Shared Mental Models in Improvisational Theatre

Daniel Fuller
School of Literature, Communication, and Culture
Georgia Institute of Technology
686 Cherry St., Atlanta, GA
dfuller3@gatech.edu

Brian Magerko
School of Literature, Communication, and Culture
Georgia Institute of Technology
686 Cherry St., Atlanta, GA
magerko@gatech.edu

ABSTRACT

This article presents our currents findings from an empirical study of the cognition employed by performers in improvisational theatre. Improvised theatrical performance is an activity in which one or more individuals create a dramatic or comedic performance in real-time and is an interesting example of creative, real-time, collaborative problem solving. Unlike other forms of creative problem solving, improvisers are constrained from explicitly coordinating with the other improvisers on stage or revising their decisions after the fact. This article focuses on the means by which a group of improvisers converge on a shared understanding (i.e. a shared mental model) of what a scene is about and how it should proceed. We present our findings on how improvisers build shared mental models during a performance and discuss our applications of these findings to the design and development of improvisational intelligent agents.

Keywords

Improvisation, cognition, theatre, intelligent agents, mental models

ACM Classification Keywords

I.2.0 General: Cognitive simulation.

General Terms

Theory.

INTRODUCTION

Theatrical performance is an activity in which one or more individuals create a dramatic or comedic performance in real-time. It involves intricate orchestration of emotional expressions, communication, interaction strategies, and problem-solving, all of which can place varying levels of cognitive demands on the performers depending on the degree of improvisation in a particular performance setting.

There is a spectrum of spontaneity in theatrical acting, from completely predetermined (e.g. heavily scripted acting) to completely non-predetermined (e.g. children at play). In the middle of the spectrum one will find the genre of theatre called *improv* [8, 9, 22]. Improv is a remarkable example of creative group performance because (a) the creation process of narrative content is completely in real-time, (b) there is no explicit coordination between the improvisers, and (c) the constraints on a performance typically follow the form of a set of game rules plus audience suggestions (called *short form* improv).

While there have been studies of improvisation and cognition in other art forms [16, 21, 25], these studies have relied mainly on observational techniques coupled with applying music theory to describe what happens on stage. Little work has been done to elicit data at the level of goals and knowledge (as opposed to fMRI research [11], for instance) on the decision making processes of improvisers [15, 16] and no work, to our knowledge, has been done on cognition within the domain of improvisational theatre[1]. Therefore, our goal is to fill in the gaps of our understanding of creativity and improvisation through the study of improvisational theatre and by better understanding the knowledge and processes employed by improvisers, to build computational improvisation agents that represent our formal findings on studying humans.

Many of the standard approaches to data collection in artistic domains must be adapted to theatre because of the real-time, dynamic, and group collaborative nature of performance. Our current work has focused on methodologies from (a) observational study [1], (b) concurrent verbal protocols, (c) group interview, and (d) semi-structured interview. We invited improvisers to perform a scene while we filmed, after which we replayed the footage to each individual improviser while interviewing him in regards to his thought processes during the performance. We followed up these individual interviews by interviewing the entire group at once, seeking further insight into their thought processes from a different perspective. Our current findings are based on close analysis of the video recordings of these interviews and performances. The terminology we use to describe the findings of this study is derived by comparing our data to relevant existing works. Where we found an absence of terminology to describe phenomena, we invented our own.

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[1] Sawyer's studies of theatrical improvisation from an ethno-linguistic stance are the only previous large scale study of the domain [20].

Thus, rather than approaching our study with a specific vocabulary in mind, we first gathered data and then borrowed and invented the necessary terminology to describe what we observed. For more information on the details of this methodology, see [13].

The key contributions of this work are:

The identification of (a) cognitive processes underlying improvisation, and (b) knowledge employed in improvisation, through a variety of studies involving human improvisers. Improv performance utilizes rich, diverse, and constrained cognitive processes that are not well understood. In this article, we focus on shared mental models and the processes by which performers, in conditions in which they are not able to explicitly communicate or coordinate, are able to converge on a shared understanding.

SHARED MENTAL MODELS

A major recurring theme in our analysis of improv performances is of the construction of shared mental models by performers. Shared mental models are an extension of the concept of mental models (i.e., "organized knowledge structures for an individual" [3, 19]) to the notion of shared knowledge between individuals in a group. For our purposes, mental models are any underlying assumptions held by an improviser. Therefore, shared mental models are "knowledge structures held by members of a team," or in other words, assumptions (i.e. mental models) held by a group such that "members think about a phenomenon in a similar manner" [10].

