BlockTower: A Multi-player Cross-Platform Competitive Social Game

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BlockTower: A Multi-player Cross-Platform Competitive Social Game

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Abstract This research aims to explore the usability and gameplay experiences of a two-player game across three platforms. The game is based on a variation of the board game Jenga—a game played in social, casual settings. Our game requires spatial, tactical, and mental reasoning from players to win and consists of a tower of blocks piled on top of each other. Players take turns to remove one block at a time from the tower then place it on the top of the tower; the game ends when at least one block of the tower falls to the ground—the losing player is the one whose turn caused this fall. The game can be played by two players simultaneously through the use of virtual reality head mounted displays (HMD) like the Oculus RIFT or HTC Vive, two separate mobile tablet devices, or a shared television (TV) display. The first two platforms provide players with their own independent views of the game, whereas the third platform allows the players to use one single screen. This research is an attempt to better understand how virtual reality and mobile technologies can support multiplayer gaming experiences when gamers are engaged in a competitive casual game.

Keywords Virtual reality · Head-mounted displays · Mobile tablets
Multiuser gameplay · Social gaming

1 Introduction

There has been growing appreciation for the use of virtual reality head-mounted displays (HMD) such as the Oculus RIFT (Oculus Rift | Oculus 2016) and the HTC Vive (Vive | Discover Virtual Reality Beyond Imagination 2016) to enhance and

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add variety to users' gaming experiences (Tan et al. 2015). Due to the technology's rapid development, the types and variety of games that are compatible with HMD are currently limited. In addition, the types of gaming experiences that VR technologies can lead to are still relatively unknown. In this research, we explored the affordances and gameplay experiences of a game designed for two players using VR HMD. We also aimed to investigate differences between the VR experiences and those produced by mobile tablet use and TV use (Lindt et al. 2005), which represent two of the most popular settings for multiplayer casual gaming (Kuittinen et al. 2007). While the large TV setting remains the most common way of playing console games, gaming on mobile tablets has become more mainstream, as exemplified by the introduction of devices like the Nintendo Switch—a console that is also a gaming tablet.

This project explored the three gaming platforms (i.e., VR, mobile tablet, and TV) and their corresponding gameplay settings when two gamers play a competitive casual game. The chosen cross-platform game would have a separate user interface depending on the interaction affordances of each platform (Lindt et al. 2006). To this end, we have developed a variation of the Jenga board game which requires spatial, tactical, and mental reasoning from players to win the game. The original Jenga game consists of a collection of rectangular blocks piled on top of each other, creating a tower of three-block layers (see Fig. 1). Players take turns to extract one block at a time while ensuring that the tower does not become so unstable that blocks fall off the tower. As in the original game, the players need to put the blocks that have been taken out back onto the top of the tower and can place them at any angle that is physically possible so that it is challenging for later blocks to be placed on top. As our game utilizes physics laws, players can use their physics knowledge to place blocks in sophisticated and difficult positions on top of the tower so as to make it challenging for the other player to position blocks during their turn. The game ends when a block falls to the ground. The game allows gameplay via HMD, mobile tablets, or a large TV display. Physical distance between the players is not an impediment as the first two settings allow for remote gameplay.

In this chapter, we introduce our game, BlockTower, and describe how players can play it on each of the three platforms. We also report the results of a study with the game.

2 BlockTower

BlockTower is a turn-based game for two players. Our implementation of the game consists of 18 blocks placed in groups of three to make up each level of the tower (thus, gameplay begins with a tower containing six levels of three blocks each). When it is a player's turn, they need to select a block and take it out of the tower, then place it on the top of the tower. The system calculates if any block in the tower would fall or whether the whole structure is stable enough that no block will fall onto the ground. If a block falls on the ground, the player loses the game. If the tower is stable, the other player takes their turn. The game obeys all laws of physics, besides

Fig. 1 The Jenga game being played by two players. Each player takes turns to remove a block from the tower and place it back on the top of the tower while making sure the tower remains stable. The game ends when the tower or any piece falls to the ground

