A Framework for Cooperative Communication Game Mechanics from Grounded Theory

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ABSTRACT

A rich element of cooperative games are mechanics that communicate. Unlike automated awareness cues and synchronous verbal communication, *cooperative communication mechanics* enable players to share information and direct action by engaging with game systems. These include both explicitly communicative mechanics, such as built-in pings that direct teammates' attention to specific locations, and emergent communicative mechanics, where players develop their own conventions about the meaning of in-game activities, like jumping to get attention. We use a grounded theory approach with 40 digital games to identify and classify the types of cooperative communication mechanics game designers might use to enable cooperative play. We provide details on the classification scheme and offer a discussion on the implications of cooperative communication mechanics.

Author Keywords

Game design; analysis; cooperation; communication; teams

ACM Classification Keywords

H.5.3. Group and Organization Interfaces: Computer-supported cooperative play

INTRODUCTION

In cooperative digital games, *communication is a core mechanic*, an activity that players explicitly regularly invoke in play. While synchronous verbal communication via voice or text chat is common for online games, either directly or through an external program, rich alternate channels for communication to teammates exist: *cooperative communication mechanics*. These in-game systems enable players to direct attention and provide information in ways that are difficult or impossible verbally. The present research investigates game mechanics that players actively invoke to provide information to other players in the game and support team situation awareness. Using a grounded theory approach on a corpus of game mechanics selected from 40 cooperative games, we develop a framework of game mechanics for cooperative communication. The present framework can be used to identify the types of communication available in a game, which has implications for cooperative play. The framework is also used to identify areas of potential for new and innovative mechanics for team communication.

The present research focuses on game mechanics explicitly invoked by players in synchronous PC and console games. We exclude both synchronous verbal communication and automated awareness mechanisms, such as those in groupware systems [17]. Many games include automated awareness cues; however, we are interested in the opportunity cost of communicating versus other in-game actions. Verbal communication is already well-studied in groupware [17], group work [18], and games [5], but cooperative communication mechanics have not yet been investigated.

This paper is structured as follows: we synthesize background on teams, game design, collaborative virtual environments, and embodied cognition. Next, we provide details on our grounded theory methodology, from which we constructed a framework of cooperative communication game mechanics. We discuss the framework, describing each component and providing examples. Finally, we discuss the implications of the framework, highlighting gaps in existing designs and seeds for future research.

BACKGROUND

The background for cooperative communication mechanics is diverse, drawing on research in teams, game design, collaborative virtual environments, and embodied cognition.

Teams

The fields of situation awareness, distributed cognition, and team cognition influence the present research, providing a framing for understanding how cooperative communication mechanics are used and why they are valuable. Teams are "a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common or valued goal/object/mission, who have each been assigned specific roles or functions to perform, and who have a

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limited life span of membership" [28]. Cooperating players form teams during play; they develop and maintain situation awareness to succeed at a game.

Situation awareness refers to the ability of individuals to understand their environment and how it will likely change [8, 9]. A high level of situation awareness supports an individual in making intelligent decisions about how to act in an environment and support her/his team in problem solving.

In a *distributed cognition* environment, such as cooperative game play, information is used to make decisions and enact change; it is transferred throughout a cognitive system consisting of people, interfaces, and objects [19, 21, 22]. As information is translated among media and through time, its form and values change. Distributed cognition accounts for how information form is altered to ensure its usefulness for a task or its ability to be transferred further. A team player might need to observe multiple components of a game's state and communicate it to teammates using her/his avatar.

Team cognition theory [12, 24, 29] posits a team (as defined above) as a unit capable of thought. Team members share information and develop an understanding of one another's roles, capabilities, and knowledge as these are needed to accomplish the team's objectives. Teams must contend with *communication overhead* [10, 24], the cost in terms of time, cognitive bandwidth, and technological bandwidth of sharing information with other team members. Communication is thus *not "free"* and highly efficient teams develop strategies and understanding that limit their need for communication. These efficient teams *implicitly coordinate* [10, 11, 24, 35], anticipating and fulfilling one another's information needs.

Game Design

Salen and Zimmerman characterize games as systems of interrelated *rules* and *play* [30]. Rules are the structures that constrain player action, while play is the freedom to make decisions within the rules. A *game mechanic* is a moment at which a player makes a choice and observes the outcome [23, 30]. *Core mechanics* are the essence of a game, and are engaged with repeatedly. Game scholars have created frameworks to analyze subsets of game mechanics, such as Consalvo's review of social mechanics in social games [6]. The present research develops a framework that identifies game mechanics that support cooperative communication.