Shared mental models are heavily related to concepts in other fields, such as "grounding" in discourse studies, which also deals with navigating and correcting misunderstandings [4, 23]. Amongst all of these related ideas, we consider "shared mental models" to be the most appropriate concept for our work on group improvisation because of its association with team decision-making and problem solving [3, 10, 14]. Work on grounding, on the other hand, provides useful secondary terminology for understanding the specific techniques used to construct these shared mental models.
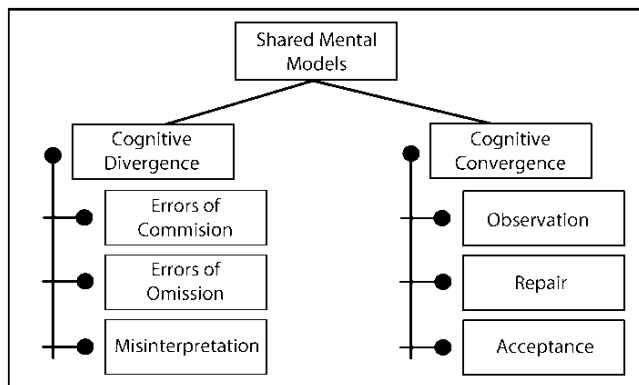

Figure 1: Divergence and Convergence

SHARED MENTAL MODELS IN IMPROVISATION

Since improv performances lack a script or other predetermined plan, there are inevitably moments during performances that improvisers describe as "not being on the same page." This phenomenon is the result of an initial absence of shared mental models. Improvisers share little knowledge about a scene before beginning it–they typically know only the functional and content constraints and little to nothing about the plot, character definitions, or what the focus of the scene will be. This phenomenon of "not being on the same page" is *cognitive divergence*, a disagreement of mental models. The term is borrowed from Levesque et al's work on cognitive divergence and shared mental models in software development project teams and is implicit in other similar works in the field of organizational psychology [10]. For instance, Mohammed and Ringseis use the terms "cognitive diversity" and "dissensus" to describe the same phenomenon in their discussion of group decision-making [19].

Divergences are inevitable: every new element or change to a scene has the potential to cause a conflict between mental models. Therefore, how improvisers navigate these divergences when they occur is central to the progression and development of any improv scene. This process is *cognitive convergence*, the opposite of cognitive divergence. Cognitive convergence in a group repairs cognitive divergences and develops a group understanding, i.e. a *shared mental model*.

The ultimate goal of cognitive convergence is *cognitive consensus*, the state of agreement of assumptions (that is, mental models) between two or more improvisers [18, 19]. Cognitive consensus is directly tied to the concept of shared mental models. When a divergence is transformed into a shared mental model, cognitive consensus is achieved. The presence of cognitive consensus means that the process of cognitive convergence succeeded.

Creating shared mental models involves a constant process of cognitive divergence, convergence, and consensus of mental models (see Fig. 1). Sometimes this process is instantaneous, but other times it requires significantly more effort. Specific to improv is how shared mental models are often created without explicit means (e.g. explicitly stating one's own mental model) due to the performative nature of being on stage; every act on stage is done within the context of performing a scene. Instead, indirect techniques are used to navigate divergences in real-time as they occur, correcting mistakes without disrupting the narrative flow of a performance. This process of constructing mental models in performance is explored below within the specific domain of improvisational theatre, which we have determined has its own contextual variations on what divergences can exist and how they are dealt with by improvisers.

COGNITIVE DIVERGENCE
Causes of Cognitive Divergences
Cognitive divergence occurs whenever two or more mental models disagree (i.e. diverge). Divergences may occur because of errors of *commission, omission,* and *sensory misinterpretation* (see Figure 1). These three phenomena are *how* divergences may occur. Detailed later are the types or divergences, or *what* information the divergence concerns.

Errors of Commission
An error of commission occurs when an improviser portrays a model that another improviser misinterprets. An example is a scene in which an improviser was pretending to rake leaves, but a second improviser interpreted that action as sweeping, resulting in a misinterpretation of the meaning of the first improviser's actions.

Errors of Omission
An error of commission occurs when an improviser portrays a model that another improviser does not understand. For example, in one scene an improviser mentioned "queso," but a second improviser became confused because he did not know what "queso" (Spanish for "cheese") was. The omission is due to the first improviser's reference to knowledge that the other did not have.

Sensory Misinterpretation
An error of sensory misinterpretation occurs when an improviser portrays a model which another improviser mishears. For example, one improviser mentioned "pitchers" but a second improviser heard "pictures," leading to two entirely different interpretations of the setting of the scene ("baseball game" and "movie theatre").

Types of Cognitive Divergences in Improv
There are several types of divergences in improvisation depending on what type of information diverges: character, environmental, future-oriented, external knowledge, theoretical, methodological, moral, actor, audience, sensory, and repair divergences. Many of these are adapted from Mitroff and Emshoff's list of types of assumptions [17], which was based on studying business management. The original list is inadequate for describing the specific domain of improvisation (excluding, for instance, divergences relevant to a narrative). Therefore, we have expanded the original list based on our own observations to include several more items. The mechanics behind each type of divergence is explained in detail below.

