Enhancing Communication and Awareness in Asymmetric Games

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Abstract. Asymmetric games rely on players taking on different gameplay roles, often with associated different views of the game world and different input modalities. This asymmetry can lead to difficulties in establishing common referents as players collaborate. To explore communication and group awareness in asymmetric games, we present a novel asymmetric game, combining a tablet presenting a 2D top-down view and a virtual reality headset providing an immersive 3D view of the gameworld. We demonstrate how communication can be afforded between the two types of views via interaction techniques supporting deixis, shared reference, and awareness. These techniques are bi-directional, enabling an equitable collaboration. A pilot study has shown that players adapt well to the system's two roles, and find the collaborative interaction techniques to be effective.

Keywords: Game design · asymmetric games · virtual reality

1 Introduction

Modern computer hardware affords a wealth of new styles of gaming. An emerging style is *asymmetric* games, where cooperating players take on different roles, sometimes using different forms of interaction, different hardware, and different views of the game world. For example, in *Maze Commander*, two players collaborate to traverse a dangerous maze [20]. One player can see the entire maze, using a virtual reality headset, but cannot navigate. The other sees only a small part of the maze, represented by connected Sifteo Cubes, and can manipulate the cubes to move the avatar. The key behind this game is that each player's views and interaction affordances support part of the gameplay task, and the players must cooperate closely to win the game.

Asymmetric games frequently require players to engage in tightly-coupled collaboration [10], despite having often radically different ways of interacting with the game. Such collaboration can be difficult if players have different views of the game world. Players may lack consistent frames of reference, and may have difficulty understanding what the other player can see.

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Fig. 1. The *Our Virtual Home* game: One player decorates a house on a large tablet device and the other uses immersive VR to assess the result.

In this paper, we explore the problems of group awareness and communication in asymmetric games. Through *Our Virtual Home*, a novel house decoration mini-game (Figure 1), we show examples of potential breakdown in collaboration. *Our Virtual Home* combines a large 2D touch tablet and a VR headset, enabling tablet players to view and position furniture in a house while a VR player explores how the furniture will appear to people. This mini-game is inspired by the house decoration features found in games as varied as Bethesda's *The Elder Scrolls V: Skyrim* and Microsoft's *Minecraft*.

This choice of hardware is based on the strengths of the tablet and VR headset devices used. Tablets naturally support planning around 2D representations of physical space such as maps and architectural plans. Example applications support design of interior spaces [13], exploration for oil and gas [22], emergency response planning [4], and determining routes for military vehicles through hostile terrain [3]. However, some situations require a full understanding of the space represented in the map or plan, and in such cases, a top-down 2D view may not be sufficient. For example, when arranging furniture in a room, it is necessary to have a realistic perception of depth and distance to create an aesthetic and enjoyable space [14]. Adding the use of a VR headset, however, seriously compromises group awareness. The player using the headset cannot see where tablet player is looking or pointing, and may not see when the tablet player is moving furniture. To address this problem, *Our Virtual Home* provides a novel set of collaborative widgets supporting communication between tablet and VR players.

3D views can help with such tasks by presenting the space directly to the player. For this reason, many commercial games combine immersive first-person views with an additional top-down view for establishing context. For example,

	Same Perspective	Different Perspective
Same Input Modalities	League of Legends, World of Warcraft	Natural Selection, Savage, Nuclear Dawn
Different Input Modalities	Frozen Treasure Hunter	Beam Me 'Round Scotty!, Maze Commander, Tabula Rasa

Fig. 2. Examples of how asymmetric games can provide players with differing perspectives on the gameworld and different input modalities supported by different hardware.

Activision's *Call of Duty* game provides a first-person 3D view of the scene, augmented by an inset 2D "minimap" providing a top-down view. However, switching between views can be cognitively demanding, leading players not to take full advantage of all available perspectives [27].

Recent advances in virtual reality (VR) technology have made immersive views of 3D spaces widely available. Immersive VR goes beyond the desktop by providing stereoscopic 3D views that can be explored using natural movements. Compared to desktop computers, VR headsets have been found to provide a more accurate sense of distance [19], support spatial cognition through the use of natural head movements [18] and provide a more satisfactory experience [21].