Prior work has investigated cooperation in game play. Much of this is centered around the design of cooperative game mechanics [2, 15, 31, 34], the verbal practices of teams [33], or how people play in co-located settings [5]. Communication channels and awareness cues are critical to keep players engaged in game play in a challenging teamwork environment while maintaining situation awareness.

Importantly, Chuang et al. [5] found that co-located players collaborate not only through explicit communication channels but also an implicit awareness of each other; this can be likened to the work of high-performance teams. One key communication channel they and Tomi and Tony [34] identify are "virtual gestures": players use avatar movement to send information to partner(s). This research suggests the importance of investigating other potential communication channels that are unique to games.

Collaborative Virtual Environments

Collaborative virtual environments (CVEs) are shared, persistent computer-simulated spaces. Users interact in a virtual environment with each other in real-time [39]. Zutshi et al. [39] identify key features of virtual environments, some of which are relevant to cooperative play: user presentation (e.g. using avatar to present the player), gesture (e.g. avatar gestures [5, 34]), and communication (e.g. voice or text chat).

CVEs enable groups to work on a common task, where they benefit from sharing resources, sharing ideas, and learning from each another [39]. Games represent one such context. Players in a cooperative games work together to solve problems, where the game highlights contribution, challenge, and fun [1, 39]. Playing in a CVE has been recognized as increasing technical playing ability; the collaborative aspect allows players to explore games with the backing of a social infrastructure, which creates a strong bond between players [3].

Embodied Communication

Embodied communication occurs in real life between individuals when they cannot communicate through a direct method of transferring meaning [13]. Language is not static; it evolves as individuals are exposed to new settings and need to convey novel meanings [27]. Embodied communication is not restricted to the physical world, but has expanded into the virtual realm, as seen in the present and prior [5, 34] research.

Despite voice and text communication availability in games, designers and players have devised communication methods that use neither. Players are frequently exposed to novel settings and mechanics where their language and conceptual understanding adapt to cope with new problems. This has implications in digital game play where voice or text communication are not available or are not viable (e.g. playing a first person shooter game without a headset). One player does not inherently know what others know; a disconnect of perspectives occurs. Each player's viewpoint gives one set of information: information is distributed [37]. Players must use the communication channels available to them—the mechanics and affordances of the game itself—to share information.

Summary

These bodies of literature explain the information needs of team members, which are met through other team members in the shared CVE of the game. Teams can and do use game mechanics as collaborative tools to accomplish in-game goals and to communicate. No review of cooperative game mechanics separate from synchronous verbal communication exists. As researchers, we believe this work will provide tools for future investigation of collaboration patterns in online play; as designers, we are interested in how we can enable players to have rich, game-centric communication.

METHODOLOGY

We conducted a qualitative study to investigate the game mechanics players may use to communicate with others in lieu