Character Divergence
A *character divergence* is a disagreement concerning the attributes, relationships, history, goals, or emotions of a persona in the scene, which is distinct from the improviser's actual identities. For example, in one scene in which a male improviser portrays a female character, his co-performer became convinced that the former was portraying a male character, commenting later "I thought you were a very effeminate man."

It is important to note that character divergence is one of the types of divergences that can exist implicitly in the rules of the scene. In the improv game *Party Quirks*, the rules dictate that one improviser plays the role of a party host does not know the quirks (i.e. character attributes) of any of the other improvisers, who each play guests at his party. The host has to correctly guess the quirks of each guest in order to complete the game. This creates several inherent divergences between the host and the guests.

Environmental Divergence
An *environmental divergence* is a disagreement concerning locations, objects, or the attributes of locations or objects in the scene. One scene progressed almost entirely to the end with one improviser thinking he was in an office break room while the other two believing that they were in a coffee shop.

Environmental divergence is the other type of divergence that can exist implicitly in the rules of the scene. In the improv game *Blind Scene*, the rules specifically dictate that one of the improvisers does not know the initial setting or premise. There can be other types of implicit divergences, but character and environmental are the most common.

Future-Oriented Divergence
Future-oriented divergences are about the direction of the development of the story. As opposed to disagreements about the current state of an improv scene, this type of divergence involves different ideas about what will happen next. One improviser noticed this happening in a scene that alternated control of the story between several improvisers: "I kind of had a different idea of what might happen next and then [another improviser] will come in and say something."

External Knowledge Divergence
An *external knowledge divergence* is a disagreement about a reference to cultural knowledge from the "real world" (i.e. beyond the context of the scene). An external knowledge divergence might arise simply because one of the improvisers involved does not know anything about the referent. The earlier example of confusion over the word "queso" is an external knowledge divergence.

Theoretical and Methodological Divergences
Our study confirmed the existence of both theoretical and methodological divergences, both of which have been studied previously (although we interpreted a relevant mapping to the domain of improv). A *theoretical divergence* [17-19] is a disagreement concerning the broad nature of improvisation and its practice as it relates to the current scene. A *methodological divergence* [17-19], on the other hand, is a disagreement concerning the methods, procedures, or conventions of a specific improv game. While these two types of divergences may seem similar, methodological divergences differ from theoretical divergences in terms of scope. Both types may refer to improvisational techniques, but their context is different. Theoretical divergences relate to improvisational theory as

a whole, while methodological divergences relate to the specific game being played in the scene.

One improviser introduced elements of "negativity" to a scene while the second improviser was motivated to maintain a positive attitude in the scene, explaining later that his "goal was to be positive because conflict's easy. We do that all the time, and we talked about it in our Wednesday rehearsal. This weekend we should try as much as we can in every scene that we can to be positive." A theoretical divergence resulted when the first improviser did not behave in accordance with the discussion from rehearsal while the second one did.

In a scene of *Party Quirks*, the party host began to welcome a second party guest to the stage before she had guessed the quirk of the first party guest (refer to the section on Character Divergence above for the rules of this game). This action worried one of the other improvisers, who said that "I did get concerned at this point…'cause [another improviser] looked at me and was like 'isn't she supposed to guess before the next person comes in?'" The party host, on the other hand, explained, "I didn't realize that. I thought that it was ok to come back to the person." The conflict of opinions on how to play *Party Quirks* resulted in a brief methodological divergence. The divergence was not theoretical because it specifically concerned the game *Party Quirks*.

Interpersonal and Moral Divergence

An *interpersonal divergence* is a disagreement concerning what is an appropriate way for improvisers to interact with each other [17-19]. The key factor of interpersonal divergences is trust. This is related to, but not the same thing as, *moral divergence*, which is a disagreement concerning what is appropriate for public performance [17-19]. Instead of issues of trust and personal space, a moral divergence involves issues such as taboo topics, drinking alcohol on stage, or swearing in front of a young audience.

In one scene, an improviser ended up kissing another improviser on the cheek even though they had never performed together before. The second improviser commented "I've never met her before and I mean later on I think she kisses me on the cheek or somethin' which is kinda like one of those things that you don't really expect when you don't know somebody." The second improviser's surprise at the forward actions of the first improviser is an example of interpersonal divergence.

In a different scene, the story eventually became about Jesus being a "pimp", which disappointed one of the improvisers who had to act it out:

> I had no idea it was going to go into Jesus, you know? But at the point that it did go to Jesus, here's a few things that I try to stay away from when I do improv: politics and religion…because you don't know who the hell you are going to offend.

In this case, the improviser had different ideas than his scene partners about what was appropriate, resulting in a moral divergence.