Fig. 2 The three versions of the BlockTower: (Left) Players wearing VR HMD; (Middle) Players using a mobile tablet each; and (Right) Players sitting in front of a large display

allowing the selected block to float in the air while the player is deciding on where to put it, and can be played with the players being physically next to each other or connected via remote networks. Each of the three technology platforms supports a different type of gaming experience. The VR headsets let the player be immersed in the game. The players can change their views of the game by moving their heads up or down, left or right, and closer or further. When players play using a mobile tablet, they need to use the touch capabilities of the device's display to interact with the game elements. In contrast with the VR goggles and tablets where each player has an independent view of the game, the large display platform provides a shared screen on which both players see the same display. However, when players who are using the mobile platform are physically close together, the tablets can be seen as semi-independent as each player can choose to let the other player see their device display. Finally, the controls for the VR and large display platforms are based on an Xbox controller (Fig. 2).

3 Experiment

3.1 Design, Apparatus, and Participants

We conducted a study to examine the usability issues and gameplay experiences of the game on the VR, mobile tablet, and large display platforms. In all three versions, the ray casting technique where the player casts a ray at a point on the two dimensional (2D) display to indicate an object in the three dimensional (3D) scene (Liang and Green 1994; Hinckley et al. 1994) is utilized for block selection. Although the technique is limited in its distant object interaction capabilities (Pierce et al. 1997), it is sufficient for achieving precise results. In our implementation, the ray casting method varied in each version based on the display type. For the VR and large display versions, the ray casting point was indicated by an onscreen cursor as visual feedback. The point cursor was chosen to ensure fast selection times with low moving footprints (Vanacken et al. 2007). In the mobile version, the ray casting point was directly determined by where the player's finger tapped on the screen.

In the VR platform, participants each wore an Oculus RIFT CV1 HMD, which was connected to a computer running an i7 @ 2.7 GHz with 8 GB of memory and a GTX1070 dedicated graphics card. During each player's turn, a ray was cast from the center of the view to generate a cursor on the surface of the first target object (see Fig. 3).

When the cursor became attached to the surface of a target block, clicking button "A" (see Fig. 3, Left) on the game controller would shade that block red to indicate that it had been selected. When a block was selected, it could then be moved forward/backward/left/right (along the X and Z axes) with the use of the left joystick (up/down/left/right) or up/down (along the Y axis) by moving the right joystick (up/down) (see Fig. 4, Right).

The mapping of actions in the game controller control was based on the similarity between the finger movement and the in-game object movements. Note that the selected block would not be affected by gravity in that it would not fall while moved in midair—this was intended for easy manipulation. After deciding where to put the selected block (and hence to finish the turn), the player would need to press the "A" button again to deselect the block, after which the influence of gravity would be restored and the block would ideally fall onto the top of the tower and rest on the blocks below it. If no block continued to move or fell to the ground within a certain period of time, this meant that the tower was stable and that the other player would be able to start their turn (see Fig. 5). No matter which player's turn it was, both players could change their viewing angles and viewing distance by moving their head or walking around.

Each participant in the tablet platform group used an 8 in. NVidia Shield with 1920×1200 multi-touch screen resolution, 2 GB of memory, and a 2.2 GHz processor. For this platform, participants played by making gestures on the touch display. One finger tap was used for selecting and deselecting blocks according to the ray casting technique (see Fig. 6).