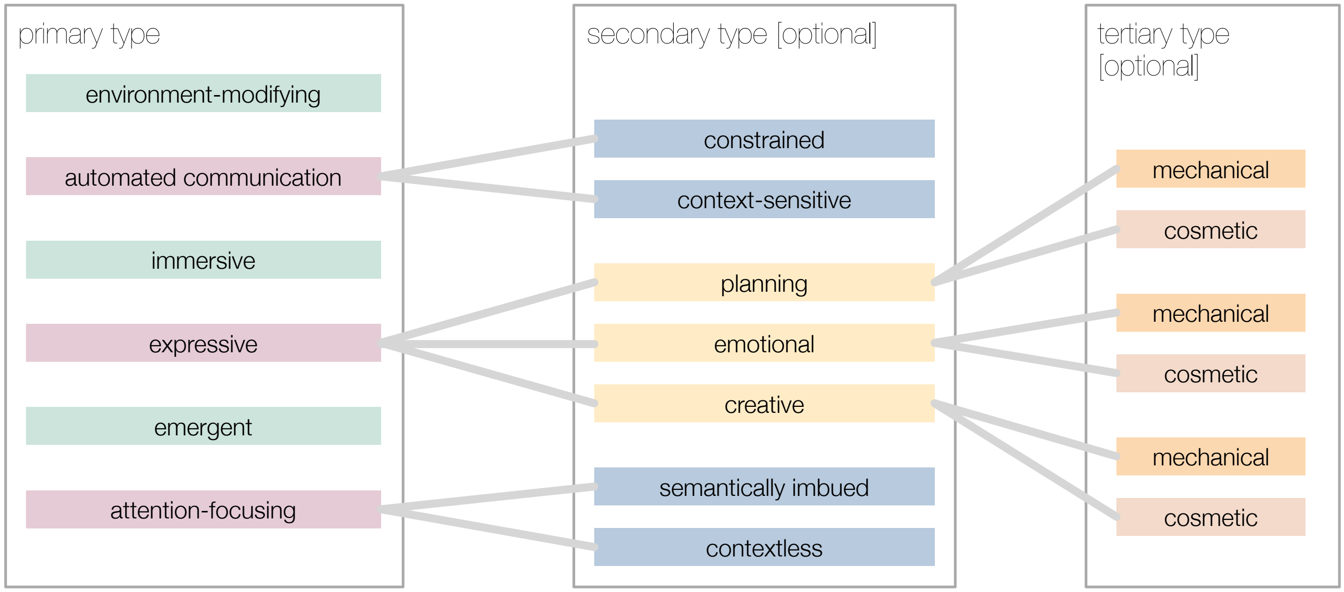

Figure 1. Framework for cooperative communication game mechanics produced from a grounded theory analysis of game designs. There are up to three levels of classification for game mechanics: primary, secondary, and tertiary.

of, or in addition to, synchronous verbal communication. We engaged in grounded theory methodology [4, 14, 32], iterating between data collection and analysis. Beyond identifying the mechanisms of communication in play, we developed a framework to classify patterns of cooperative mechanics.

Four researchers independently identified cooperative games from prior experience, ultimately developing Table 1. Data was drawn from personal play experiences and oberservations of players, both in person and through sites such as Twitch.tv. Within these games, the researchers identified the specific game mechanics that support cooperative communication in play, samples of which are discussed later and listed in Table 2[1]. The researchers independently open coded their experiences with cooperative game mechanics. Within this context of coding the data was conceptualized and classified independently [32]. During this process, researchers developed theoretical memos [32] to further refine emerging ideas.

Initially, we independently developed an 8-code, single-layer scheme and a two layer scheme with 4-codes on the top layer and two sub-codes for each super-code to identify mechanics. Then we compared codes, merging similar categories or developing new ones; we compiled a list of interesting game contexts where the identified coordination mechanisms occur. Codes and phenomena were categorized; the independently conceptualized codes were integrated and reiterated to form the beginning of a framework. This new intermediate framework was similar to the final version. An additional round of comparison, merging, and developing codes followed to produce the present three-level framework shown in Figure 1 and discussed in detail in the next section.

[1]Table 2 includes the final coding, based on Figure 1, which was not developed until the final cycle of theory generation.

A selective coding process followed: fieldwork was done to verify certain codes and phenomena by playing the games in question and/or observing gameplay through internet sources. This selective coding was done within the emerging framework allowing for a more focused investigation of communication mechanisms. This process allowed us to see an array of ways players communicate within specific games as well as where communication mechanisms are lacking.

FRAMEWORK FOR COOPERATIVE COMMUNICATION

Based on a grounded theory approach, we present a framework for classifying cooperative communication game mechanics based on the way they provide information to teammates. There are three layers of classification, primary, secondary, and tertiary, that correspond to deepening levels of specification for some of the types. Figure 1 diagrams the framework. The primary types of mechanics, discussed in detail below, include environment-modifying, automated communication, immersive, expressive, emergent, and attention-focusing. A game mechanic may fit into multiple types.

We note that the player behaviors we describe below are a representative, rather than exhaustive, set of ways that players use cooperative communication mechanics. These play techniques are supported by the cooperative communication mechanics, and as such are available to all players of a given game. However, we do not claim that *all* players use a particular mechanic in a particular way. Rather, we argue that these cooperative behaviors are *enabled* by the cooperative communication mechanics, and that based on our observations are used on a regular basis by at least some players.

Environment-Modifying

Environment-modifying game mechanics allow the player to permanently or semi-permanently change some component of the game world to convey information to other players.