Actor and Audience Divergence

One of our key findings from the study is a form of divergence that we call *actor divergence*. Actor Divergence is a disagreement concerning the mental model of another improviser. It is a divergence of assumptions about assumptions. Actor divergences occur in addition to any other divergences. In one game of *Party Quirks*, a party guest drew the wrong conclusions about the party host's assumptions. The guest thought that the host had just figured out the quirk of another party guest ("someone who is invisible"). As the improviser explains, "I thought [he] knew who she was." Believing that the host had figured out the quirk of the first party guest, the improviser decided to enter the scene as the second party guest. As it turns out, the host had not actually figured out the first guest's quirk. In this example, there was a character divergence between the host and the invisible guest and an actor divergence between the host and the second guest.

Another key finding from the study is *audience divergence*, defined as a disagreement between an improviser's mental model and his perception of the collective mental model of the audience. It deals with what an improviser perceives the audience understands. It is an assumption about assumptions, similar to an *actor divergence*. An audience divergence need not confirm the audience's point of view in order to exist. It is impossible to gather data on what an entire audience was thinking during a performance, but it is adequate that the improviser *perceived* the divergence. In their mind, there is a divergence.

The improv game *Three Sheets* is one of a category of improv games called *knowledge disparity games* that explicitly create divergences as part of their rules. In this game, each improviser has a sheet taped to their back describing one aspect of the scene's frame, visible only to the other improvisers. Over the course of the game, consensus about the frame must be reached. In one scene of this game, an improviser made a guess that the audience incorrectly confirmed:

> "So I was like, "Oh, maybe missionaries!" So when I said we're on a mission, people started clapping and [snaps] doing all that kind of stuff, so I was like, "Oh, we're missionaries!" But that wasn't it, and I was like, "What the hell are we?"

The improviser perceived the audience feedback as a sign that his guess was correct, but he soon realized that his guess was wrong, making it seem as if the audience led him astray.

There are several conditions when an improviser might perceive an audience divergence. The first three are cases we have observed so far while the last case is an anticipated condition that we have yet to observe directly. The first case is when the improviser believes that the audience does

not understand what has just happened. For example, one improviser repeated that an imaginary object in the scene was a Barbie car in order to remind his fellow improviser and the audience of the fact.

The second case is when the improviser believes that the audience will not understand what is about to happen. In a scene of *Three Sheets*, one improviser gave a clue that he knew his fellow improviser would understand even if the audience did not:

> "I knew that he was going to get that so that's why I said it… Even thought the audience didn't get it, people were like [makes a confused face], nobody reacted to that, but he got, I knew he was going to get it so, whatever."

The third case is if the improviser realizes that the audience does not find his behavior appropriate (also a *moral divergence*). A good example of this was mentioned earlier: the improviser who was worried about offending the audience when the scene became a story about Jesus being a pimp.

The fourth and final case is when the improviser believes that the audience does not have the correct social context for what is going on (as might be the case with "in-jokes").

Sensory Divergence
A *sensory divergence* (defined by us) occurs when one improviser does not notice or hear information communicated by another improviser. As one improviser reports: "There was a moment where I did not understand something that [he] said, and so I almost asked him…I almost was just like 'What? What did you just say?' 'Cause I didn't hear him…" A sensory divergence can simultaneously be another type of divergence based on the content of the information that the second improviser attempted to communicate. If the "something" that the improviser did not hear had been about the location of the scene, an environmental divergence might have developed from the sensory divergence.

Repair Divergence
A *repair divergence* (defined by us) occurs when one improviser uses a *repair* technique (discussed more in the next section) that another improviser does not perceive as a repair technique. A repair divergence can also be about the nature of a repair technique. One scene of *Party Quirks* escalated into a group of three party guests all giving clues for each other about their quirks. During this, the party host could not discern which clues were intended for which guests, resulting in several repair divergences.

COGNITIVE CONVERGENCE
Once one or more improvisers recognize that a divergence exists, improvisers must correct it in order to achieve cognitive consensus. This begins the process of cognitive convergence. However, it is possible that some improvisers will not even realize that a divergence has occurred. In one performance, three improvisers played out an entire scene of romantic tension while each believed different facts about the relationships and even the gender of everyone else. The problem was a lack of *observation*, the usual first step of cognitive convergence [18, 19]. As Mohammed and Ringseis point out, "[o]ne of the first steps in the development of cognitive consensus is the simple recognition that differences exist among group members, not just with regard to decision preferences, but also with regard to assumptions and interpretations underlying the issues"[19]. Based on this description, observation is an improviser's perception of a divergence. Since observation is a *perception*, it does not matter whether or not the divergence actually exists. It still occurs within the mind of the improviser.

Once an improviser observes a divergence, he or she can attempt to correct it (initiating the process of *repair*). One of the interesting points of our study is that we found instances in which observation was not a necessary precondition for an attempt at correction. We identified instances in which improvisers try to correct divergences that they *anticipate* without even waiting to see if they have occurred. In general, however, we found that cognitive convergence usually takes place in three steps: observation, repair, and acceptance (see Figure 1).