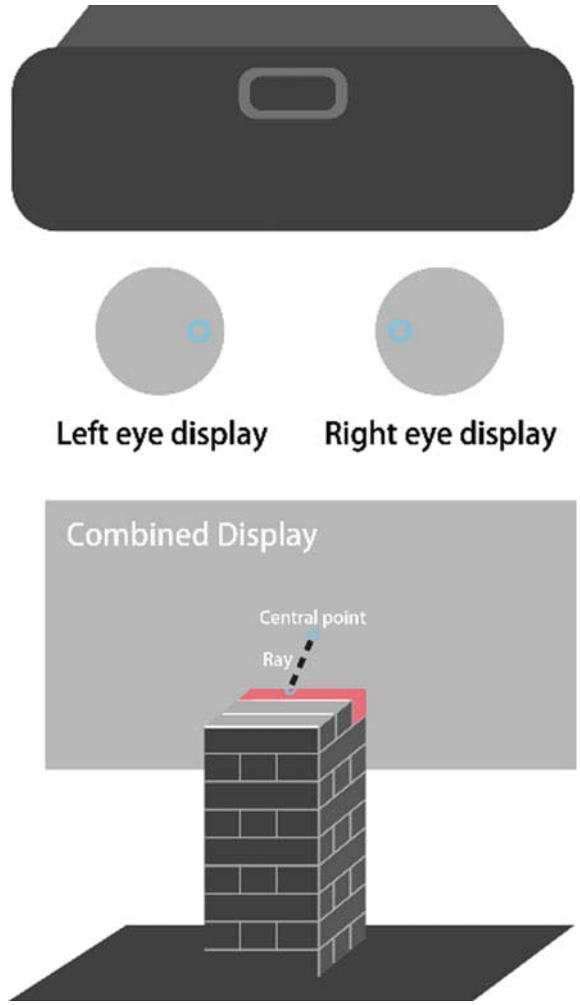


Fig. 3 The ray casting technique implemented in the Oculus and similar VR HMD

The other gestures were designed based on three principles. First, continuous finger position (i.e., dragging) for control mapping was used to maximize performance—this was based on previous research (Zhai 1998). Additionally, other gestures were designed based on their similarities to the transformation of 3D objects in games (Rekimoto 2002). Finally, as recommended in the gestural patterns provided by Remi Brouet for surface interactions (Brouet et al. 2013), the number of touches detected on the screen was used to distinguish ambiguous manipulations and to link associated gestures to actions (see Fig. 7, Right).

In other words, during a player's turn, tapping on the screen would cast a ray from the tapped position and the first block hit by the ray would be selected and freed from gravity. To manipulate the selected block, two types of gestures were possible. By

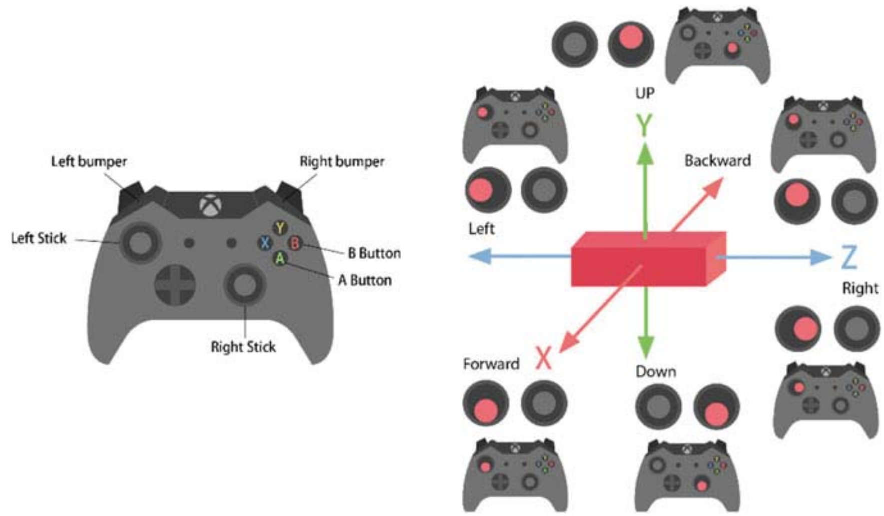


Fig. 4 (Left) A typical modern game controller; (Right) How to move the selected block along the X, Y, Z axes

dragging with one finger, the block could be moved forward/backward/left/right (in the XZ plane) based on the drag direction, while using two fingers to drag up/down would make the block move up or down (along the Y axis) (see Fig. 7). To compensate for the weakness of the ray casting selection technique regarding distant objects (Pierce et al. 1997), tapping anywhere else on the screen would deselect the block and restore its gravity.

As in the VR version, if none of the blocks moved or fell within a certain period of time and the tower became stable, the other player would be able to start their turn (see Fig. 8 for a sample sequence of actions). Although players were still allowed to alter their viewing distance using the two-finger pinch gesture or rotate their view around the tower using the two-finger rotate gesture, their viewing angle became fixed when their turn was over.