game	play mode(s)	genre(s)
1.) *Army of Two*	coop	TPS
2.) *Assassin's Creed III*	free-for-all	Ac, Ad, St
3.) *Castle Crashers*	free-for-all	BEU, RPG, Ac
4.) *Counter-Strike: Global Offensive*	team comp.	FPS
5.) *Counter-Strike: Source*	"	"
6.) *Dark Souls*	single player	Ac, RPG, metroidvania, DC
7.) *Dark Souls II*	"	Ac, RPG, HS
8.) *DayZ*	free-for-all	Su
9.) *Destiny*	coop	Ac, RPG, FPS
10.) *Diablo*	coop	Ac, RPG, HS
11.) *Diablo II*	"	"
12.) *Diablo III*	"	"
13.) *The Elder Scrolls Online*	team comp., coop	MMO, RPG
14.) *Final Fantasy: Crystal Chronicles*	coop	Ac, RPG
15.) *Halo: Combat Evolved*	team comp.	FPS
16.) *Halo 2*	team comp., coop	"
17.) *Halo 3*	"	"
18.) *Halo 4*	"	"
19.) *Hearthstone: Heroes of Warcraft*	1-vs.-1	collectible card game
20.) *Journey* [2012]	single player	Ad
21.) *League of Legends*	team comp.	MOBA
22.) *Legend of Zelda: Four Swords Adventure*	free-for-all	AcAd
23.) *Little Big Planet*	coop	PP
24.) *Little Big Planet 2*	"	"
25.) *Mass Effect 3*	team comp.	Ac, RPG, TPS
26.) *Minecraft*	free-for-all	Sa, Su
27.) *Monaco: What's Yours is Mine*	coop	Ac, St
28.) *Payday: The Heist*	coop	FPS
29.) *Payday 2*	"	"
30.) *Planetside 2*	team comp.	MMO, FPS
31.) *Portal 2*	coop	PP
32.) *StarCraft*	team comp.	RTS
33.) *StarCraft 2*	"	"
34.) *Super Mario Galaxy*	coop	platforming
35.) *Rust*	free-for-all	Ac, Ad, Su
36.) *Titanfall*	team comp.	FPS
37.) *Starseige: Tribes*	team comp.	FPS
38.) *Tribes 2*	"	"
39.) *Tribes Ascend*	"	"
40.) *World of Warcraft*	team comp., coop	MMO, RPG

Table 1. List of games considered in analysis. All cooperative games considered as data sources; not all games were found to include cooperative communication mechanics. Genres derived from games' Wikipedia.org entries. Genre abbreviations: Ac: action; Ad: adventure; BEU: beat 'em up; DC: dungeon crawl; FPS: first-person shooter; HS: hack and slash; MMO: massively multiplayer online; MOBA: multiplayer battle arena; PP: puzzle platformer; RPG: role-playing game; Sa: sandbox; St: stealth; Su: survival; TPS: third-person shooter.

Such mechanics may function as cairns, marking out a safe trail to other players, or might be used to store lore created by players. Although we are interested in cooperation, environment-modifying mechanics can also be abused to grief or troll players. These game mechanics may not be for a *team* per se, as environment-modifying mechanics are often asynchronous, but they may be used to provide help to others facing similar in-game challenges in the future. Environment-modifying game mechanics were among the rarest observed in our sample, but function as cooperative communication mechanics and are thus included in the framework.

Exemplar Mechanics: Signposts. Signposts allow players to leave persistent text messages in the game environment, an **environment-modifying** game mechanic. Some games allow only messages that are pre-generated by the designers, while others allow players to input arbitrary text. Signpost mechanics may be synchronous—players building signs in front of other players—but they are more commonly asynchronous. Players create messages and choose where to leave them in the game world; they must make assumptions about how other players will later see it and react.

Signpost mechanics generally involve the signpost-making player taking a break from other gameplay to interact with a messaging sub-system. Players who read the signpost, on the other hand, may need to take much less of a break from other in-game activities. This asymmetry means that signpost creation may be best suited for non-urgent moments or tasks, but the messages can be relevant for even critical situations.

Games with signpost mechanics include *Dark Souls* and *Dark Souls II*, in which players can write messages on the ground to be read later by others. *Minecraft* is another example, in which players can create signs that other players can later read. Built environments in *Minecraft* can also be understood as signpost mechanics, such as buildings shaped like arrows to indicate to other players where resources can be found.

Automated Communication

Automated communication game mechanics enable efficient communication among teammates, reducing the burden on the player to provide context or detail. The subtypes of automated communication are constrained and context-sensitive.

Automated Communication/Constrained

Automated communication/constrained takes the form of predefined announcements or responses that the player invokes to explicitly indicate something to teammates. These types of cooperative communication mechanics require the player to decide what information to share with teammates, accounting for context manually, activating it through a game mechanic. The game must have an expressive-enough interface to support the kinds of automated communication/constrained that the player needs to provide teammates.

Exemplar Mechanics: Message Macros. Message macros allow the player to efficiently select from a limited set of pregenerated messages and share them with teammates, a form of **automated communication/constrained**. The player issues a command (for example, by typing a three-key combination) that is translated into an audio or text message shared with other players. The messages in question may be aimed at allies or at enemies. The former tend to be either informational or instructive, such as "I need help" or "Follow me!" The latter include taunts and threats to disrupt opponent concentration.

Message macros are quick and easy to access, once learned. They minimize the time it takes for players to call up a particular message, so that players can use the macros even in high-stress, high-speed scenarios. However, players are limited to the messages chosen by the game designer, which may not cover every situation in which the player finds him/herself. Additionally, message macros rely heavily on player recall for access.