Repair
Regardless of whether a divergence is observed or merely anticipated, any attempt to reconcile a divergence is a *repair*. The term "repair" is one of several terms we adapted from literature on discourse theory. A repair is made in order to correct (potential) misunderstandings [4, 23]. In improv, repairs are the techniques used by improvisers to move toward cognitive consensus. There are several specific techniques that improvisers use to accomplish this purpose. Repair techniques can be influenced by the constraints of a particular improv scene. For instance, improvisers in *knowledge disparity games* may employ multiple techniques for giving information to others.

All repair techniques have an intended target, making them either *other-oriented* or *self-oriented*. Other-oriented techniques attempt to affect someone else's mental model. These techniques are *presentation* and *clarification* [19],[4],[23]. Improvisers use self-oriented techniques to help themselves get on the same page with someone else's mental model. These techniques, inspired by Traum's work on representing common ground in discourse [23], are *clarification requests*, *deferment*, *verification*, and *blind offers*.

Presentation
The foremost repair technique is *presentation*, which is a demonstration of what an improviser believes to be true [4, 23]. In other words, presentation introduces new information that relates to an individual's mental model. In knowledge disparity games such as *Party Quirks*, presentation typically manifests as a "hint." The idea of presentation is borrowed from Clark and Schaefer [4], who use the phrase "Presentation Phase" to describe the part of a

conversation when someone makes an assertion for someone else to consider.

Presentation is other-oriented in intent. However, in knowledge disparity games especially, improvisers sometimes make presentations on behalf of someone else. In one game of *Party Quirks*, the first party guest had the quirk "someone who is invisible." Late in the scene, another party guest tried to help the host realize the first guest's quirk by mentioning "H.G. Wells," who wrote the book *The Invisible Man*.

In the context of a performance space, there is a special type of presentation that improvisers refer to as *side-support*. Side-support is when an improviser who is offstage temporarily intrudes upon the scene in order to make a contribution (such as a presentation). Side-support can also be a type of clarification (see the next section).

Clarification

Clarification is another other-oriented repair technique used by improvisers to correct any misunderstandings or misinterpretations of information that has already been communicated. It is different from presentation in that it does not introduce any *new* concepts (unless those new concepts are meant to clarify old ones). The idea of clarification is taken from Mohammed and Ringseis, who discusses it as a part of the process of achieving consensus:

> "Through listening to other members clarify ideas and provide rationales for their interpretations, members may proceed from understanding the different perspectives of others to accepting the legitimacy of alternative points of view" [19].

There are three main types of clarification: actor, audience, and side-support. *Actor clarification* is clarification directed towards a fellow improviser. Similar to presentation, sometimes an actor clarification can be made on behalf of another improviser's mental model. *Audience clarification* is simply a clarification directed towards the audience. *Side-support clarification* is the same as side-support presentations except that the intrusion is made to clarify rather than to introduce new information.

For each type of clarification, there are two sub-types: *anticipated* and *perceived*. A perceived clarification is one that an improviser makes in order to correct a divergence that he observes directly. An anticipated clarification, on the other hand, attempts to address a potential divergence. For example, one improviser clarified that somebody was *literally* Jesus because she believed that it was ambiguous whether he was Jesus or just some guy named Ron pretending to be Jesus. Even though she did not observe a divergence, she made the clarification to correct any divergences that might have arisen from the ambiguity of the situation. Anticipated clarifications are evidence that observation is not always a prerequisite for repair.

Another common technique we identified in our study, which we call *reverse scaffolding*, involves the performer giving subtle hints at the onset of the scene and increasing the clarity of his hints over time. The term "scaffolding" comes from educational science. Scaffolding is a technique employed by educators in which they give a large amount of guidance to a learner early on in a learning experience and then "fade" the amount of support of the student as the student gains mastery [6]. *Reverse scaffolding* is therefore our term for the use of subtle hints early on and increasingly heavy-handed hinting over time.

The purpose of reverse scaffolding is to avoid the other performer quickly reaching cognitive consensus in a knowledge disparity game and thus ending the scene prematurely. This technique directly influences the content of a repair technique, leading a given repair to intentionally convey more or less information depending on the situation.

Another noteworthy phenomenon is the use of *reincorporation* (i.e. referring to past concepts or events from a performance) as a tool for clarification. As mentioned earlier, one improviser mentioned a Barbie car a second time after another improviser seemed to forget what the object was. The first improviser explained later that he didn't want the audience to think that they (the improvisers) had forgotten what it (the Barbie car) was, making this an example of both *actor clarification* and *audience clarification*.

Deferment

The first type of self-oriented repair technique that we have identified is *deferment*. It is a deliberate choice to wait and listen for more information, hoping that consensus will occur with time. Deferment is unique among all repair techniques in that it is a choice to be passive rather than actively engage another improviser (a quality that otherwise defines repair requests).