This paper makes two contributions. First, we illustrate a novel combination of a large tablet device with a VR headset in an asymmetric game. Second, we show how communication and group awareness can be supported despite the different perspectives of tablet and VR players.

2 Related Work

Asymmetric games provide players with different roles, possibly providing different perspectives on the game world, and possibly using different hardware. For example, in *Frozen Treasure Hunter*, two players attempt to capture trophies while being attacked by snowball-wielding enemies [29]. The players cooperatively control a single avatar, where one moves the avatar by pedaling a bicycle, and the other swats away the snowballs by swinging a Wii Remote. Asymmetric games allow players to experience a variety of gameplay, allow people with different interests to play together, and provide a form of game balancing by allowing people to choose a role that plays to their strengths [11].

Figure 2 lists examples of asymmetric games. In the simplest case, games such as Riot Games' *League of Legends* and Blizzard's *World of Warcraft* allow players to take on different roles in games (character classes), while sharing the same hardware and same perspective on the game's action. As described earlier, *Frozen Treasure Hunter* is an example of a game where players share the same third person view of their avatar, while playing different roles using different hardware (Wii Remote vs bicycle.) Several commercial games have explored the provision of different perspectives to different players. Unknown World Entertainment's *Natural Selection*, S2 Games' *Savage: The Battle for Newerth*, and

Iceberg Interactive's *Nuclear Dawn* all involve a player in a commander's role, using a real-time strategy interface to direct players on the ground who play as individual units.

A more radical form of asymmetric games offers players different playstyles involving both different perspectives on the gameworld and different hardware interfaces to the game. For example, *Beam Me 'Round Scotty!* allows one player to use a game controller and PC to guide an avatar through a level, while the other player uses a touch tablet to enable special effects that aid the player [10]. Similarly, in *Tabula Rasa*, one player uses a standard PC and game controller to navigate platformer levels, while the other player uses a digital tabletop to create and modify these levels on the fly [7]. This form of asymmetric gameplay allows interesting forms of collaboration, where players are responsible for different parts of the gameplay task (e.g., building a level vs playing it). The differing visual perspectives allow players to see the gameworld in ways that are appropriate to their tasks, and the different input modalities are customized to the tasks the players perform (e.g., touch to build a level, controller to navigate it).

Research outside the realm of gaming has shown how collaborative tasks require people to perceive and manipulate physical spaces, and how these tasks can benefit from a system in which some users manipulate the space using a top-down view while others are immersed in the space using a VR headset. This form of work has been termed *mixed-space collaboration* [8, 17, 24]. For example, when designing the layout of an apartment, architects draw the floor plan from a top-down perspective and also draw sketches of the space from a first person perspective [13]. The floor plan is useful for exploring spatial constraints and helps the architect to share design decisions with other stakeholders. The first-person sketches help with perception of volumes and of the space's look and feel. In military route planning, officers collaboratively plan how their troops will travel through hostile terrain via discussion over a large map [3]. To plan safe routes, commanders determine the visibility of units along the road, from multiple strategic points. A first-person view can help assess the potential of ambush of units following a proposed route. The common element between these collaborative tasks is that planning and design is discussed using a top-down overview of the space, while specific features are verified at a human scale. Top-down views are used to arrange elements, to resolve spatial constraints and to obtain an overview of the space. Conversely, a first-person view helps in understanding distances, volumes and sightlines. Work benefiting from these two perspectives is referred to as mixed-space collaboration.

The benefit of 2D and 3D perspectives on design tasks was identified as early as 1997 in a modeling interface combining both perspectives [5]. More recently, systems have explored the combined use of a virtual reality headset with a traditional desktop PC display. One user is immersed in the space with the headset while the other controls an overview of the space on a screen. Systems have been created for search and rescue [1, 23], authoring of virtual environments [12],

	Tabletop to VR	VR to Tabletop
Deixis	Glowing green column	Blue laser pointer
Shared Reference	Cardinal direction display	Compass bar
Awareness	Avatar and vision cone	See-through effect; side-icon; dragging sound

Fig. 3. Interaction techniques used in *Our Virtual Home* to support bi-directional collaboration between tablet and VR players.

guided navigation [26], and exploring museum exhibits [25]. This decomposition has been shown to improve efficiency in searching and traveling tasks [8, 30].

