Collaboration in Co-located Collaborative Digital Games - Towards a Quadripartite Taxonomy

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ABSTRACT

In this paper, we propose a taxonomy for the classification of collaborative interaction situations derived from studying a set of co-located collaborative gameplay sessions. The taxonomy builds on the MDA framework and Activity Theory (AT) as top-level attributes, and offers the analytical dimensions WHAT, WHO, WHEN and HOW, each containing a number of sub-categories, for evaluating different levels of collaborative interaction mediated by games. The work is based on a three stage process: design of game instances, data collection, and analysis of play sessions. This taxonomy is an initial step towards capturing the complexity of collaboration mediated by games, and helps in understanding and studying collaboration as a phenomena in game design. Our preliminary work provides a characterization of multiple dimensions of collaborative interaction, providing game designers a starting point for deeper understanding into collaborative interaction mediated by a collocated gameplay.

CCS CONCEPTS

• **Human-centered computing → HCI theory, concepts and models**.

KEYWORDS

Collaboration; design; games; HCI

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1 INTRODUCTION

The vast majority of games played all over the world are collective in nature, and multiplayer has become an important part of computer games [24, 30]. However, designing collaborative games has been identified as being extraordinarily difficult [30], requiring an expanded view of group dynamics, social roles, and interactions between the players [10, 18, 22]. Further, there is no systematization of the terms used for collaboration in games, and no shared taxonomy for identifying gameplay characteristics and game mechanics that characterize a game as collaborative or cooperative[24].

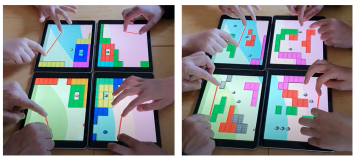

Figure 1: Example of co-located collaborative game instance using multi-display composition during gameplay [8]. The balls destroy the bricks in the matching color, and the balls are controlled by the red paddles that appear between players' fingers.

One step towards understanding gameplay characteristics that can support and stimulate collaboration in collaborative games, is to develop methods for analyzing the interplay in a collaborative game session. In this paper, we present results from the development of a taxonomy for understanding different levels of collaborative interaction mediated by games. The main contribution is the taxonomy, which was derived from the players' utterances, that were transformed into analytical dimensions and categories for collaborative interaction.

Recently, we have seen a tendency to adopt the levels of collaboration as defined in Activity Theory (AT), in order to define collaboration in an operational way [1, 3, 7]. AT provides a method for understanding and analyzing a phenomenon, finding patterns and making inferences across interactions [14]. Based on AT as a theoretical foundation, Engeström defined three levels of collaborative interaction [6], and building on this definition, Bardram introduced a framework for collaborative interactions between users mediated by technology [1]. This framework consists of three different levels of collaboration, from the simplest to the most complex form: Coordination (employ individual independent activity), Cooperation (adjust the actions to others actions), and Reflective Communication (redefine the object, reformulate the problem, reconceptualize the roles, rules or routines, and change or transform the practice). Acknowledging that there are many other models for defining collaboration, we will in this paper make use of the three levels deriving from Activity theory [1, 5].

There are many frameworks within game design (e.g. [2, 9, 27]), and the Mechanics-Dynamics-Aesthetics-model (MDA) [13, 16] is one of the most well-known and commonly applied frameworks [23, p. 20], and is one of the fundamental approaches [21, 23, 28]. The model consists of three main elements: 1) Mechanics - the

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particular components of a game, such as rules, at the level of code and data representation and algorithms. Mechanics are interactions as they create meaning from the game's perspective. 2) Dynamics - the runtime behaviour of mechanics responding to player inputs and system outputs over time. Dynamics are useful for understanding the emergent properties of the game, meaning what happens when the mechanics interact. 3) Aesthetics - desired emotional response and affect evoked in a player when she interacts with the game. Aesthetics explore the abstract cohesive interaction between the underlying design elements.

Inspired by literature on using the MDA model as a basis for analysis of gameplay, and Activity Theory (AT) as a basis for analysis of collaborative interaction, the taxonomy presented in this study establishes the elements and analytical dimensions needed for capturing the verbal interaction of players pertaining to the game elements (e.g. shared resources) that mediate their collaborative activity. Below, we further elaborate how we developed the taxonomy by analysing the verbal data through MDA and synthesizing the results through the lens of AT to build an understanding for the level of collaborative interaction offered in different game instances.

