcile divergence [21]. It can be *self-oriented* (actions taken in order to align oneself with another actor's mental model) or *other-oriented* (actions taken in order to align another actor with one's own mental model).

A *self-oriented* repair comes in the form of a *deferment* or *repair request*. *Deferment* is when, after a divergence is observed, an actor decides to wait on more input/clarification from other improvisers with the intention of eventually resolving the divergence. It is choosing to take a passive role in a scene until the mental models of others are presented more clearly. A *repair request* is the communication of a need for clarification, and it breaks down further into three types: *clarification request*, *verification*, and *blind offer* [21].

A *clarification request* is an explicit request for clarification, often short and simple, such as "Pardon?" It can sometimes "break the scene" (i.e. inject an awkward moment into the progression of the scene) when it is made out-of-character, such as what happened in one performance of Party Quirks when improviser D2 pointed out that "I'm not getting any help here!"

Verification is when an improviser presents what they think another's mental model may be, either by guessing or repeating/rephrasing what has just been said [21]. For example, in one performance of Party Quirks, improviser D2 mentions that "I could get Ghost Hunters in here" when he is trying to guess the quirk of improviser D3. D2 confirms in a later interview that this statement was a guess that D3 might be a ghost.

Clarification requests and verification may seem very similar. To clarify, a clarification request occurs when an actor has no understanding of another actor's mental model. Verification occurs when an actor thinks they might understand another actor's mental model but want to verify whether or not they are correct.

A *blind offer* occurs when an improviser introduces new information to the scene that is deliberately vague and partially defined with the intention that others will use the new information to clarify their own mental model. In the scene of Party Quirks mentioned earlier, D2 employs this technique while trying to guess D3's quirk, mentioning a fight on TV and the possibility of gifts that D3 may have brought for D2. These details were D2's blind offers to D3 in hopes that she would respond to them and give D2 more clues.

Other-oriented repairs are divided into three types: *presentation*, *clarification*, and *acknowledgment request* [5,21]. *Presentation* is when an actor presents new information (explicitly or implicitly) that is intended to communicate his assumptions to another actor [5,21]. In the improv game Party Quirks, this type of repair is the equivalent of a "hint." *Clarification* is an actor's attempt to correct any potential misinterpretation of information he has already communicated [21]. In Party Quirks, this happens when a party guest responds to a guess (verification) about their quirk with "Yes, but..." or "No, but...", confirming or denying the guess and then explaining why the guess was close or wrong. This explanation is clarification.

There are two sub-categories of clarification: *actor* and *audience*. *Actor clarification* is an improviser's attempt to clarify his assumptions to others in the scene (often involving repetition of earlier ideas). In the words of an improviser whose actions reflected clarification, his intention was "reaffirming the clues that have already been said." *Audience clarification* is an improviser's attempt to clarify his assumptions to the audience. This usually involves exaggeration or an aside.

Finally, an *acknowledgment request* is an actor's request (see *acknowledgment* under *acceptance*) to confirm that another actor has reached consensus with her [5,21]. This is essentially an

attempt to communicate, "Do you understand?" One improviser summarized her thoughts as she made an acknowledgment request as "Spit it out! I know you know! Come on, you're so close!"

Acceptance. *Acceptance* is the resolution of all attempted repairs [5,21]. At this point, cognitive consensus is either achieved or it is not achieved. Either way, the improviser "accepts" a new mental model, whether it is the right one or the wrong one. If his mental model changes correctly, there is consensus. If it changes incorrectly, there is a new divergence. Thus, there are a few possible conclusions to the process. There can either be *perceived cognitive consensus*, *true cognitive consensus*, *groupthink*, or *rejection* [5].

Perceived cognitive consensus results when an actor accepts their own *perception* of another actor's mental model [14,15]. This results in a change of that actor's mental model, which can potentially lead to further divergences. Also, this consensus can be partial—it does not necessarily mean that *all* assumptions will match. For example, in a performance of Party Quirks, the party host pointed out that "I didn't get flying, necessarily, from [her hint] but I did realize that it had something to do with how she was moving." In this case, the host came to understand part of his fellow improviser's quirk (that it had to do with movement), even though he did not understand its entirety (that she could fly). He then adjusted his mental model accordingly.

True cognitive consensus results when an actor truly accepts the mental model of another [14,15]. Whether or not this occurs can only be confirmed by interviewing the improvisers as a group, which we do as part of each run in our study.

Acknowledgment is when an actor explicitly, externally communicates to another actor that there is cognitive consensus between them [5,21]. Improvisers can sometimes mistakenly do this when consensus does not actually exist. For instance, another actor can perceive a guess that happens to be right as an acknowledgment. In one performance of party quirks, the party host D2 made a comment to D4 that happened to be very close to guessing D4's quirk. D4 responded to this by saying "yeah," communicating that D2 was correct. D2, however, did not recognize this "yeah" as acknowledgment. He still lacked the cognitive consensus that D4 thought that they had. Also, to clarify any confusion about the difference between acknowledgment and cognitive consensus: acknowledgment is externalized in action while cognitive consensus is internalized by a change in mental model.

Groupthink, as mentioned earlier, is "the illusion of consensus" [1]. Janis originally applied this concept at a broad cultural level [7]. However, in the context of improvisational theatre, we use this term to describe when an improviser accepts the strongest mental model of a group without ever contributing her own personal creativity to the group. This often leads to passive mimicry on the improviser's part. This attitude is captured very clearly by the testimony of improviser B5:

> "I think she's getting that I will go along with whatever choice she makes…she took more control of the scene than I did—which is fine, um, cause…I'm a player that kind of goes along… I think, um, she probably has more experience than I do, so, I'm kinda like, comfortable with letting her lead."

While the usual process of achieving consensus occurs by adapting and adjusting multiple mental models into a single shared mental model, groupthink simply rejects all but the perceived strongest mental model. Groupthink arises from the perceived unimportance of one's own ideas/assumptions, from an overzealous desire to prevent divergence, or simply from bad improvisation technique. It is usually negative because it limits the ability of a group to explore a range of possibilities for a scene.

Finally, *rejection* results when a decision is made not to resolve competing models [4]. This could happen because of stubbornness, indifference, intended comedic effect, or an actor simply getting frustrated and giving up. In one performance of Party Quirks, the party host justified his rejection by the fact that he was "resigned." After a long series of failed attempts to guess his fellow improviser's quirk, "the last thing [he] wanted to have to do was admit that the word was 'kleptomaniac.'"

4. Discussion

Our preliminary findings are illuminating in terms of the success and failures of previous approaches to improvisational agents. As opposed to focusing purely on specific improvisation skills that are taught, such as how to communicate status or accepting propositions made by other improvisers, we have built our theory of improvisation based on top-down (i.e. organizational psychology finding) and bottom-up (i.e. data-driven) analysis. We have shown that shared mental models are a fundamental aspect of the improvisational process and need to be taken into consideration in the construction of synthetic characters.

We do understand the different strategies that improvisers use to recognize cognitive divergences and attempt to reach cognitive convergence, but have yet to discover when they are used or why. Once our performance data is coded based on the coding scheme described in Figure 1, we will then conduct an analysis of novice vs. expert data. If we can understand specifically how experts reach cognitive convergence, we can then incorporate those strategies into our computational model of improvisation. Improv agents should have processes that incorporate the convergence processes of *observation* of *diegetic* and *non-diegetic divergences*, *repair*, and *acceptance*. These processes alone do not make an improviser, but are fundamentally related to their decisions about story, character, setting, and comedy.

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