A central problem in systems mixing touch tablets and virtual reality is that the hardware can block communication between the two types of players. The virtual reality headset covers the player's eyes, blocking their view of the physical world around them. Consequently, a VR player cannot see the tablet player or where they are looking or pointing, and cannot see the shared artifact displayed on the table. Similarly, the tablet player cannot see where the VR player is looking. Interaction techniques have been proposed to help players overcome this barrier, some of which are summarized by Stafford et al. [24]. For example, in the context of disaster relief, Bacim et al. allow a "commander" (PC user) to place waypoints to guide a "responder" (VR player), and allow the responder to place virtual markers to alert the commander to places of interest [1]. Holm et al. [12] and Stafford et al. [23] provide similar "god-like" techniques. These allow the PC user to guide the VR player, where the actions of the PC user are illustrated through movements of a giant hand in the VR view. Nguyen et al. demonstrate a range of cues that a "helping user" can provide for an "exploring user", including directional arrows, a light source to flag paths, and an over-the-shoulder camera to allow the helper to see the world from the exploring user's point of view. In the *ShareVR* game, non-VR players maintain awareness of the virtual world through projection of the world onto the floor [9].

3 Enhancing Communication in Asymmetric Gameplay

To better understand communication in asymmetric games involving different perspectives and input modalities, we introduce the *Our Virtual Home* house decorating mini-game (Figure 1). The system is composed of a large interactive touch tablet and a VR headset. The tablet shows a top-down view, allowing players to position furniture by dragging and rotating. The headset provides an immersive view where players can change their perspective by moving their head, and can walk through the house using a game controller. This supports a natural division of duties. The tablet player maintains a large-scale view of the house design, allowing them to conceptualize the global layout, and to easily reposition furniture through touch gestures. The VR player can see the furniture layout in place, getting a clearer idea of scale, sightlines and movement through

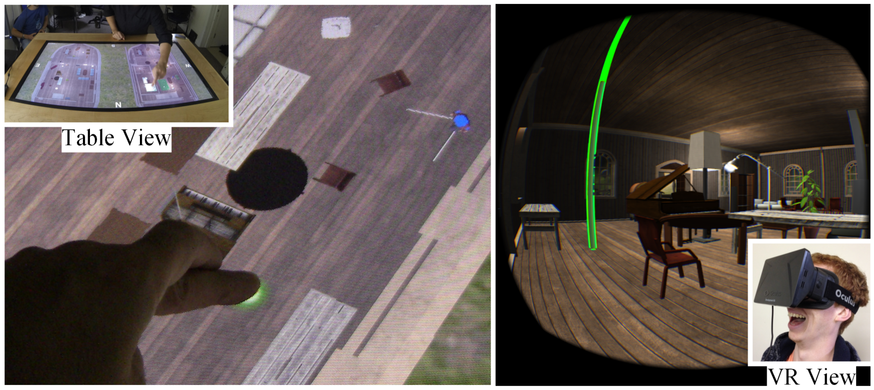

Fig. 4. The sky-laser technique supports deixis from tablet to VR. A tablet player's pointing action is shown in the virtual world as a glowing column of light.

the space. The tablet player may try a decoration idea, and ask the VR player to evaluate it. Equally, the VR player may request modifications to the design based on their first-person view. This means that it must be possible for either player to initiate and guide communication. As discussed earlier, however, the fact that the VR players' eyes are covered by the headset forms a barrier to collaboration. As suggested by Dix' framework [6], users require three forms of communication, all of which are hindered by their different perspectives on the gameworld, and particularly through the reduced visibility of the VR hardware:

– *Deixis* to establish explicit referents in conversation (e.g., "try putting that chair over there").
– *Shared reference* (e.g., "what do you see to your left?").
– *Awareness* (e.g., realizing that a table is being moved).