2 METHOD

The taxonomy was developed based on the analysis of data from playtests with co-located collaborative game instances using multi-display composition [17]. The game instances were designed to have different degrees of interdependence between the players. The range of interdependence goes from no interdependence to high. The choice to study game instances investigating the effects of varying interdependence among the players is based on previous work, e.g. Seif El-Nasr et al. and Harris and Hancock, showed that asymmetry between players' roles increases the complementarity between their actions [11, 25], and it has also been noted that complementarity between the functional roles support a more complex collaborative interaction that not only leads to retrospective reflection but also reflecting forward in the form of tactical planning which involves sequential thinking for future actions [3, 29].

The game instances used in this study, Quadropong [8], are inspired by the classic video game Pong. However, they are implemented for 2-4 co-located tablets arranged next to each other in a multi-display composition [17], to form a shared interactive game space. The collaborative game instances, make use of the entire shared space as a single screen where each player controls the part represented by their own tablet (see Figure 1). Players were 11-13 years old, 2 male siblings, and two of their female friends. The participants were recruited using convenience sampling [15]. Informed consent was sought with both parents and children, and the incentive was a gift card for ice cream. The play sessions took place in the siblings' home. The session was video recorded, 89 minutes were captured, and later transcribed and translated to English. One researcher was present for observations, but did not intervene.

2.1 Inductive and deductive analysis

To identify and annotate players' collaborative interactions mediated by the game instances, we analyzed the verbal communication taking place during the gameplay. Due to the emergent nature of collaborative communication, the challenge of analyzing gameplay video is to find commonality among a large number of incidences that manifest the same type of verbal exchange in different levels of collaboration across variations of dependency among players. To address this, we coded the video data by an iterative inductive coding approach [20], allowing themes to emerge from the data. In total, 10 game instances containing 889 utterances were transcribed. Utterances involved an uninterrupted chain of words that players produced at a time. Thus, they may include only one word or several sentences. A shared document was made to capture this data collection. The coding workflow involved three iterative steps:

1st iteration - **Inductive coding**: The three researchers sorted each of the utterances in all game instances and coded all transcripts by applying one or more data-driven conceptual categories which included game, action, feeling, set-up, and non-sense. However, there were too many inconsistencies between the individual codings due to that some utterances fit in more than one category.

2nd iteration - **Axial coding**: Two researchers grouped the utterances into MDA categories, and a number of sub-categories (i.e., from inductive open coding to axial coding [26]). The subcodes were: exchange of resources (asking or offering), planning (strategic and tactical), reasoning about the game, breakdown. The taxonomy was tested individually by three authors. Four instances (varying across low to high dependency) were re-coded separately according to the re-aligned understanding reflected in the taxonomy. This was repeated several times to ensure that all categories were saturated, meaning that through continuing analysis we formulated descriptions of each sub-code (see Table 1) .

3rd iteration - **Refinement of categories through consensus coding**: Given the complex nature of collaborative interaction, we chose a standard qualitative research approach [12], and attained *interpretive validity* (or interpretive understanding) [19], for the authors' account of the meaning of the players' utterances through the consensus coding. All three authors took part in the interpretation to capture the relevant semantic context of each of the utterances. The categories of the taxonomy emerged as an outcome of these semantic discussions. In this way, the coders settled on the non-mutually exclusive observable and analyzable factors identifying collaborative interaction (e.g., Dynamics such as planning, suggestion, call for action and etc.), as an extension of the MDA framework (see Table 1).

3 THE QUADRIPARTITE TAXONOMY

The four analytical dimensions WHAT, WHO, WHEN and HOW will be presented in separate sections below.

3.1 The WHAT Dimension

The WHAT dimension of the taxonomy is divided into the components of the MDA framework [13], that is Mechanics, Dynamics and Aesthetics. Mechanics deal with the components of a game