Clarification Request

The remainder of the self-oriented repairs fall under the category of the *repair request* (called "request repair" by Traum [23] when referring to discourse), in which an improviser engages with other improvisers in order to elicit additional information that can be used to develop cognitive consensus.

The first type of repair request is the *clarification request*, a term invented to combine the meanings of clarification [19] and request repair [23]. A clarification request is when an improviser explicitly asks for help because he does not understand something. An improviser might say "What do you mean?" "I have no idea what you're talking about," or "Somebody help me out here!" This technique is sometimes directed towards the audience and usually "breaks the fourth wall" or "breaks the scene" (i.e. interrupting the narrative flow).

Improvisers tend to use other repair techniques instead of clarification requests. From a non-performance point of view, directly asking for help is the most efficient way to receive help. However, it seems that improvisers consider such behavior undesirable, perhaps because it throws off

the performance and interrupts flow of the scene. As some improvisers have reported, there are sometimes more important things than just "being right." Reverse scaffolding, as mentioned earlier, is another example of prioritizing other factors over correctness. This phenomenon is why knowledge disparity games are more than just guessing games. Otherwise, improvisers would be much more aggressive about getting the right answer right away.

Verification

When an improviser has an idea of what another improviser's mental model *might* be, he often communicates his impression to his scene partner(s) in order to verify it. This is *verification*, a self-oriented repair technique. The term is borrowed from Traum [23], who describes it as "a repetition or reformulation of what has just been said." In knowledge disparity games, verification usually takes the form of a "guess."

Verification is not always an exact formulation of what an improviser believes. It can also manifest as a statement that is related to a belief that an improviser wants to test for accuracy (i.e. wants to *verify*). For example, when one improviser thought that he and his scene partners might be preachers, he did not ask "Are we preachers?" but instead commented "Preach the people!" In a different scene, an improviser made the verification "I could get Ghost Hunters in here" instead of just guessing that someone was a ghost. This method of verification seems to be the typical application of the technique. The motivation is unclear, but perhaps improvisers make these verifications because they are less disruptive to the scene and integrate better with narrative flow.

Blind Offer

A *blind offer* (related to the canonical improv *offer*, which is when an improviser presents a new potential contribution to a scene) is the final self-oriented repair technique. Improvisers use this term to describe when they intentionally introduce new, vague, and poorly-defined information. The purpose of this action is for the improviser's scene partner(s) to take the information and expand upon it, using the blind offer as an opportunity to present or clarify their mental model(s). In one scene of *Party Quirks*, an improviser playing the party host mentions "gifts" to a party guest and implies that she might have brought some gifts for him. He later identified his comment as a blind offer, explaining:

> "If she says 'Oh yeah! Actually I got you—' and she could actually give me a clue at this point…I could open it up, and she could say 'It's a whatever' and that would be clue as to what I'm supposed to be guessing."

Acknowledgement Request

Sometimes an improviser will suspect that cognitive consensus exists between himself and another improviser, but evidence of the consensus is not immediately obvious. In such cases, the improviser might make an *acknowledgment request,* indicating to his scene partner(s)

that he desires a sign of consensus (i.e. acknowledgment). The term is a modified version of Traum's "request ack" [23], which Traum describes as a "[s]ignal for other to acknowledge." In one scene of *Party Quirks*, this technique manifested very explicitly when one of the party guests asks "Do you really know who I am? …You do? Please tell me! Please tell me!" At that point in the scene, the scene had continued for several minutes without the party host guessing the quirk of the last guest. However, the host acted as if he knew, he just hadn't said the quirk aloud. Because of this, the guest acted the way she did: "I'm like 'Spit it out! I know you know! Come on, you're so close!'"

Assessment

Most repair attempts end with *assessment*. Assessment is an improviser's evaluation of whether or not an other-oriented repair was successful. According to Clark, "The route by which A and B reach [mutual understanding] depends on the partner's initial assessment of his understanding" [4]. Assessment can either reveal that a repair was successful and that cognitive consensus was achieved, or that a repair was unsuccessful and that another repair needs to be made. For example, one improviser tried to communicate the idea of "Mormans" to another by mentioning bikes and t-shirts. The first improviser quickly realized (i.e. assessed) that this statement confused the second improviser, so he came up with different clues to communicate the same information. Before an assessment can be made, however, the recipient of the repair must *accept* the repair (unless he simply did not notice it).

Acceptance

After an attempted repair, there are two possibilities. The first is that the repair fails or goes unnoticed such that the divergence continues or a new one takes its place. The other possibility is that the repair is met with *acceptance* [4, 18, 19, 23]. Clark and Schaefer also identify this dichotomy:

> "Almost every time a speaker starts a new turn, he or she either (a) accepts what the last speaker has just said or (b) initiates a repair of the problem they ran into in accepting it" [4].