Games with message macros include the *Tribes* series of team-based first-person shooters and the *Diablo* series of action role-playing games. *Journey* is a corner case here: there is just one message macro, the ability to sing. Singing is a core mechanic for interacting with the environment in addition to being an **emergent** communication mechanic.

Automated Communication/Context-Sensitive

Automated communications/context-sensitive rely on game state to parameterize a communication to teammates. They reduce the burden on players, effectively allowing the player to transmit information that the avatar is presumed to "understand" from the current situation. In these types of mechanics, players make decisions about when at what to share, but the game handles some of the cognitive burden.

Exemplar Mechanics: Contextual Macros. Contextual macros are like message macros, but include contextual information in addition to a pregenerated message; these are **automated communication/context-sensitive**. The player selects an in-game object, then issues a macro command. Information related to the context selected is then sent to other players in the game, either by voice or by text. For example, *Diablo III* allows players to automatically send the extended description of a piece of treasure to allies, which is ordinarily only visible to the player carrying it. This allows allies to quickly evaluate whether found treasure is desirable—for example, if it is a more powerful weapon than the one they are using—without putting an undue burden on the player sharing the information.

Contextual macros, like message macros, are quick and easy to access. They minimize the time it takes for players to share information that relates to a particular game situation, such as needing to evaluate whether an item is useful to any of the players on a team. They also rely less on memory, as they are often linked to contextual behaviors rather than arbitrary command triggers. For example, in the PC version of *Diablo III*, players activate item linking by clicking on the item—a contextually sensible action—while holding shift.

However, players are more limited than with message macros, as contextual macros often cannot even be evoked except outside the specific context for which the designers planned. They also function in a specified manner. If the player is unfamiliar with how the macro works, s/he may also find it does not function in the way intended, or that what the game design considers context differs from the player's intent.

Games with contextual macros include the ability to share item information with teammates in *Diablo III*, sending a visual readout of information about a selected enemy to teammates in the *Tribes* series, and voice macros that incorporate enemy-specific information in *Tribes Ascend*.

Immersive

The purpose of immersive game mechanics is to provide information to players in a way consistent with the game's fiction, deepening the player's experience of being in the world and enhancing the play experience. These game mechanics highlight elements of the game's narrative as a component of play. Rather than directing other players toward specific game-winning behavior, immersive game mechanics invite teammates to join in a shared experience.

Exemplar Mechanics: In-Character Emotes. Many games include the ability to *emote*, or act dramatically, in character. Hailing from the early years of MUD (Multi-User Dungeon) text-based multiplayer games [7] and recommended by Tomi and Tony [34], emotes allow players to deepen the immersive experience with other players (and, possibly, communicate to support situation awareness) as **immersive** cooperative communication mechanics. Emotes may be single player, such as waving to others, dancing, etc., or involve multiple players, such as high-fives in *Portal 2*. Emotes are found in many games, including *Destiny*, *World of Warcraft*, the *Little Big Planet* series, *Hearthstone*, and *Portal 2*.

Expressive

The expressive tree of game mechanics is the deepest and most complex. It includes mechanics that support players in sharing information about themselves. Expressive mechanics are used for planning and sharing emotion; each of these may be more deeply classified by whether they enact state change on the game (mechanical) or if they are only cosmetic.

Expressive/.../Mechanical or /Cosmetic

The tertiary component, the leaves of the expressive tree, classifies each mechanic as either mechanical or cosmetic. Mechanical subtypes meaningfully modify the state of the game. Cosmetic subtypes do not change the state of the game directly, but change how the game environment is perceived by other players. Cosmetic subtypes thus may change the game mechanically indirectly, as they potentially change how teammates play.

Expressive/Planning

The expressive/planning subtree includes game mechanics that are used to express future intent in play. Planning mechanics may be used to direct teammates. Mechanically, this generally means enacting some change to the player's interface (such as a waypoint with HUD indicator or using an automated communication to transmit enemy data). Cosmetic expressive/planning mechanics provide less formal or temporary directive information, such as an avatar gesture. Expressive/planning mechanics might support team situation awareness by indicating what a player will do in the near future.

Exemplar Mechanics: Holding. Holding mechanics limit how many in-game items the player can have active at a given moment, and determine how long it takes to swap between items. While many games have holding mechanics, holding mechanics for joint communication allow other players to see what item a player is holding, and how it is being held (e.g. holding a weapon in a stance ready for combat, or sheathed in peace). When the item held is visible to other players, the holding player can signal her/his own intentions and plans. Such game mechanics are thus **expressive/planning**.

This is particularly true when holding an item has a mechanical impact. For example, in the game *Rust* it takes time for players to switch between items. A player holding a non-aggressive item, such as a torch, is at a clear disadvantage should violence erupt. As a result, a player holding a torch is signaling a commitment to non-violence, or at least that they believe they can salvage the situation should violence occur. Since no deception is possible about what item a player is holding, other players can trust that the torch-holding player is truthfully signaling and willing to accept any mechanical penalties that might arise.