Our Virtual Home shows how it is possible to support all three forms of communication, originating either from the touch or the VR player. As summarized in Figure 3, *Our Virtual Home*'s collaboration techniques support bi-directional deixis, shared reference and awareness. The techniques are designed to match the capabilities and conventions of the devices. Some techniques have been proposed by others (e.g., Stafford et al.'s "god-like" pointing [23]); others are new. The key novelty of *Our Virtual Home* is to demonstrate that this combination of interaction techniques allows all three forms of communication to originate from either player. This affords an equitable collaboration where both the tablet and VR and VR player have the same communication opportunities.

3.1 Deixis

Deixis is almost as important as words for face-to-face communication [2]. Traditional finger pointing is hindered when one player wears a VR headset, as that

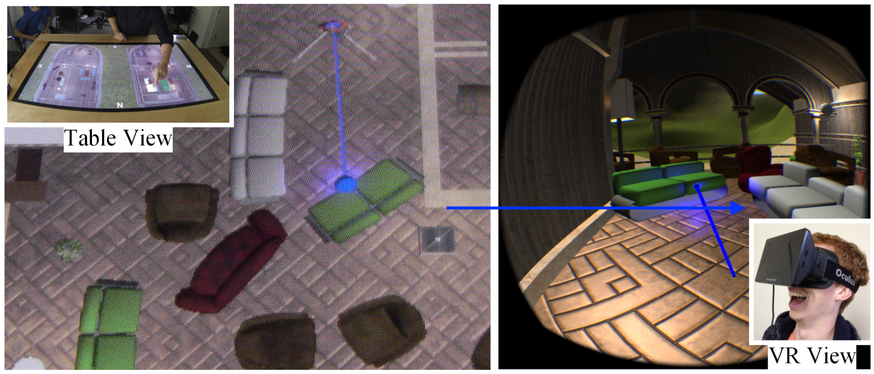

Fig. 5. The laser pointer supports deixis from VR to tablet. Here, the VR player is pointing at a sofa.

player cannot see the other person's hands or the touch device itself. To help VR players see where tablet players are pointing, we designed and implemented a two-way pointing system.

When the tablet player touches the screen, a glowing, green marker appears below their finger (Figure 4: left). This feedback is immediately reflected in the VR player's view as a column of green light (Figure 4: right), showing the location of the touch. The green feedback follows the tablet player's touch gestures, and its position is updated in real-time in the VR view. This technique, inspired by Stafford's "god-like" pointing technique [23], enables the tablet player to communicate locations to their VR partner. Deixis is therefore provided via touch. The glowing green marker is important to show the tablet player that the touch is being communicated to the VR player.

In the other direction, the VR player can hold a button on their game controller to trigger a blue laser pointer (Figure 5: right). When the laser pointer appears in the VR view, it also becomes immediately visible on the tablet surface (Figure 5: left). The laser's end point is marked with a lightning ball in order to disambiguate which object is being referenced. Lasers have proven to be users' preferred technique when pointing in collaborative virtual environments [28]. This enables a VR player to point at objects and locations in the space to communicate with their tablet partner. As with physical deixis, this mechanism can be used to disambiguate references to elements in the space.

Together, these techniques enable deixis in both directions, allowing both tablet and VR players to reference locations or objects for the other to see.

3.2 Shared Reference

Another advantage of face-to-face collaboration lies in the establishment of shared references. For example, people working on a map typically have a shared understanding of which direction is north, allowing the use of cardinal references

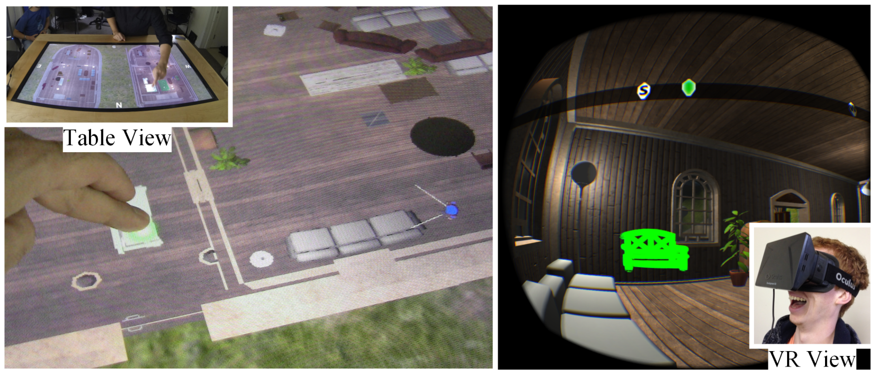

Fig. 6. Left: The tablet player is moving a bench. The blue avatar shows the position and orientation of the VR player. Right: The bench is highlighted with the see-through effect in the VR view. The compass on the top shows that the player is facing south and shows the direction of the selected bench.