Acceptance, however, does not necessarily equate to cognitive consensus. Acceptance is merely an intentional response to a repair attempt.

Perceived Cognitive Consensus

Ideally, the type of acceptance that occurs is always cognitive consensus, the state of agreement between mental models (i.e. the existence of a shared mental model). Cognitive consensus is "similarity among group members regarding how key matters are conceptualized" [19]. This similarity of mental models is the ultimate goal of the process of cognitive convergence. However, even among cognitive consensus there are variations that are less desirable. When an improviser accepts his *perception* of another improviser's mental model, *perceived cognitive consensus* occurs. Perceived cognitive consensus results in the change of an improviser's mental model, but this

change is not always correct. An improviser might incorrectly accept what he perceives to be true, which then leads to further divergences. In contrast, groups may arrive at a decision without reaching a commonality in how issues are framed (e.g., [5]). For example, [24] contrasts *operational* consensus (group members agree upon decisions but do not share underlying beliefs) with *perceptual* consensus (group members experience a commonality of representations).

An example of perceived cognitive consensus is one scene in which an improviser had to figure out whom he and his fellow improvisers were supposed to be (a fact that his fellow improvisers and the audience knew but that he did not). The improviser eventually decided that the "who" must be "missionaries." After the audience seemed to confirm his guess, the improviser assumed that he was correct. At this point, he achieved perceived cognitive consensus. Soon afterwards, however, he realized that he was wrong and that "missionaries" was not the correct answer (it was actually "Mormons"), proving that perceived cognitive consensus is not always accurate.

True Cognitive Consensus
The ideal form of consensus is *true cognitive consensus*. True cognitive consensus is when an improviser correctly accepts another improviser's mental model. It is different from perceived cognitive consensus because the consensus necessarily exists. It can only be identified through unanimous confirmation by all the improvisers originally involved in the divergence (a phenomenon we capture in our group interview data). Cognitive consensus, however, can be partial: it does not necessarily mean that *all* mental models will be identical. Instead, it means that at least two mental models that used to be different have become the same. In the same scene as the last example, a different improviser had to guess the goal of the scene. He eventually figured out that it had to do with "dragons." While the correct answer was "converting dragons," the improviser still achieved partial cognitive consensus by understanding part of the whole. However, a divergence still existed in regards to "converting."

Sometimes acceptance is followed by *acknowledgment* [4, 23]. Acknowledgement is an improviser's confirmation that he is on the same page as someone else. It is often accompanied by a form of cognitive consensus. Traum explains that acknowledgment serves to "[d]emonstrate or claim understanding of previous material" [23]. The manifestation of acknowledgment can be as simple as "yeah," "ok," or even just a nod or meaningful eye contact. Improv differs from the standard forms of communication that Clark and Traum discuss because acceptance frequently does not involve acknowledgement because the act of acceptance might be construed as breaking out of character. However, even though improvisers can often understand each other without needing to say anything, sometimes acknowledgment is necessary for all parties involved in a divergence to achieve complete consensus,.

Furthermore, even acknowledgment can occur mistakenly. Just because an improviser says that he understands does not mean that he necessarily does (as might occur with perceived cognitive consensus).

Groupthink
Not all forms of acceptance are desirable. *Groupthink*, for example, is when an improviser accepts someone else's strongly-portrayed mental model without ever contributing his own personal creativity [2, 7]. Groupthink was originally conceived by Janis to describe a psychological phenomenon on a much larger level [7]. Many aspects of it, such as "pressures for uniformity," are still relevant to improvisational theatre. Groupthink often leads to passive mimicry and usually a less "entertaining" scene. It can result from laziness, lack of experience, the perceived unimportance of one's own ideas and assumptions, or from an overzealous desire to prevent divergence. Instead of making offers (i.e. actions that are potential contributions to a scene), groupthink repeats offers. It is a lack of individual thought. Unlike the improv technique of doing "yes, and" (i.e., accepting what another improviser has done and adding to it), which contribute to a scene while seeking consensus, groupthink neither contributes to the scene nor seeks understanding.

According to interviews with our subjects, a phenomenon that we can match to groupthink is identified as the "easy way out." Therefore, the biggest distinction of groupthink from other techniques is the negative connotation that it carries. While consensus is good, groupthink is bad because it limits the ability of a group to explore the full range of possibilities for a scene. As Mohammed and Ringseis point out, "because one of the benefits of the group context is the harnessing of multiple perspectives, cognitive consensus can become a liability when the uniqueness of individual contributions is lost" [19].

It is important to distinguish between groupthink and a common non-groupthink technique employed by improvisers in knowledge disparity games called "yes-anding." Improvisers who do not possess certain knowledge due to the constraints of the game may agree with everything their scene partner says and does. However, yes-anding is a natural and acceptable way to discover knowledge that the improviser does not posses. The distinguishing factor is whether or not the improviser is *contributing* and whether or not he is *seeking to understand* the mental model of his scene partner(s). If he is doing both of these things, then he is not using groupthink.

