Composing Social Interactions via Social Games

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ABSTRACT
This paper addresses the problem of enabling non-scripted social interaction with virtual characters, and of authoring the underlying behavior in reusable form. We hypothesize that social behavior can be decomposed into *social games*, which are collections of affordances surrounding social state, and claim that non-scripted player interactions can be generated by the execution of social games in various combinations. We describe three social games (for alliance, authority, and threat management), the implementation architecture that executes these games, and the resulting behavior, which is set in a military house-search scenario. The architecture consists of a decision process that selects motivations appropriate to the games, selects social moves appropriate to the motivations, and finally performs behaviors that implement social moves, all in a situation-responsive, dynamic fashion. We show that social games form a loosely coupled system that generates a space of possible interactions.

Categories and Subject Descriptors
I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence – *Intelligent Agents.*

General Terms
Algorithms, Design

Keywords
Virtual Agents and Humans; Socio-Cultural Behavior; Human-Agent Interaction; Agent-Based Simulation; Social Simulation

1. INTRODUCTION
Social interaction is a core element of human experience, but it is difficult to achieve with virtual characters. The underlying issues are both technical and theoretical. In particular, social phenomena are inherently complex and require sophisticated mechanisms to express in automated form. While the social sciences provide inspiration in the form of explanatory analyses of social behavior, we have yet to transform those models into generative forms that can drive synthetic characters. Finally, although there is a growing interest in the games, training, and autonomous agent communities, there is little prior work on social characters.

Despite these difficulties, a number of projects have taken important steps. Work in games and training systems has made progress on enhancing the social presence of virtual characters, and on improving the dynamic (vs predetermined) quality of interactive social experiences. For example, AAA games like Bioware's Mass Effect create social presence through highly scripted interactions and nuanced visual performances [2]. Microsoft's Kinectimals [17] pursue the opposite strategy; they enhance the believability of virtual pets by supporting simple unscripted interactions. Several ICT projects employ a combination of agent technology and structured narrative to enhance social presence. The museum guides, Ada and Grace, respond socially to visitors, while occasionally taking initiative, using technology that maps utterances into available next actions [24]. Gunslinger lets players converse freely with characters in an augmented reality setting en route to an impending gunfight, although the narrative is strongly controlled [7]. BiLat provides negotiation training across culture boundaries, with automated choice of tactics, but the experience relies on a strong narrative flow [8]. A few games, like PromWeek [15] and Versu [9] employ explicit models of social practices to enhance believability, while Façade [14] emphasizes real-time, dynamic flow to create social presence. Several research efforts have developed other forms of social agent models to create believable characters. For example, Prada and Paiva [20] model individual and group dynamics to create believable autonomous agents, Callejas et al. [3] employ social attitudes to drive training interactions within a virtual recruiter, and Osborne pursues a model based on "social masks". Overall, the vector of development is towards the use of sophisticated social models to support increasingly dynamic and believable interactions with virtual characters.

This paper describes work towards the goal of supporting emergent social behavior for use in games, training, and simulation contexts. We pursue a generative approach based on an explicit model of social practices that enables non-scripted interactions with characters who possess a social agenda. We are simultaneously interested in the problem of authoring such interactions, that is, of constructing social competencies from component parts. Towards that end, we take inspiration from Berne [1] and Goffman [6] by pursuing the metaphor of *social games*.

In more detail, we define a social game as a family of practices surrounding particular elements of social state, and associate social motivations, moves, and preference logic with each game, as well as a body of executable behaviors that implement social moves. We define an architecture for utilizing social games that selects motivations appropriate to characters and their situations, and then resolves them through moves into executable behaviors.

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These behaviors flow into a social simulation that supports real-time, whole-body interaction with virtual characters that exhibit nuanced performances.

In addition, we show that social games can be executed individually, or in combination to generate increasingly complex social behavior. We demonstrate this with behavioral examples, and by graphically depicting the space of possible interactions. In particular, because social games are weakly coupled through social state, the set of active games defines a space of possible trajectories. As a result, the interaction follows a dynamic sequence determined by the social consequences of the player's and characters' joint action.

The following sections describe an interactive experience produced by social games, the architecture for representing and executing social games, and our approach to authoring behavior by composing social games (including illustrations of the interaction space). Following this, we examine related work in more detail, and conclude with a discussion of this work's implications and limitations, plus directions for future research.

2. BREAKING BREAD EXPERIENCE

Breaking Bread is an interactive experience conducted via a whole body gestural interface, where the player takes on the role of a US soldier deployed in a foreign country to which the US military is providing aid and training (See Figure 1). The player is accompanying a local national soldier (LNS) through a village to do house inspections, looking for contraband weapons and drugs. While the player has some authority over the local national, her role is to watch and advise as the LNS takes the lead in conducting the search. The local national soldier speaks some English but not much; the civilians in the village do not speak any English. At the start of the Breaking Bread scenario, the player and the LNS have entered the home of a villager while the rest of the squad waits outside.