when discussing directions. Similarly, when working side-by-side, it is easy to reference elements using phrases such as "to your left" or "the chair behind the table". In an asymmetric game like *Our Virtual Home*, these referencing mechanisms are broken because players do not see the space from the same point of view. Müller et al. recognized the importance of shared reference through the inclusion of shared virtual landmarks [16].

To afford absolute reference, we designed and implemented a compass widget that is visible using the VR headset. As shown in Figure 6 (right), the compass is a bar at the top of the VR view showing the four cardinal directions. (In the figure, the player is oriented in roughly the southerly direction.) The compass rotates with the player's direction of view. Cardinal directions are also displayed on the tablet, with north pointing toward the top.

To aid with relative references, the position and orientation of the VR player is shown on the tablet. As shown in Figure 6 (left), the VR player is represented as a small avatar (a blue circle) whose current field of view is shown as an open cone (delineated by two white lines). This shows the tablet player the direction in which the VR player is looking, allowing references such as "look to your left".

3.3 Awareness

Shared spaces such as our table-sized tablet afford awareness by allowing people to see the actions of others through direct and peripheral vision. VR players cannot see others' work if that work is out of their field of view. For example, if a tablet player moves a piece of furniture behind the VR player or behind a wall, the VR player may not be aware that the movement has taken place. In *Our Virtual Home*, we addressed this problem via (1) a see-through effect that extends the VR player's sight through obstructions, (2) a "side-icon" indicating activity out of the field of view, and (3) an audio "furniture dragging" sound that is activated when a tablet player moves furniture.

As shown in Figure 6 (right), when a tablet player touches a piece of furniture, it takes on a glowing, green appearance in the VR view, and becomes visible through obstructions such as walls or other furniture. This draws the VR player's attention to furniture that is being moved, even if it is not directly visible. This allows the VR player to see the movement of occluded objects. This see-through effect requires the object to be within the VR player's field of view. To help with this, as an object is moved, a green marker appears on the compass aligned to the horizontal position of the moved object (Figure 6 (right)). If the object is outside the VR player's field of view, this green marker appears on the left or right hand side of the display ("side-icon"), indicating that activity is taking place, and showing the direction in which the VR player should turn their head.

Finally, a "furniture dragging" sound is played when furniture is being moved, providing a second cue to the presence of activity that the VR player may not be able to see.

Thus, the VR player's awareness of group activity is enhanced by the ability to see through walls, the highlighting of furniture selected by tablet players, the side-icon visual cue indicating activity out of the field of view, and the use of an audio cue representing furniture being moved. Meanwhile, the tablet player is provided with cues to help show the location and orientation of the VR player. As seen in figure 4 (left), the position of the VR player is shown on the tablet as a blue circle. White lines delimit the VR player's field of view. This blue-circle avatar and vision cone help the tablet player to understand what the VR player can currently see.

In sum, this section has presented interaction techniques used to support bi-directional communication between tabletop and VR players in an asymmetric house decorating mini-game. As summarized in Figure 3, these techniques support deixis, shared reference, and awareness. The implementation of these techniques in *Our Virtual Home* shows that it is possible to support all three forms of communication in a bi-directional form. This is key to allowing equitable collaboration, where both players have the ability to lead and respond to the group's activity.

4 Early Evaluation

To gain feedback about the usability of our combination of techniques, we carried out a qualitative pilot study. We recruited four pairs of participants (7 males, 1 female, 18-31 years old). The participants were asked to arrange furniture in a two-story house to create a functional and aesthetic layout. The participants were provided with the techniques described above, supporting deixis, shared reference and awareness. Participants were assigned to use either the tablet or the VR headset and were directed to rearrange the first floor of the house. They then switched roles, and were directed to rearrange the second floor. On average, each participant spent 10 minutes using each device (M=10:26, SD=1:32). The sessions were video-recorded and participants were interviewed at the end of the task. We performed a video analysis to identify interesting behaviours and communication issues between players.