Finally, a computer with the same configurations as used for the VR setting was employed in the large display setting. In both the VR and large display settings, participants controlled game elements using Xbox game controllers, as opposed to the tablet version where touch gestures on the display were used as input.

Using the ray casting technique, we placed an onscreen cursor on the shared display. The cursor was controlled by the left joysticks of both players' game controllers. However, only the player whose turn it was would be able to control the cursor; the other player had to wait for their turn to gain the control. The basic controls were a combination of the VR and mobile versions' controls. By clicking the "A" button, a ray would be cast from the cursor position and the first block hit by the ray would be selected and freed from gravity (Fig. 9).

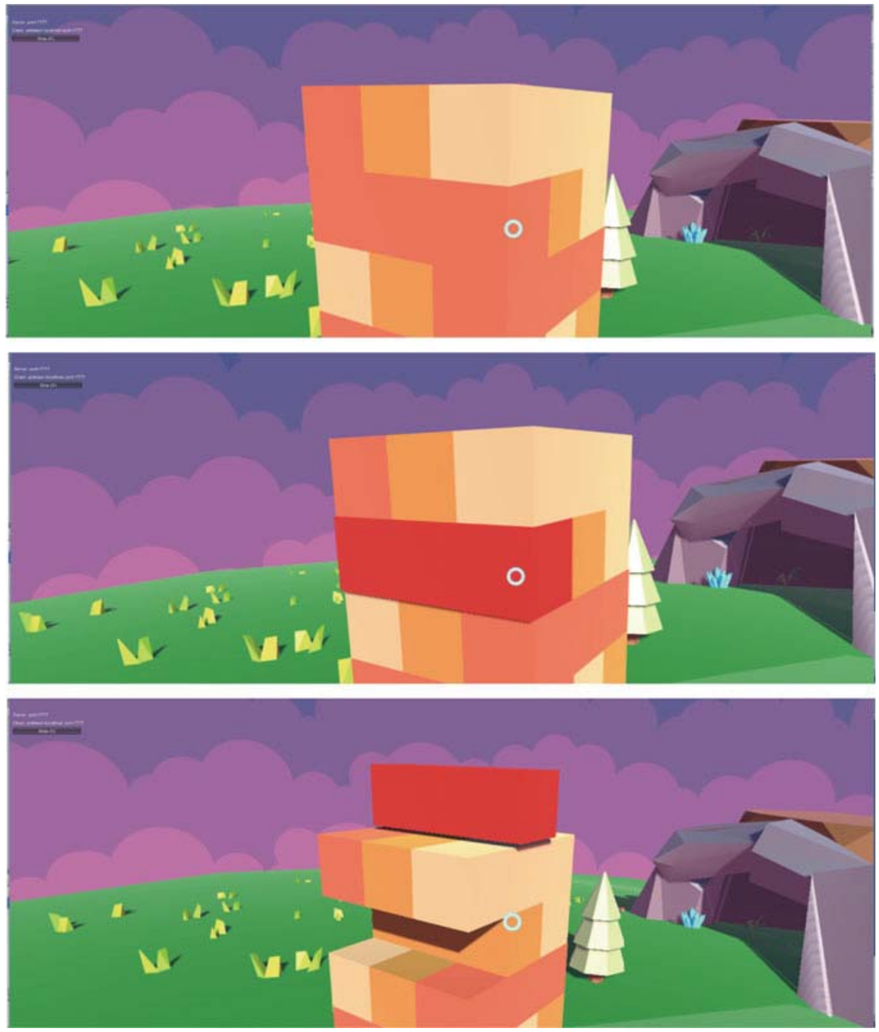


Fig. 5 Screenshots of a sequence of actions: (Top) The cursor represented by the blue circle positioned on a block to be selected; (Middle) The selected block highlighted in red; and (Bottom) The selected block moved and placed on top of the tower

To move a selected block forward/backward/left/right (along the X and Z axes), the player would need to trigger the left joystick (up/down/left/right). On the other hand, by triggering the right joystick (up/down), the player could move the block up/down (see Fig. 10).