Breaking Bread presents the player with a social puzzle. She wants to complete her house search mission, achieve cooperation from the civilians in the house (rather than resistance), and assist the LNS, who is supposed to lead the search but is unfortunately badge-heavy. If the player takes no action, due either to inattention or failure to understand the social conventions, the scenario plays out as follows: The head of the household (HoH), a middle-aged man who speaks no English, warily allows the player and LNS into his home and gives a greeting of a small bow. He offers a bowl of fruit to the player and is offended when the gift is not accepted. The LNS begins wandering around the house and touching objects, agitating the head of household. The LNS, who seems to enjoy demonstrating his power and role in the local military, continues to provoke the villager by touching his things and arguing with him about his right to do so. He arrogantly commands the HoH to open a set of cabinets, and the HoH grudgingly complies, revealing an empty interior. The situation crosses a line when the LNS picks up a piece of bread and eats it, enraging the HoH. He grabs a bowl of fruit from the table and smashes it to the ground, yelling. Shortly thereafter, the HoH's son enters the tense room and begins yelling at the player and LNS to get out. Both the man and his son become increasingly agitated, shooing the intruders out the door.

Figure 1. A snapshot from Breaking Bread

Throughout all of these interactions, the player has an opportunity to observe passively, or to intervene. Several de-escalation moves are possible to either calm down the HoH in the face of the LNS's transgressions, or to dissuade the LNS from provoking the homeowner. Successful de-escalation can lead to a less volatile situation. If the LNS is sufficiently controlled and the HoH is placated, the scenario ends much more positively.

A more active player might generate a runthrough that plays out as follows: Upon entering the kitchen, the HoH greets the LNS and player with a small bow, which the player returns, garnering a favorable response. The HoH then offers a piece of fruit to the player, which the player accepts, further pleasing the HoH. As the LNS begins wandering around and touching things, the player asks him to stop and put the objects down. The player apologizes to the HoH for these infractions. The player then asks the HoH to open the cabinets, successfully communicating through mimed gestures. The HoH complies and reveals an empty cabinet. The LNS persists in touching objects and attempting to eat the bread, so the player calls him over to stand near her by the door, which prevents further transgressions. The player asks the HoH to open a second set of cabinets, which reveals medicine of questionable legality. At this point, the son enters the room, alarmed by the presence of strangers in the house. Because the situation is not nearly as tense as the previous example run-through, the HoH calms the son down and introduces him to the visitors. The player thanks him and leaves courteously, deciding to preserve the cordial relationship with the HoH and the successful restraint of the LNS rather than push the issue of the dubious drugs. The drugs have at least been found in this scenario, whereas in the previous iteration they were not even uncovered before the player and LNS were forced to leave the kitchen.

An active, but less socially adept player can produce a noticeably worse outcome by ignoring the LNS's excesses and actively suppressing the HoH's pleas. As before, the plate smashes and the son enters the room at the maximally tense moment, but now with an interaction history where the player has allied heavily with the LNS. The LNS or the player can raise their weapon in this circumstance, resulting in a dangerous standoff. Overall, the goal of Breaking Bread is to give the player experience and training with interpreting social interactions across language and cultural barriers. If the player picks up on social conventions, like returning the bow and accepting the offered fruit, the interaction is generally positive. If the player can also recognize and respond to non-verbal cues like forceful gestures, raised voices, and physical pleas for assistance, the situation can be controlled. In order to support the variety of interactions within Breaking Bread, characters must be able to take social initiative and respond to the player in a dynamic and essentially unscripted way. The following sections describe the technology underlying Breaking Bread, which is produced by a set of *social games* that model a character's social knowledge, motivations and actions.

3. SOCIAL GAME ARCHITECTURE

A social game is a family of practices surrounding social state. We have defined three social games for use in Breaking Bread: *Alliance, Authority,* and *Threat.* The *Alliance* game deals with forging and damaging relationships, while *Authority* concerns power dynamics and ownership over objects and space. *Threat* deals with the management of physical force and danger. Each game monitors certain elements of state, and contains representations of relevant social motivations and abstract social actions called moves, together with rules for prioritizing them.

Figure 2 illustrates the architecture for executing social games. It consists of a memory (for holding background knowledge, observations, and inferred beliefs), an intention formation process for selecting motivations and moves for characters across games, and a performance mechanism for executing and interleaving the associated behaviors. We discuss social game content (state, motivations, moves, and ranking rules) and the process of utilizing games to select social moves, below. Shapiro et al. [21] examines the performance system, viewed as an interactive, real-time, immersive simulation, so we only comment on its structure with respect to social games here.