Other games with holding mechanics include *DayZ*, in which others can see if the player is holding a weapon, which weapon they are holding, and where the weapon is pointed. Physical signals such as weapon-pointing, which have mechanical consequences and which are visible from a distance, are a critical part of establishing initial trust in a game where any player could potentially be an enemy.

Expressive/Emotional

In the expressive/emotional subtree, players indicate to one another their emotive state, supporting team cohesion. Known to be important in stressful environments, such as firefighting [35], conveying emotion supports team members in situation awareness, enabling team members to understand the readiness of fellow players. Expressive/emotional cooperative communication mechanics may support emotional contagion [20], causing positive emotions to cascade through the team.

Exemplar Mechanics: Gesturing. Gesture mechanics, a form of **expressive/emotional** cooperative communication mechanics, allow players to press a key or key combination, and to have their avatar respond with a virtual gesture in the game world. These gestures might include solitary gestures, like a fist-pump, or collaborative ones, like attempting to high-five a nearby player. Gestures can be triggered by simple key presses, or by typing commands to the character like `/wave`.

All nearby players can see gestures performed by the player, allowing players to use gestures to broadcast how they are feeling. Since gestures are a constrained set of pre-defined animations, that means players are selecting their emotional expressions from a small set of options. On the other hand, gestures do not require players to articulate how they feel in words, and constraints can help players decide on an emotion to express quickly.

Observed games with gestures include *Portal 2*, *DayZ*, *Army of Two*, *Elder Scrolls Online*, and *World of Warcraft*.

Emergent

The category of emergent [30] cooperative communication mechanics include game mechanics not expressly constructed for communication, but that have been appropriated by small groups or whole communities as a meaningful way of communicating. These are the most common type of game mechanic encountered in the analysis. Emergent cooperative communication typically uses some capability of the avatar to move or intervene in another player's environment (such as Cheung et al.'s virtual gestures [5]). The information communicated through emergent cooperative communication mechanics may have to be learned, and may exist only within certain communities of practice. Prior to learning, players may find that they do not know what the intended communication is.

Exemplar Mechanics: Jumping. Because jumping does have in-game meaning, there is a difference between jumping to play and jumping to communicate. This is a game design decision, as jumping mechanics may be designed to happen automatically as needed, rather than be under player control.

Jumping without an immediate purpose for the jump can mean anything from "Pay attention to me" to "I am impatient." The semantic meaning of the jump varies between play communities, and is usually highly dependent on the specific context of the particular situation in which the players find themselves. While the ability to jump without purpose is a game design decision, the exact messages conveyed by apparently purposeless jumping are emergent and situational.

Games with the option of communicative jumping include *Journey*, *Portal 2*, the *Halo* series, *Elder Scrolls Online*, and *Minecraft*.

Attention-Focusing

Attention-focusing game mechanics enable one player to provide another with a directive, calling attention to someone or something in the game environment. Deictic reference can be difficult in game play, especially using verbal communication mechanisms without embodied communication. Attention-focusing game mechanics enable deictic reference, as well as embed actionable intelligence into the game environment or interface for other players. Subtypes of attention-focusing mechanics are unbound and semantically imbued.

Attention-Focusing/Unbound

Attention-focusing/contextless mechanics do not provide any additional information. A ping on a map or in the environment, which requires additional data to decode by teammates, were the most common of this mechanic type observed.

Exemplar Mechanics: Map Pings. Map ping mechanics allow players to identify locations to one another by placing icons on a map or in the virtual space of the game. The pinging player must select the location they wish to ping, then indicate that they wish to ping it. Some games combine these steps by providing a mini-map on which players can click to automatically set up a ping at the clicked location. Map pings are an example of **attention-focusing/unbound** cooperative communication mechanics.

For example, in the *StarCraft* series, a player can ping the map for an ally. This ping carries no information beyond its location, so understanding the meaning of a ping requires disambiguation.

Other games with pinging mechanics include the *Tribes* series and *Diablo III*.

Attention-Focusing/Semantically Imbued

Attention-focusing/semantically imbued game mechanics provide some shared meaning, encoded in the game's rules. These somehow identify a characteristic of the thing indicated, or provide a call to action for one or more teammates, attaching semantic information to an indicator in the game environment.

Exemplar Mechanics: Augmented Environment Pings. Augmented environment pings operate like standard map pings, but include contextual or directive information, making them **attention-focusing/semantically imbued**. Because the game world is not uniform, the pings can respond to the features of the location in the game world that was clicked, conveying more information with the same amount of effort on the part of the player. Of course, as with contextual messaging systems, contextual pings also lock the player into *needing* to send that additional, contextual information even if they do not wish to.