4.1 Results

All groups completed the task without problems and reported in the interviews that they had no difficulty in playing the game and in collaborating. The combination of our interaction techniques with verbal communication supported effective communication. Exchanges between the two players were mostly verbal, supported by our collaboration widgets. For example, the VR player could call the attention of the tablet player to a furniture item and then disambiguate the object referenced by using the laser pointer: “Hey look! Let’s put that ⟨*points at furniture item*⟩ over here ⟨*points at location*⟩”. Participants reported that the cardinal references were useful at the beginning of the session when exploring the house.

Not surprisingly, the tablet provided better awareness than the VR view. As stated by group 1, “When you are on the tablet you have full awareness of what the other person is doing”, but when using the VR headset, “I was aware that something was going on but not exactly what”. The dragging sound was successful in alerting VR players to activity, but players easily overlooked the side-icon indicating the direction of the activity.

All participants reported that the two views were complementary. Tablet players repeatedly asked the VR player how the space felt. Interestingly, not only were the use of space and distance important, but lighting was also frequently discussed. For instance, a tablet player asked a VR player: “Are there enough lamps in the eating area?” When changing from the tablet to the VR headset, participants expressed surprise at how the space looked from the inside. This highlights the complementarity of the two views.

The study showed the importance of bi-directional support for communication. Both tablet and VR players made use of pointing gestures (through the laser pointer and the column of light). The position and orientation of the avatar was used to determine what the VR player was seeing, helping to disambiguate conversation. The see-through movement of furniture objects helped the VR player quickly locate the tablet player’s activity.

The video analysis also highlighted interesting behaviours and situations where the techniques were successful, and areas where future work could improve the approach.

Path finding. Although not designed for this purpose, the sky-laser was used to direct the VR player’s movement. We observed multiple instances where the tablet player dragged the laser from one location to another to guide the VR player to a specific area. This usage is similar to Bacim et al.’s more explicitly-provided waypoint feature [1].

Missed eye contacts. While talking, some tablet players sporadically looked at the VR player even though the VR player couldn’t see them. This is a good indicator that the tablet player felt the presence of the VR player and felt the need for non-verbal communication. This hints that while deixis is useful, communication of the tablet player's gaze could helpful to indicate specific instances where the tablet player is attending to the VR player.

Missed gestures above the table. Several participants performed gestures above the table even though the VR player could not see them. For example, one tabletop participant asked the VR player: "is this whole thing roofed?" while gesturing in a circle with his hand above the table. Marquardt et al. have stressed the importance of providing awareness of activities above the table [15]; such awareness could be provided to the VR player for example through finger tracking.

In sum, both tablet and VR players made use of interaction techniques for deixis, shared reference, and awareness. Participants played the game as expected, with the tablet player taking advantage of the spatial presentation afforded by the top-down view, while the VR player focused on the immersive 3D presentation of the furniture layout. Participant response was positive, with all dyads successfully completing the task. While this study was based around the specific hardware of a tabletop-sized tablet and a VR headset, these approaches could be applied to other hardware. For example, the touch device could be replaced by a smaller tablet such as an iPad. This would extend awareness difficulties, as the tablet would be harder for two people to view. A VR headset could be replaced by an augmented-reality (AR) headset, such as Microsoft's *Hololens* product. This could allow the VR player to be more aware of the tablet player's actions; however, current AR headsets obscure the eyes of the wearer, and so awareness cues would still be required.

5 Conclusion

In this paper, we have explored an asymmetric implementation of a house decorating mini-game, using a touch tablet and a VR headset. We described a set of interaction techniques to support non-verbal communication between the two players. These interaction techniques support equitable collaboration in which both players can take the lead. An informal study revealed that players were able to carry out an interior design task using this asymmetric collaboration, and that they understood and used the widgets supporting communication and group awareness. Opportunities for improvement were identified, such as the use of gaze detection and tracking of the finger above the table, but the lack of these features did not inhibit the players from completing the task.

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