WHAT	Sub-Code	Short	Example	Description
Mechanics	Game	M(g)	Then I think maybe it's about getting them destroyed first.	Reasoning how the game works including exploring the rules, goals, a breakdown situation, and what general inquiry of a game instance entails.
	Resources	M(r)	Is it a stick?	Understanding the form and function of the resources (e.g. paddles and balls).
			I hold the blue lap.	Understanding the control of a resource
	Agreeing	M(a)	Yes, that's why you came out o me Otto.	Agreeing on a game element.
	Disagreeing	M(d)	No, but not this one. Can you see the bright one, it is one shot, but the one here it is three shot.	Disagreeing on a game element.
Dynamics	Resources	D(r)	I need the green one.	Asking for or offering a resource, or current action performed on a resource.
	Call for action	D(c)	Viggo hurry up.	Expressing necessity of an immediate action with a brief head-up.
	Suggestion	D(s)	Try playing it through there.	Explaining the necessity about a game state or an action, or reflection on a past action.
	Planning	D(p)	I'll have to just take my own first.	Describing cause and effect relations between possible actions that involve tactical planning (thinking one step ahead) or strategic planning (multiple steps ahead).
	Agreeing	D(a)	So do I.	Agreeing on an action.
	Disagreeing	D(d)	What? Astrid she can not. Like that!	Disagreeing on an action.
Aesthetics	Feeling	A(f)	Oh, how annoying.	Expressions pertaining to emotions (e.g. fun, boredom, stress, etc.).
	Performance	A(p)	We have become really good at it.	Expressions to reflect on the individual or group performance.
	Out of context	A(x)	Oggiv, man. It's my name backwards or my new name.	Irrelevant utterances appeared during gameplay.
	Agreeing	A(a)	Yes, it's the hardest.	Agreeing on a feeling or performance.
	Disagreeing	A(d)	You did not win.	Disagreeing on a feeling or performance.

Table 1: Overview of the final taxonomy for the WHAT dimension.

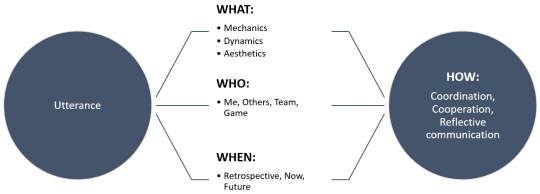

Figure 2: The quadripartite taxonomy, with the dimensions WHO, WHEN, WHAT and HOW.

and how they work. These lead to Dynamics, i.e, the interactions and behaviors resulting from mechanics, and finally Aesthetics are about the emotional response and affect invoked in players. In line with the MDA framework, the taxonomy divides the conversations taking place during gameplay into the main codes M, D and A. An example of an utterance coded as M can for instance be "What, why can I not move mine?", which is about understanding the mechanics of the game. An example coded as D is "I take the green one", describing an action to take. An utterance like "I like it" is coded as A since it corresponds to an experience or feeling resulting from gameplay. To allow for a more fine-grained coding, the taxonomy further the divides the elements of MDA into subcodes. For example, utterances in the D category can be coded as resource (r), call for action (c), suggestion (s), planning (p), agreement (a) or disagreement (d). Following this approach the utterance "I take the green one" is coded as D(r) since it deals with how to handle a resource. The full list of WHAT codes with examples is given in Table 1. Since utterances can be connected to more than one topic, the taxonomy allows for assigning multiple codes to a single utterance. This can be assigning several subcodes, like D(cr), indicating a call for action related to a resource, or using several elements from MDA like M(g)A(f).

3.2 The WHO Dimension

The WHO dimension is designed to code who is involved in an utterance. Since the taxonomy is targeting collaborative interactions, it is interesting to capture who says what to and about whom. The WHO dimension contains the following codes: "me" (short m) as the first person of the speaker, "other" (o) for someone specific

being mentioned by the speaker, "team" (t) as referring to more than one member of the playing team, "anyone" (a) that refers to anyone who might play the game in general. Finally, there's the code "game" (x) for referring directly to the game. Examples using all the WHO codes are shown in Table 2.

The method to define who is actually involved in an utterance is as follows: Firstly, the subject in an utterance containing a verb is coded. E.g., in the sentence "I need green" the subject of the verb "need" is the person speaking and coded as "me" (m). Secondly, to catch collaborative actions in utterances like "You should have given it to me" object pronouns (a.k.a. prepositional pronouns) need to be coded. These are references to a person that come after a preposition like to me, over for you, from her, etc. Thirdly, there is a need to include actors in the analysis pertaining to the hidden verbs (or nominalization). For instance, in the following sentence "Okay, I need the yellow Astrid", the speaker strives to urge Astrid's attention to be able to get the resource s/he needs. The player here is aware of the fact that achieving a resource is dependent on another player's cooperation. These type of sentences are tricky because the noun here refers to a person who needs another player to do an action. However, the action is manifested only in the form of the person's point of view of who is in need, albeit the action can only be complete as soon as the subject of the hidden verb responds, e.g. here when Astrid takes care of the resource to be passed over to the speaker. Thus, there is a need to code the hidden verbs to capture the actors of indirect actions referring to situations whereby some players are given information or called for action that requires another player to act collaboratively.