We represent the social game state via binary predicates or continuously valued relations. For example, the *Alliance* game monitors a *degree of alliance* (a scalar-valued directed relation between two NPCs, or the NPC and the player), and a binary predicate encoding whether those agents are *allies.* Each social game also contains a characteristic set of motivations to create (increase) or remove (decrease) that state, as well as to express its value through agent actions in the virtual world. The Alliance game supports *AllianceUp*, *AllianceDown*, and *AllianceExpress* relative to the degree of alliance, and *AlliesMake*, *AlliesBreak*, and *AlliesExpress* relative to the allies distinction. The moves within a social game represent abstract actions for pursuing motivations. In general, there are multiple moves for each motivation. For example, *Greet* and *GiveAGift* address *AllianceUp*, while *BackupAlly* and *FriendlyGoodbye* address *AllianceExpress*.

As a second example, the *Authority* game governs interactions related to power dynamics and ownership over objects and spaces. The underlying state consists of *AuthorityOver(X,Y, val)* relations, and permission levels for access to objects ranging from "no access" (0) to "can consume/destroy" (5). The motivations are *AuthorityUp, AuthorityDown, AuthorityExpress*. The Authority game contains a wide variety of moves for the house search scenario. These include *MessWithOthersStuff, OpenYourCabinets, EatOthersStuff, HoardMyStuff, Outburst, PutMyStuffDown, GiveMyStuffBack, DirtyLook*, and *DerisiveChuckle*.

3.1 Ranking Motivations and Moves

Each social game contains a set of preference rules for ranking motivations. For example, the following rules simultaneously nominate and rank motivations:

```
Alliance(X, Y, <50)
→ AllianceUp(X,Y) + 2

Alliance(X, Y, >50) ^
Alliance(Y, Z, >50) ^
Alliance(X, Z, <50)
→ AllianceUp(X,Z) + 3
```

The first rule acts to elevate the importance (called volition) of increasing the degree of alliance between two characters whose