Blocks could be deselected and the turn would be ended by clicking the “A” button. If none of the blocks moved or dropped within a certain period of time and the tower remained stable, the other player would be able to start their turn. Regardless of

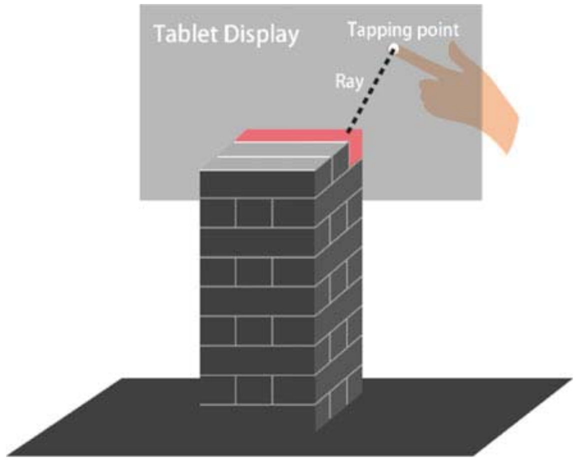


Fig. 6 The ray casting technique implemented in mobile tablets. Touching a block to enable selection

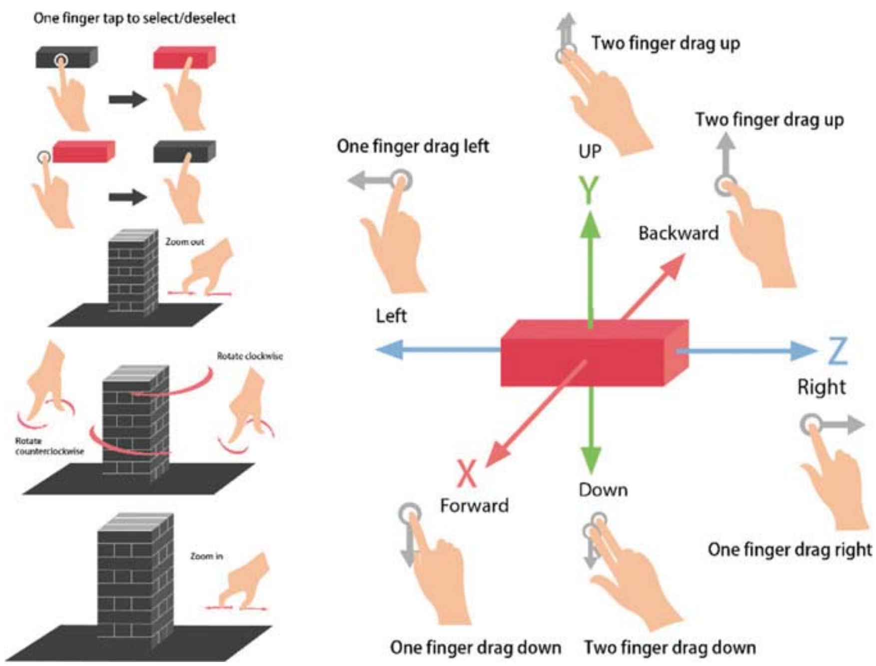


Fig. 7 The gestural set used in our tablet implementation of the game

whose turn it was, both players were only allowed to rotate their view around blocks clockwise/counterclockwise by clicking the "Left bumper/Right bumper" buttons (see Fig. 11).