The three forms of sub-codes identified above for the WHO dimension indicate a level of *awareness* of what the game requires or one or more receiver's needs, role, cooperation, resource, or presence that links with the collaborative action being referred in the speech. The utterances which do not contain a verb (e.g., "Well, that way"), or which contain an ambiguous subject, meaning that it is impossible to decide whether they refer to the team or a particular person (e.g., "Try playing through there."), were and should be excluded from the analysis in WHO dimension.

3.3 The WHEN Dimension

The WHEN dimension covers variations of temporal reflections on the collaborative interactions taking place during gameplay. There are only 3 codes to use namely "now" (n) for talking about instant or current, present matters, "future" (f) for prospective talk, e.g., planning future steps, and "retro" (r) for retrospective utterances. Examples showing the use of the WHEN dimension are given in Table 2.

The WHEN dimension does not merely rely on the grammatical tense of an utterance for deciding its code. Rather, the idea is to code if the utterance is about what happens now, earlier or in the future. For instance, utterances that indicate a probabilistic thinking (e.g., "What if I shot it through there?"), or a suggestion (e.g., "Try playing through there.") should be coded as forms of prospective talk invoked by the game, and coded in the future category. Likewise some utterances that appear to be in present or future tense like "But sometimes you can also just let it be and it shoots.", or "Martha is going to walk out of it all the time." are coded as retrospective since they demonstrate an utterance with a reasoning based on the previous knowledge gathered from the game experience.

Some utterances in the WHEN dimension such as sentences that do not contain a verb (e.g., "Haha Martha", or "Yes, okay"), exclamations pertaining to a feeling (e.g., "That's it"), or sentences that do not relate to the gameplay as such (e.g. "I'm going to have to straighten it a little bit because Otto's elbow is gigantic") were and should be excluded from the coding.

3.4 The HOW Dimension

In Activity theory (AT), coordination relates to the interaction between individual subjects and the mediating object to serve an overarching shared goal (subject-object relation), while cooperation relates to intersubject interaction mediated by the object (subject-object-subject relation) [1]. In this study, the players are the subjects, and the game instances are the mediating object. Thus, game mechanics which we coded as M(g) and M(r) refers merely to the object. For instance, the following sentence is a clear example for subject-object relation which corresponds to the coordination level; "I hold the blue lap." or "Then I think maybe it's about getting them destroyed first." (Examples in Table 1). The utterance is concerned with a collaborating actor's individual interaction with the mediating object to perform assigned actions and roles. The interplayer interaction mediated by the game can be described by the dynamics of the game which in our case appeared around sharing or exchanging the resources D(r), or acting towards a shared goal such as call for action D(c), or suggestion D(s). For instance, the following sentences are suitable examples for the cooperative level of interaction: "Okay, I do not need the yellow one anymore, so I'll shoot it over for you." (E3 in Table 3) and "We have to push everyone's over to Astrid to hit." in Table 2. These utterances indicate each player relate the joint task to both their individual and shared object, as the cooperative level of activity explained in AT.

Reflective communication, in AT, refers to a more complex interaction between subjects to transform the current practice through redefining the object, reformulating a problem, reconceptualizing routines and/or changing the action if needed [1]. When it comes to analysing the reflective communication during gameplay, the relevant examples manifest themselves in more complex utterances such as "Okay, we can move them a little closer to Otto and Viggo because you can see that there is a fairly big difference in who has them closest" which demonstrates the player's understanding of the mechanics and dynamics and strive for transforming the collaborative action or effort through an intersubject solidarity for the sake of reaching the shared goal. The intersubject solidarity, in this case, is mostly created by the interdependent roles and skills and limited access to resources which create challenges that urge players to plan and rethink about the actions to take. By using the taxonomy, we found these examples in the sub-code planning, which belongs to Dynamics. However, the taxonomy also showed us that mere planning may not be an indicator of a reflective practice as such. For instance, the following sentence is coded as planning: "I just let it go around like that. Then it should probably do it." (E2in Table 3) , because it involves

WHO	Code	Example
Me	m	I need green.
Others	o	Astrid what are you doing
Team	t	We did it!
Game	x	Why are you behaving like this blue!
Me+Others	mo	Astrid, you need green and I am sending it to you
Others+Team	ot	Astrid needs green, someone should give it to her.
Me+Team	mt	I need the blue, so when you have time just give it to me.
Me+Game	mx	Come to me blue!
WHEN	**Code**	**Example**
Future	f	We have to push everyone over to Astrid to hit
Now	n	I need green.
Retrospective	r	You should have given it to me.