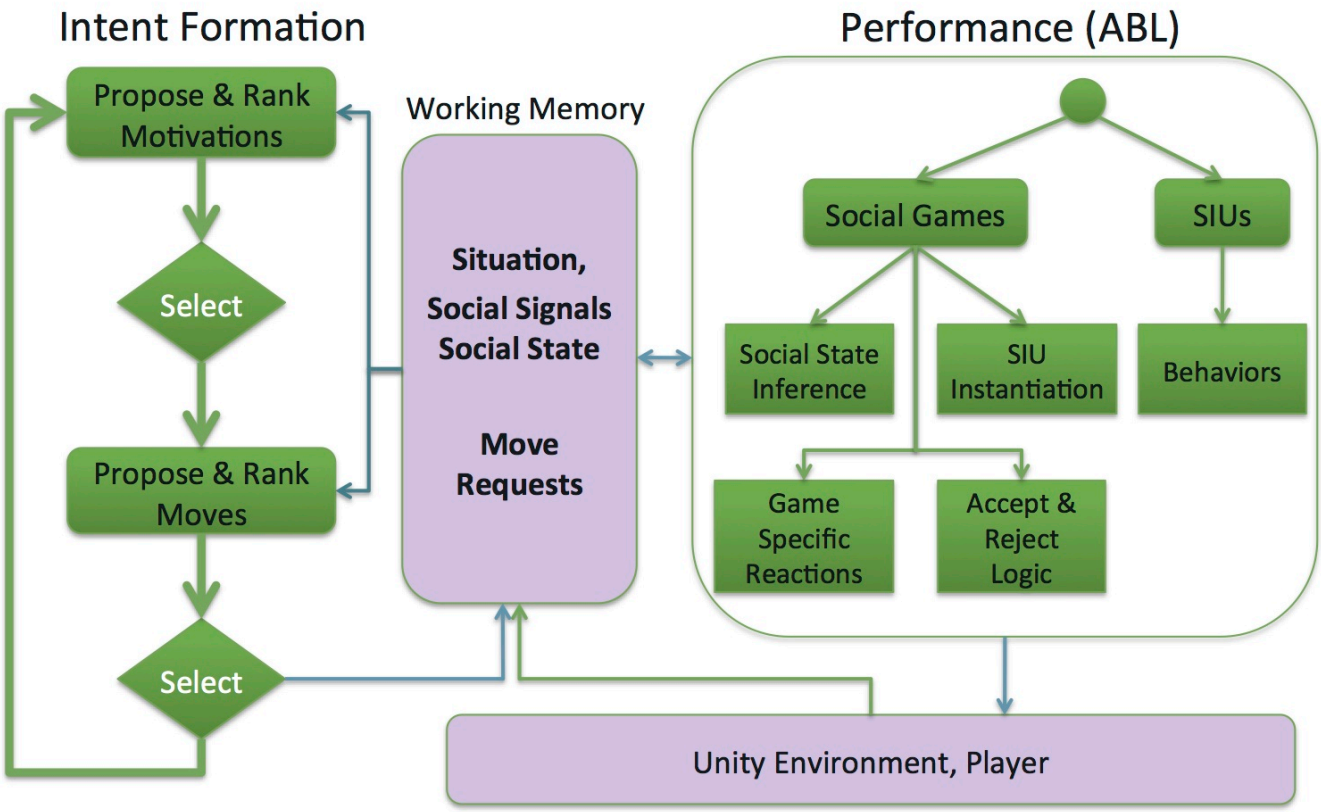

Figure 2. The architecture for executing social games

bond is suffering. The second motivates a character to build networks of alliances. X observes that he is friendly with Y but not Z and Y *is* friendly to Z, so he reaches out to Z. Similarly, the Authority game contains these two rules:

```
Arrogant(X) ^
Authority(Y,X,<50) ^
Authority(X,Y,<80)
→ AuthorityUp(X,Y) + 6

Permission(X, Obj, Owns) ^
Permission(Y, Obj,  LookAt) ^
Touch(Y, Obj)
→ AuthorityUp(X,Y) + 8
```

The first expresses an inclination for one character to dominate another, while the second expresses a desire to reassert authority when a character exceeds its allowed permission to manipulate an object. An analogous set of preference rules govern moves. For example:

```
AllianceUp(X,Y) ^
GiftingAppropriate(X,Y) ^
Object(tag=="gift", Obj)
→ GiveAGift(X, Y, Obj) + 5

AuthorityUp(X, Y) ^
Permission(Y, Obj,  Owns) ^
Permission(X, Obj, <Touch)
→ ViolateObjNorm(X, Obj) + 7
```

These rules simultaneously nominate and rank moves. The first suggests X give an appropriate object to Y as means of increasing the degree of alliance between those two characters. The second rule incites X to deliberately exceed permission levels with respect to Y's belongings in a bid to increase authority.

In general, social games contain a large number of rules for ranking motivations and moves, and these rules can depend upon accumulated knowledge, character status, and current environmental state. For example, *GiftingAppropriate(X, Y)* only becomes true after characters have greeted one another, and the environment must contain objects tagged as giftable for the GiveAGift rule to apply. Similarly, only characters flagged as *Arrogant* seek to dominate others within the Authority game.

Volition values add across rules. For example, the player and LNS begin with an *Alliance* in Breaking Bread, so if the player and HoH become allies, the motivation rules for *AllianceUp* (above) combine to influence the HoH to increase his alliance with the LNS, and vice versa. However, the *AuthorityUp* motivations have higher volition; the LNS will care more about dominating the HoH, and the HoH more about increasing his authority over the LNS in response to his prior bad behavior.

Taken together, the rules that assign volition to motivations and moves represent an agent-held utility function. Their additive semantics mediate situation specific influences, while the specific volition values (large or small) follow authoring conventions.

3.2 Social Game Execution

The mechanism for executing social games begins with an iterated intention formation process that reasons top-down from games, through motivations, to moves. This process gathers and applies all motivation rules across games, and outputs a ranking for all situation relevant motivations for all characters. The algorithm down-selects this set to the top two motivations for each character whose volition scores exceed a preset threshold. The next step nominates and ranks all motivation and situation relevant moves via an analogous computation. The final stage of the decision process filters this set to the single best move for each character above the same threshold. The architecture repeats this decision process on a regular basis. Since each move invokes relatively fine-grained behaviors, we set the decision interval to 1 second.

The performance side of the architecture in Figure 2 enacts social moves selected by the intention formation process. It provides a real-time, interactive, multi-agent simulation that accepts whole-body gestural input from the player as well as limited speech, and it realizes character behavior in a 3D virtual world based on the Unity engine [21]. From the perspective of the performance system, moves correspond to plans to pursue in response to player input. They are implemented as hierarchical, reactive, parallel programs in the ABL language [13]. Each social move involves 5 - 30 seconds of interactive performance, and is analogous to a dramatic beat. We call the ball of behaviors that implement a move a Social Interaction Unit (SIU). As an example, *GiveAGift* causes a character to navigate to an object, pick it up, approach the player, and interact with the player to transact the object. The SIU also encodes the nuances that lend emotive quality to that performance. These include glances at the object and the player, facial expressions, choice of motion styles (bold, hesitant), and more. A single SIU can control the behavior of multiple non-player characters. The intention formation process outputs a stream of SIUs that arrive in a dynamic, non-scripted order. As a result, their performances must interleave with ongoing activities. The performance system contains a priority based resource allocation mechanism that achieves this interleaving while resolving conflicts. The individual SIUs are written such that they can be smoothly interrupted and resumed.