Pings in *League of Legends* are an excellent example of augmented environment pings. Five-player teams battle for control of a virtual space that contains objects like allied turrets (in-game structures that aid the player and their team), enemy turrets (the same structures, but fighting for the enemy), and enemies controlled both by other players and by the game's AI. When players ping a location on the map, their teammates see a different response depending on what they have targeted. If they target an enemy character, whether controlled by players or the game's AI, a red exclamation point appears above the target to indicate it was selected. If they target an allied structure, such as a turret, a green shield appears above the structure indicating it needs to be defended. If they ping a location without either enemies or allies, a simple blue dot appears in the game world and on the minimap, indicating to allies that some action needs to be taken at that location.

Other games include different types of pings. For example, *Portal 2*'s collaborative mode includes two different ping types that players can choose between. The *Look Ping* displays an eye icon on both players' screens, indicating where the pinging player wishes the other player to look. The *Timer Ping* displays a countdown timer icon, starting at three seconds, that appears on both players' screens when it is initiated. These pings serve different functions, but both provide functionality that would be difficult to achieve by speaking. The Look Ping accurately, concisely, and specifically identifies a particular location in the game; the Timer Ping ensures that players can perfectly synchronize their actions.

DISCUSSION

In this section, we discuss the ways in which future game designers might leverage cooperative communication mechanics to construct new and exciting ways to play. We also discuss how cooperative communication mechanics may be used to analyze player performance, guiding game design and providing a means to analyze game experiments. We close by highlighting how cooperative communication mechanics should be designed and leveraged to be effective.

Potential for Future Design

Through this research, we have made a number of discoveries about cooperative communication mechanics that may aid designers in building future games. We see that players have many ways to offer, but little ability to request, information from their teammates; that environment-modifying game mechanics are not well-represented; and that players may develop emergent cooperative communication mechanics when the existing design fails to provide what they need.

Ability to Request Information

Nearly every game mechanic analyzed offers a means for a team member to *push information* to teammates. While effective teams *are* proactive about providing information, reducing the number of requests for information to reduce communication overhead [10, 11, 24, 35], the ability to *pull information* is still essential. We observe a dearth of game mechanics that provide players the ability to poll teammates for information, or to interrogate the game environment or state through teammates. Only one data source provides such ability: the *Tribes* Voice Game System, which allows players to request, "What's my assignment?", "I need a target painted!", or "Is our base secure?"

In the current designs, players can *only* be proactive about communicating needed information to players. The act of communicating through these game mechanics may not become elevated to core mechanic, as two-way communication among teammates to discover meaningful information about game state is not something in which players can engage. Instead, players much rely on verbal communication to make requests, to which other players might respond with an attention-focusing mechanic. The ability to request information potentially opens up new and exciting game designs where sharing and exchanging information is a key component of play and teammates scout game environments and engage in interesting, two-way communication.

Modifying Environments

The ability to modify game worlds were among the rarest game mechanics observed in the sample, yet a rich area for future work. *Minecraft* provides the largest collection of such instances, enabling players to not only leave signs with verbal communication on them, but also to physically alter the environment so that it signifies affordances and constraints [25,

game	mechanic	details	type
Army of Two	gesturing	avatars can “fist bump" on command	expressive/ emotional, immersive
Dark Souls series	signposts	write and post text on the ground in the game world	environment-modifying
DayZ	holding	avatars can hold objects, switching objects takes time	expressive/ planning, emergent
Diablo series	message macros	number keys trigger character to speak a command or taunt in-character	automated communication/ constrained, immersive
Diablo III	contextual macros	player can hold a modifier key and click a piece of loot to share its statistics with allies	automated communication/ context-sensitive
Journey	message macros	avatars can “sing” as a core mechanic for interacting with the environment, but cooperative players also use it to grab attention	automated communication/ constrained, attention-focusing/ unbound, emergent
League of Legends	augmented environment pings	players may ping map to indicate needs or details about enemies to teammates	attention-focusing/ semantically imbued, automated communication/ constrained
Minecraft	signposts	write and post persistent sign objects in the game world	environment-modifying
Minecraft	jumping	avatars can jump to interact with the environment, which is also used to grab attention	emergent, attention-focusing/ unbound
Portal 2	augmented environment pings	players may use a timer ping or a look ping to indicate to an ally when/where to perform an action or where to look, respectively	attention-focusing/ semantically imbued, automated communication/ constrained
Portal 2	gesturing	avatars can perform a number of cooperative gestures, such as high-fives	expressive/ emotional, immersive
Rust	holding	avatars can hold objects, switching objects takes time	expressive/ planning, emergent
StarCraft series	map pings	players may cause a sound to play and a highlight to appear on the map by clicking in the game’s minimap	attention-focusing/ unbound
Tribes series	message macros	Voice Game System (VGS): voice macros triggered by 3- to 4-character commands	automated communication/ constrained
Tribes Ascend	contextual macros	identify enemy mechanic: context-specific voice macros and HUD information sent to teammates, triggered by looking at an enemy and pressing a key	automated communication/ context-sensitive, attention-focusing/ unbound
World of Warcraft	in-character emotes	avatars may dance or gesture, performing scripted animations in character	immersive