Table 2: Overview of the WHO and WHEN dimensions. Who is being mentioned as the noun, the object pwonoun, and by nominalization. WHEN is based on when in time the comment is referring to

Nr.	Utterance	WHAT	WHO	WHEN
E1	We have to keep them here for a longer time so they work better because if you just do it like this, they will not last for a very long time.	M(gr)D(p)	tg	nf
E2	I just let it go around like that. Then it should probably do it.	M(g)D(p)	mg	nf
E3	Okay, I do not need the yellow one anymore, so I'll shoot it over for you.	D(r,p)	mo	nf
		HOW		

Table 3: Example of utterances coded with the WHAT, WHO, WHEN and HOW dimensions.

a probabilistic thinking with respect to the game mechanics and tactical planning about what to do next. However, the transformative aspect of reflective thinking practice is not obvious in this type of sentence albeit it involves planning.

The examples for reflective practice become more apparent when planning is articulated in sequential (cause and effect relations between actions) and projective (future-oriented reasoning based on previous knowledge) thinking in terms of temporality, which requires a retrospective understanding of the game mechanics and contemplating about how the dynamics would work better to transform the experience as well as awareness of who should act upon it; e.g. "We have to keep them here for a longer time so they work better because if you just do it like this, they will not last for a very long time." (E1 in Table 3) This example shows the complexity in which multiple temporalities (nf) as well as both M(g) and D(p), and the "we intention" are involved at the same time. However, using the taxonomy showed us that these types of reflective utterances, which indicate a complex thinking, are quite rare. This goes in line with the theory which describes reflective communication as the most advanced form of collaborative interaction [1, 6]. The complexity in coding, as we described with the taxonomy, may help designers and researchers to evaluate games when they intend to analyze the parameters that create and support this transformative and reflective interaction and mediate the highest level of collaboration in gameplay.

4 DISCUSSION AND CONCLUSION

In this paper, we have introduced a quadripartite taxonomy for analysing collaborative interaction mediated by co-located collaborative digital games. The taxonomy consist of the four dimensions WHAT, WHO, WHEN, and HOW, it extends the MDA framework, and can be used to identify various levels of collaborative interaction as defined in Activity Theory. Collaboration as a complex phenomena is often used interchangeably with coordination and cooperation [4, 24], and there is no systematization of the terms used in the field of games [24]. By incorporating MDA into the analysis of the verbal communication between players and combining the analysis with definitions of collaboration from Activity Theory [1, 6], we can hopefully come one step closer to such systematization for understanding the complex nature of collaborative interaction. Much work is still to be done, however, through the taxonomy, we can distinguish game elements that stimulate different levels of collaboration. Although it is not the focus of this paper, but further analysis could possibly indicate what kinds of shared collaborative knowledge processes that arise from different game mechanics, something that so far has hardly been studied [10]. However, the preliminary results indicate that the taxonomy can be useful to analyze collaborative interaction mediated by game instances, and also in order to identify various levels of collaborative interaction as defined in Activity Theory.

A limitation of the current taxonomy is the possible representation bias in our design for collaborative interaction created through the variations of interdependency in roles and skills in a co-located collaborative game using multidisplay composition. Since mechanics of collaborative games could vary in terms of

temporality (e.g., asynchronous) or location (e.g., remote), we may have missed out on alternative forms of collaborative interaction mediated by games which were not part of our game design. Thus, the taxonomy presented in this work could further be extended by looking at different types of collaborative games for a more holistic understanding of the mediation of collaborative interaction. Another limitation is that in some cases, the interpretation of an action, whether it is M or D, becomes tricky when the source of action is ambiguous (e.g. "So now blue comes over to you"). In this sentence we do not know whether the action is done by the player as a response to the request, or the action of the ball caused by a bounce in terms of mechanics of the game. Thus, the taxonomy is shaped by the semantic context of the gameplay, and the particular skills and judgment of the researchers in interpreting the MDA framework as well as Activity Theory.

This taxonomy is an initial step towards capturing the complexity of collaboration mediated by games, and can hopefully help in understanding and studying collaboration as a phenomena in game analysis and design. Our preliminary work provides a characterization of multiple dimensions of collaborative interaction, providing game designers a starting point for deeper research into collaborative interaction mediated by a collocated gameplay.

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