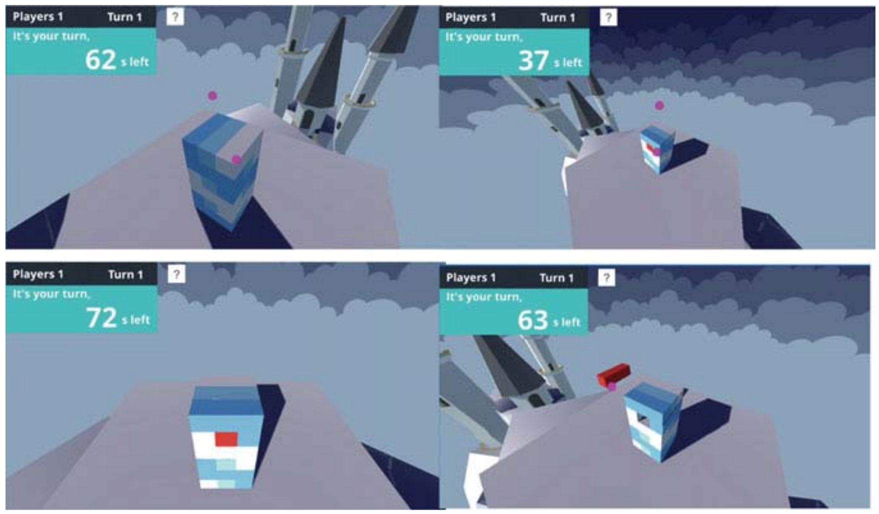
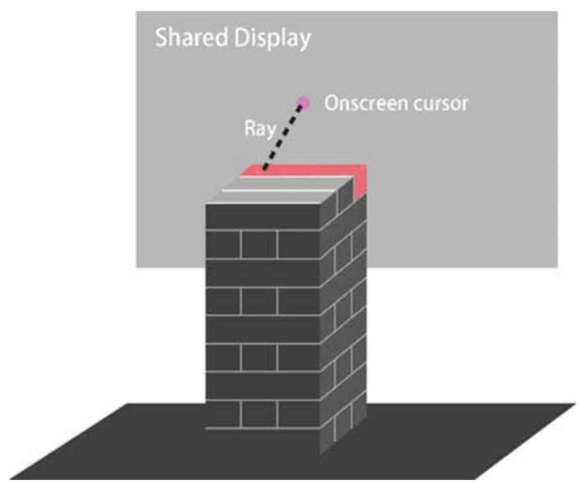


Fig. 8 Screenshots of a sequence of actions in the tablet version: (Top) zooming in and out to find a block to select and move; (Bottom) the selected block being moved with the view of the tower rotated

Fig. 9 The ray casting technique based on a screen cursor implemented in large display version



Six pairs of students (all males with an average age of 23) from a local university participated in our experiment; two pairs interacted with each platform. They were given some time to practice and become familiar with the systems, devices, and controllers. Each pair was asked to play the game twice. During the process, we recorded the following:

- The time between the start of a player's turn and when a block was selected (Selection time).

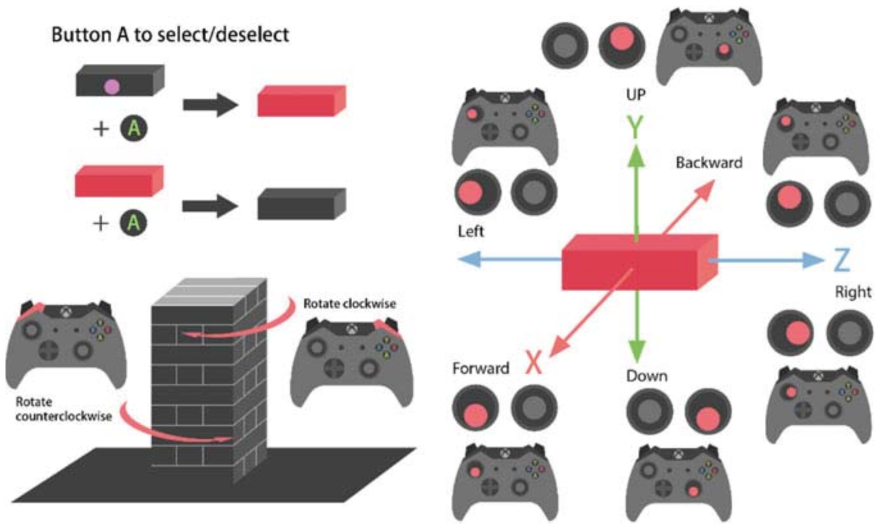


Fig. 10 The possible actions in the large display version

- The time between the selection of the block and when the block was deselected (Moving time).
- The result of each game (the total number of turns and each players' number of turns when the game ended, who won/lose/tied the game).

In addition, we collected the players' subjective feedback after gameplay.