Table 2. Data sources for grounded theory analysis connected to the resulting cooperative communication game mechanics. Interpretation may require familiarity with the game in question.

26] on action directly. The *Dark Souls* series of games does this in a more subtle manner, as other players may modify the environments in a single player game to provide advice or cause trouble.

We suggest that the modifying environment cooperative communication mechanics are a rich area for future work. There is great potential in using these mechanics to construct interesting new forms of play. Their biggest drawback is the asymmetric nature of their use—creating requires significant investment, yet using them does not. At the same time, once created, a modification to the environment may be used by many players. The creator also sometimes never receives feedback regarding their modification’s ultimate impact.

Need for More Cooperative Communication Mechanics

Emergent cooperative communication mechanics were the most prevalent observed in the analysis. This suggests that players are finding existing, designed cooperative communication mechanics insufficient (or missing altogether). Players working together need to communicate with one another, and game designers should consider carefully in what situated ways players will want or need to do this.

Analyzing Team Coordination

Effective team coordination is generally assessed by analyzing the communication between team members [10, 24, 16]. By applying a coding scheme to the utterances of team members, a researcher or educator can produce an anticipation ratio for the team, which compares the amount of communication that provides information to teammates versus the amount of communication that requests information. A high anticipation ratio means that the team is overcoming communication overhead and acting efficiently [10, 16, 24, 37, 38]. Anticipation ratio is generally calculated only on verbal (or text) utterances between teammates. A similar technique is used by El-Nasr et al. [31] by observing and coding Cooperative Performance Metrics during play, where players engage in observable behaviors outside of the game.

Analyzing communication for anticipation ratio or cooperative performance is a work-intensive and slow process. The present framework functions as a means to analyze team coordination automatically and efficiently. Once these mechanics have been identified, game developers and researchers can easily log use of cooperative communication in play, possibly to analyze anticipation ratio, or to get a more nuanced understanding of how players are explicitly coordinating with one another.

Communication Tools

Beyond gameplay, in the real world, teams need to communicate with one another. The present framework and exemplar mechanics can function as inspiration for real-world communication systems. As we advance to combinations of human-robot teams, where real-world situations look even more similar to games, this becomes even more compelling.

Designing for Communicability

Prior work has discussed the need to design game interfaces to support communicability [36], that is, render information so that it can be easily verbally communicated to teammates. The present work identifies cooperative communication mechanics that help to alleviate this need by making non-verbal communication a component of game play. Still, interfaces must be expressive enough to enable players to transmit the information they need to transmit, otherwise it must be sent verbally.

The game designer must carefully consider not only the range of expressiveness of cooperative communication mechanics, but also how they are to be invoked in play. Context-sensitivity is key to making game mechanics easy to access in intense play. As an alternative, the designer may also wish to restrict the ease-of-use of such mechanics, as gameplay is often about challenge.

CONCLUSION

In this paper, we discuss designing for communication as a game mechanic, using commercial systems as data sources for a grounded theory analysis and framework. Communication between players in these games is something about which they make decisions that affect the outcomes of the game. The game designer's primary tool to construct game mechanics is to provide rules that constrain player action.

The present framework provides six trees of cooperative communication mechanic types. Environment-modifying mechanics are used to alter the game environment to make it informative for other players. Automated communication mechanics simplify the communicator's job in intense gameplay, so that they can supply complex game-specific information to teammates. Immersive mechanics enhance the game experience by deepening the players' involvement in the game's story or world. Expressive mechanics support players in suppling information about their own state during gameplay, including their plans and emotions. Players create their own meaning through emergent mechanics, adopting their own meanings for game actions that were not primarily designed for communication. Finally, attention-focusing game mechanics allow players to point out components of the game environment to others, supporting a call to action or providing information.

A future research agenda will investigate the ways in which cooperative communication mechanics are invoked by players, how their use impacts game play, and how effective they are as a communication channel. We plan to use the present framework to code our observations of cooperative play, and look for connections across games.

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