In addition to executing SIUs, the performance architecture manages more durative aspects of social games. These include background behaviors (demons) that observe and infer the elements of state monitored by social games or that are referenced by rules in the intention formation process. They also include character reactions consistent with games, viewed as states of mind. For example, the *Authority* game contains a demon that observes when owned objects are touched, and deduces an object norm violation when permission was absent. The *Threat* game contains an alarm reaction to any sudden move, which is not present outside of the threat context. Finally, the performance system employs volition rules to determine character responses to an enforced choice, e.g., if the player asks an NPC to provide an object, the NPC must either accept or reject. This mechanism is separate from the top-down, intention formation process.

4. COMPOSING SOCIAL GAMES

Taken in isolation, each social game captures a family of practices surrounding a common theme. However, taken together, the games form a weakly interacting set. Social games couple through social state; the execution of an SIU motivated by one game may impact the state utilized in another to nominate and rank motivations or moves. Moreover, social games can be activated in in arbitrary combinations, so as the games are composed, more interactions are exposed, resulting in a form of emergent social behavior. This section describes that interaction space, first graphically and then in terms of the resulting behavior.

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As mentioned earlier, we utilized three social games in Breaking Bread, and provided detail on Alliance and Authority. The third game, *Threat,* concerns the management of physical force and danger. Threat tracks two key elements of state: *Might*, and *PerceivedDanger*. *Might* represents a character's level of power (e.g., is it armed or unarmed), while *PerceivedDanger* captures both the likelihood and the magnitude of the force that others characters could apply if a conflict arises. The Threat game contains the standard three motivations, *Threat_Up*, *Threat_Down*, and *Threat_Express*, plus moves for *ProtectSelf*, *GetHelpWithOutburster*, *HelpMeOut*, *AdvanceOn*, *WardThreat* and *AcknowledgeThreat*. It also contains multiple rules for ranking *Threat* motivations and moves.

Figure 3 provides a graphical illustration of the interaction space enabled by the Alliance, Authority, and Threat games. This diagram elides some of elements of state, motivations and moves, and only shows relational terms (suppressing arguments) in order to highlight the coupling between games. The top row of the figure lists elements of social state input to the intention formation process. The second row (boxed, with graduated shading) identifies motivations the characters can choose. The next four rows name moves that address motivations, while the bottom row shows state altered by the execution of moves. The figure also sorts the elements from left to right by social game, in the order of Alliance (in purple), Authority (green), and Threat (pink). The arrows show data flow imposed by nomination and ranking rules, or by execution of the SIUs associated with moves. More exactly, the arrows show the aggregate of the data flow across all rules (meaning a fan-in may represent multiple rules).

The main thing to note about the figure is that the data flow stays mostly in columns; *Threat* state flows through *Threat* motivations, into *Threat* moves and back to state. For example, *PerceivedDanger* effects the importance of *ThreatDown*, which impacts the volition to *ProtectSelf.* Execution of *ProtectSelf* may alter the character's *Might* and *PerceivedDanger*, depending upon how it unfolds in the world. (There is no guarantee; the SIU for *ProtectSelf* contains alternate methods, the situation enables some paths, and the player can impact the outcomes.)

The diagram also contains multiple instances of cross-talk. At the motivational layer, *PerceivedDanger* decreases the volition of motivations in all other games (as a means of highlighting the relevance of a threat, no matter its severity). If a character has Alliances, their presence tends to decrease the importance of *ThreatDown* (to counter perceived danger). A character with an *Alliance* to an authority figure looks to that figure for support via *ThreatExpress* (as the LNS does to the player in response to the HoH's outburst in Breaking Bread). While moves are almost wholly owned by games, some rules employ state from the *Authority* game called *AuthorityOver* to nominate and assign volition to *GiveAGift*.