Rejection
Sometimes consensus is deliberately avoided. Such is the case with *rejection*, the decision not to repair a divergence [23]. Improvisers choose rejection for many reasons. The improviser might be stubborn and unwilling to admit that he is wrong. An improviser also might be indifferent or he might get frustrated and give up. Some improvisers even go so far as to allow a divergence to persist for comedic effect

because they think the audience will find it funny. Along similar lines, other improvisers might decide that a certain divergence makes for a more "interesting" scene. In one unusual case, an improviser decided not to repair a divergence because he did not perceive repairing it as important. He saw his role in the scene as the person who was supposed to constantly move the scene forward, so he figured that trying to correct the divergence would cause difficulties and impede him in his greater purpose.

Summary

After the acceptance phase, the entire cycle of cognitive divergence and convergence repeats. Ideally, the repetition of the process will eventually result in the development of a shared mental model among the improvisers onstage. However, sometimes divergences persist and cognitive consensus never occurs before a scene comes to an end. Meanwhile, as the scene continues, new divergences might arise. Resolving one divergence sometimes is more urgent than resolving another. While some shared mental models will develop, others will never exist. We have not empirically derived a relationship between consensus and scene quality, but informally there seems to be a strong connection between the expertise of the performers in the scene and how long it takes them to reach consensus.

Mental models underlie everything that happens in a scene. Since improv involves the perpetual invention and contribution of new information to a scene, there is a constant potential for errors of commission, omission, or misinterpretation regarding that information. Because of this, understanding how to create shared mental models and navigate those errors is especially important. The process of cognitive convergence allows improvisers to deal with their mistakes and reach an understanding, using shared mental models as the foundation for their construction of a collaborative scene.
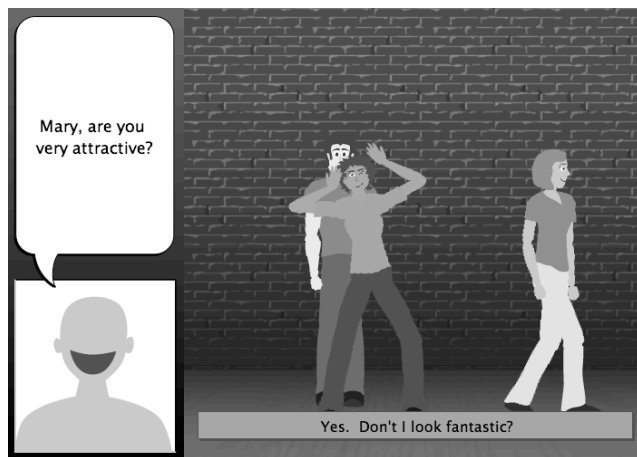

Figure 2: The Party Quirks Agent in Action

THE NEXT STEP: PARTY QUIRKS AGENT

Given the importance of shared mental models to the process of improvisation, our next step has been to construct an intelligent agent that models the process of cognitive convergence. Doing so allows us to evaluate the strength of our representation and to determine mechanically how the techniques performed by real improvisers map into actions that a machine can understand and perform.

In order to scope this phase of the project, we limited our domain to a single improv game: *Party Quirks*. The structure of *Party Quirks* lends itself well to this domain because of the built-in constraints. The purpose of the game is to resolve a divergence that is introduced at the very beginning (the host guessing the secret identity, such as "a pirate," of each of the party guests). It serves as a convenient starting point for implementing our framework as most, if not all, improv games involve some aspect of building shared mental models. This particular game is also advantageous since it typically does not involve the construction of complex stories, which would make any modeling efforts much more difficult without first understanding how to computationally represent the construction of shared mental models. The details of this implementation are described in [12].

SUMMARY

The resulting work from our empirical study of theatrical improvisation has lead us to a better understanding of the special role that shared mental models take in the performance of improvised scenes and the details for what actors do on stage to identify, address, and asses cognitive divergences. This supports Sawyer's observation that *collaborative emergence* is essential to improvisation [20] while providing the details of the process necessary to build formal computational models of it. What is special about improvisation and shared mental models is that the communication and coordination that might take place in non-performative group problem solving domains, such as a design task in a studio, cannot commonly take place on stage. In improv theatre, *the coordination is the performance* and, therefore, all attempts at reaching shared mental models must be done so within the context of the performance. This makes understanding the specific observations, knowledge, and actions improvisers employ on stage all the more important in the pursuit of formally understanding improvisation in theatre. This work also points to the kinds of reasoning and ambiguous knowledge that is reasoned about continuously in creative acts. Furthermore, the creation of improvisational agents has helped us better formalize our findings as we engage in the process of theorizing and building agents, which in turn helps us ask better questions for future studies or reinterpret our data in a clearer way so that we can build more complex agents in the future.

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