Similarly, Alliance levels are relevant to *HelpMeOut*. The cross-talk from moves to state is more profound. Within the *Alliance* game, completing social rituals (via *GiveAGift* or *Greet*) impacts

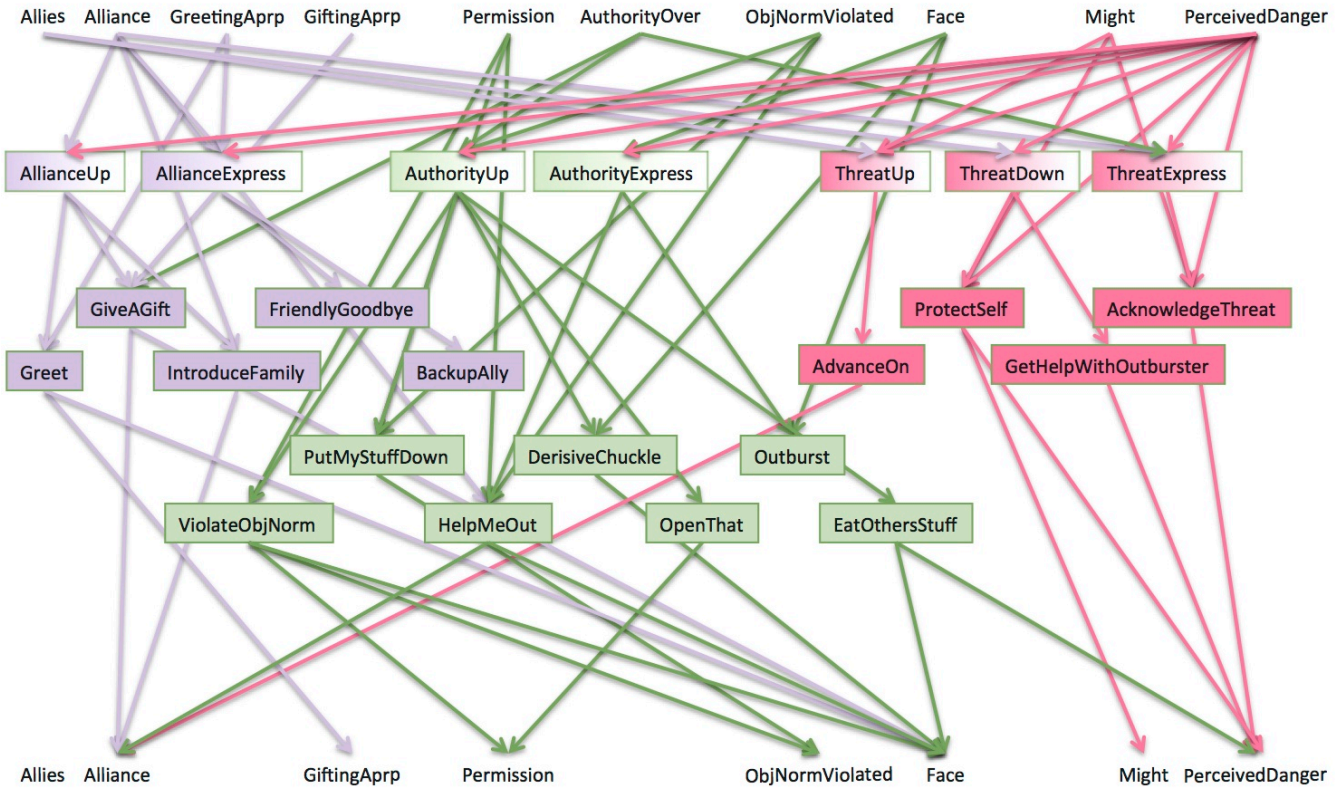

Figure 3. Social game composition

Face in the *Authority* game. Within *Authority*, requesting others to *HelpMeOut* builds *Alliance* with the helper, while *EatOthersStuff* impacts others' *PerceivedDanger* through the impression that the character is willing to take aggressive action (as seen between the LNS and the HoH in Breaking Bread). Similarly, the move to *AdvanceOn* a character within *Threat* clearly impacts any prior *Alliance*.

4.1 Layered Demonstrations of Social Games

Because social games only interact through shared state and soft constraints, no game is required to execute another. Moreover, social games can be activated in arbitrary combinations; a given combination defines a space of possible actions, and an agent can initiate any move in that space that is both motivated and feasible at any time. In order to demonstrate this point, we changed the context for executing social games to a "Sandbox" scenario where the interactions are more visible than in Breaking Bread. The Sandbox contains fewer elements; it supports interaction between a player, two non-player characters (NPC01 and NPC02), and a handful of objects on a pedestal. We illustrate social game composition through three, layered demonstrations, viewable online [23]. The first generates behavior by *Alliance*, alone, while the next two add *Authority* and *Threat* in turn.

The interaction based solely on the *Alliance* game unfolds as follows. We give NPC02 a positive *Alliance* value towards the player and mark the objects on the table as "giftable". After the player greets NPC02 in a friendly manner, *GiftingAppropriate* is created between NPC02 and the player. This *Alliance* state motivates a simple *Alliance* building move, *GiveAGift*, for NPC02 to offer the player one of the objects from the pedestal.

The interaction generated by Alliance plus Authority follows a different path. We initialize the starting state required by the *Authority* game as follows NPC01 is given ownership over the objects on the pedestal by setting *Permission* values for all the objects to the highest tier, 5, and "granted", the player and NPC02 are assigned Permission values of 1 with the status "granted", (which enables them to freely "look at" objects in the environment), and the player is marked as having *AuthorityOver* NPC02 and NPC02 is given the character trait, *Arrogant*. When the scenario starts, the player greets NPC01, and again triggers a friendly gift offer through the *Alliance* mechanics outline above. Meanwhile, *AuthorityUp* motivations coming from NPC02's Arrogant trait make him touch items owned by NPC01 without permission. NPC02's actions trigger a permission update for that object to "ungranted, pick up". The first time this violation occurs, NPC01 gives NPC02 a *DirtyLook*, a move motivated by an *AuthorityUp* response to the object violation. When NPC02 picks up the bread, this second ownership violation motivates a stronger *AuthorityUp* response. NPC01 angrily asks NPC02 to put down the bread (via *RequestPutThatDown*). NPC02 refuses to comply (a local accept/reject decision), due to his *Arrogant* trait. Finally, because of previous alliance building through gifting and greeting, NPC01 turns to the player and asks for help, an *Authority* move that is also sensitive to *Alliance* state. The player asks NPC02 to stop his annoying behavior, and this time, NPC02 complies (accepts) because the player has *AuthorityOver* relation with him. This move by the player raises his *Alliance* with NPC01 but reduces NPC02's *Face*.

Finally, adding the *Threat* game makes the fact that the player is holding a rifle salient. In this run-through, the player greets as before, but then rejects the offered gift, offending NPC01 and failing to build *Alliance*. When the wrangling over objects starts, NPC01 does not look to the player for assistance because of the lack of built up *Alliance*. Instead, he simply gets more and more upset, and continues to apply *AuthorityUp* moves in response to NPC02's provocations. NPC02's *PerceivedDanger* elevates due to NPC01's yelling and he reacts with fear. He forms the motivation to *Threat_Down*, which triggers the move to *ProtectSelf*, causing NPC02 to raise his hands in an attempt to surrender. When the player raises her weapon to take control of the situation, her *Might* and the resulting perceptions of danger motivate both NPCs to *ProtectSelf* in response to *Threat_Down*, now orienting on the player.

5. RELATED WORK

This section examines theory from psychology and sociology that underlies social games and related work on social agents. We provide a survey of similar systems that attempt to create social interaction with dynamic, autonomous agents.

5.1 Theory of Social Games

Support for approaching agent interaction as "social games" comes from literature on psychology and sociology. Goffman's dramaturgical analysis is a sociological theory that posits people's everyday behavior can be understood as inherently performative through the metaphor of a dramatic production [6]. This perspective provides the conceptual framework for our take on social games. The concept of social games originated as character performance patterns featured in the interactive drama, Façade [14]. In Façade, social games are interactions where the player is put in the position of changing the relationships between the characters. Because every possible outcome and nuance had to be individually authored, this version of social games came with a high burden on the author of the experience. Work by McCoy et al. [16] on Comme il Faut (CiF) develops a variant where each social game is authored once and is procedurally tailored to fit the participating characters and social context. Other works in psychology and sociology have looked at the role of game-like interactions and social dynamics, such as Berne's work on the "games people play" and transactional analysis [1]. Berne's categorization of social interaction includes the concept of a game, meaning a series of complementary transactions that are ongoing and organized towards a predictable outcome. Additionally, transactional analysis decouples the performance of a game from its intent (via ego and psychological states), which inspired the covert and parallel aspects of social games. French and Raven's psychological study claims that people respond to five categories of social power: reward, coercive, legitimate, referent and expert power [5]. Pereira et al. [19] embed these distinctions in a framework through which agents become aware and capable of manipulating social power. Our work on social games builds on these models, and on the viewpoint that agents should recognize practices for exploiting social power.

5.2 Related Work on Social Agents

A few games, like Prom Week [15] and Versu [9] have built social game models, but not in the context of real-time interaction where it could be employed to add a new dimension of realism to game characters. The Sims is one of the most commercially successful agent based games, where individual characters are driven to pursue autonomous goals related to their personality, needs, skills and relationships [4]. However, their memory is short, and the rules for determining goals and how to achieve them are simple. Gunslinger features movement and exploration of a virtual world via rich multi-modal input but lacks social simulation and remains bound to a pre-set narrative [7]. The Synthetic Group Dynamics Model uses theories of group

dynamics to make interactions between groups of agents more believable [20].

Other works approach social interaction by modeling the social and emotional states of characters and using that state to drive behavior. For example, emotional responses of agents are simulated via appraisal dynamics by EMA [12][11] Thespian [21] and the system it is built on, PsychSim [10], are multi-agent capable systems that realize social interactions from models of social influence. Osborne takes an approach to social modeling that is also partially based on Goffman, proposing "the mask model", which controls NPC behavior through three overlapping layers of social masks: the self-perception layer, the social layer and the interpersonal layer [18]. These efforts employ psychological and affective models to produce believable characters. As our work relies on a social agent model, they represent complementary avenues for future work.

6. DISCUSSION

Our goal for this work has been to prototype a capability that supports social interaction with synthetic characters in a non-scripted, generative form. While this is a very large problem, we have demonstrated progress along two fronts. First, we have shown that we can drive character behavior from a model of social practices called social games, via a mechanism that inputs social state, chooses situation relevant motivations, and resolves those motivations into actionable moves. Second, we have shown that social games can be combined to generate more complex social behavior. We demonstrated this effect by layering the Alliance, Authority, and Threat games, and by graphically depicting the space of social behaviors enabled by their (weak) interaction. In addition, we have utilized social games to produce a complex playable interaction set in a house search scenario.

While our work demonstrates feasibility, it raises several key questions. First, it is natural to ask if social games are general, in the sense of supporting reuse across scenarios. To date, we have a small amount of positive, anecdotal evidence from our experience porting the games to the Sandbox from Breaking Bread. This shift preserved virtually all elements of the games, with minor tweaks. However, the Sandbox environment is noticeably simpler than Breaking Bread, so a port to a more complex scenario would likely expose limitations. In general, we would like the process of porting a social game to require minimal massaging of inputs and outputs, i.e., to map available character observations and knowledge into the state required by social games, and to instantiate the moves output by social games into executable behaviors. From this perspective, the current vocabulary of social moves is a bit suspect. Looking at Figure 3, the terms *Greet*, *ViolateObjNorm*, and *ProtectSelf* suggest domain independent, abstract actions, while *IntroduceFamily*, *EatOthersStuff* and *GetHelpWithOutburster* appear too scenario-specific.

A second key question concerns the coverage of social games. Are there 3, 30, or 300 of them, and if so, what is their content? We have begun to investigate this question by considering 10-20 vignettes of social interaction in the Sandbox setting, e.g., "a woman is agitated and wants to talk to you, her companion (a man) does not approve - what happens, and what social games are involved?" Anecdotally, variants on Alliance, Authority, and Threat have a great deal of coverage. One explanation is to view games as practices for exerting categories of social power. As described above, French and Raven [5] claim there are five kinds of social power: reward, coercive, legitimate, referent and expert power. *Alliance* expresses Referent power (acting to please others), *Authority* exploits Legitimate power (the influence of social norms), and *Threat* exerts Coercive power (the ability to influence behavior through force/punishment), implying that our games implement instances of most basic types. This line of reasoning also suggests a way forward; we should encode one game for exerting each type of social power containing a family of abstract practices, and author mechanisms for applying those games in specific contexts. An alternate approach is to build a great many social games in the style of Berne [1], e.g., a victimization game, an envy game, a co-dependency game, etc. This repertoire would form a library of social strategies with associated state and internal sequence, that might be easier to define but less portable across scenarios.

More broadly, this paper makes claims about authoring social interactions as opposed to the behavior produced. That said, examining the quality of the interactions produced by social games is an important goal. Two reasonable approaches would be to (a) collect subjective assessments of player experience, and (b) measure achievement of targeted simulation states. Within (a), we could employ metrics on social and system engagement, and player questionnaires. Within (b), since Breaking Bread was created for pedagogic goals, we could measure student achievements - e.g., if the player finds the contraband, or achieves a given HoH-player alliance value. Overall, player ability to solve social puzzles reflects on the quality of the social interaction enabled by social games, and on the sufficiency of social games as an authoring construct. It would also provide insight on the feasibility of using virtual characters to teach human social interaction skills.

7. FUTURE WORK

Going forward, we intend to continue investigation of reusable social games. We plan to pursue that investigation by porting social games to new contexts, e.g., some of the vignettes we alluded to above that are easy to instantiate in the Sandbox environment. In the process, we expect to re-examine the vocabulary for social moves to make them more general, and to expand/clarify the suite of social games. We plan to examine the problem of instantiating abstract social games in more specific contexts. At a more detailed level, we hope to refine our treatment of coupling across games, e.g., by employing the concept of "counts as" to relate elements of social state.

8. SUMMARY

This work explores the question of authoring non-scripted social interaction with virtual characters. We envision application to games, social and cross-cultural training, and social simulation in general. Our work on social games connects to this vision by modularizing the capacity for social interaction. Our ultimate goal is to export an authoring tool, plus content for instantiating social games that will let authors easily create virtual social characters in contexts where that capability had not existed before.

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