3.2 Results and Discussion

Figure 12 summarizes the results of this study. The two pairs who used the VR platform made more moves and took a longer time to select and move blocks, especially in the second trial. The mobile tablet pairs made the fewest moves and spent an equal amount of time on each trial. Finally, the large display pairs sat in the middle in terms of numbers of moves, while they spent significantly more time in the second trial than in the first, similar to the VR groups.

Based on the number of moves, it would appear that the VR version enabled better gameplay experience. Players were better able to assess the blocks' positions and the overall stability of the tower. They were able to add more blocks taken out from the tower to the top while ensuring the blocks did not fall. From their subjective feedback, participants commented that they liked the immersive experience of the VR HMD. Beyond immersion, they also enjoyed the flexible viewing angles that could be achieved with relative ease—e.g., by simply walking around and moving their heads slightly. In other words, players were able to use more of their body parts

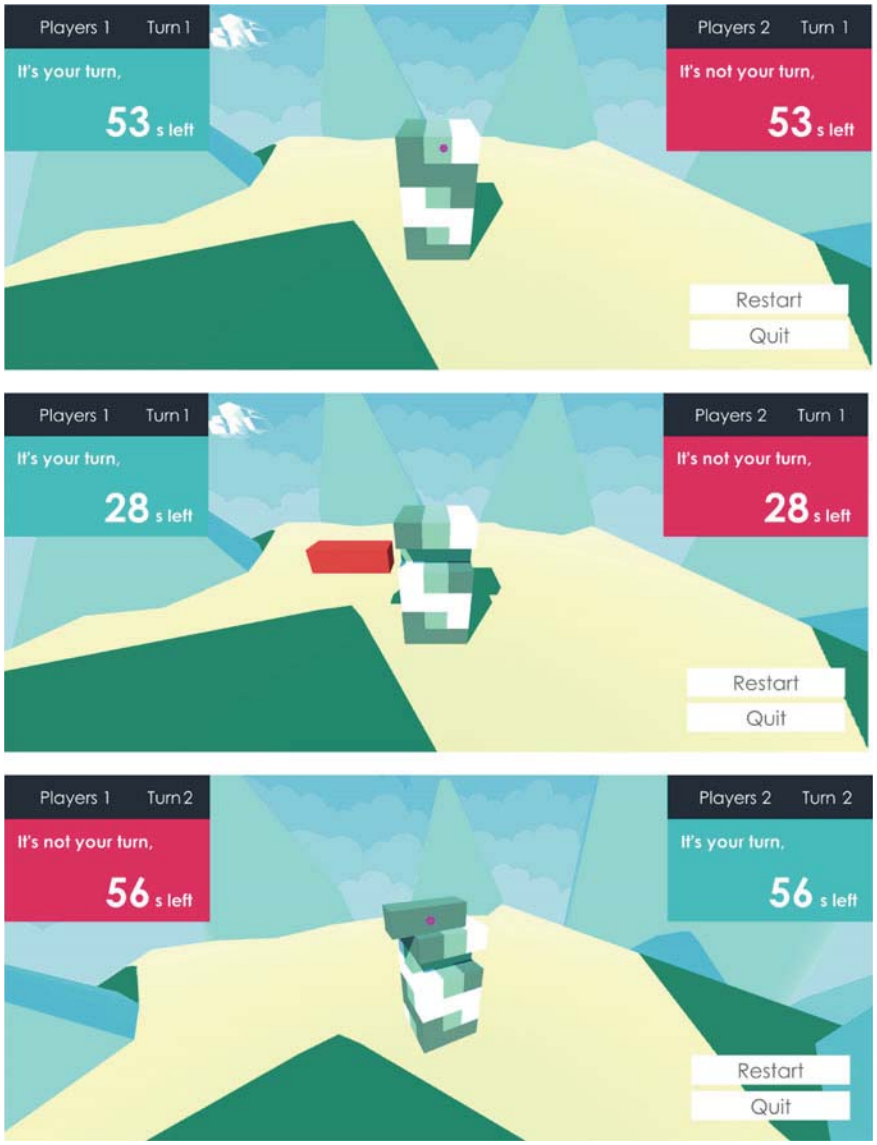


Fig. 11 Screenshots of a sequence of actions in the large display version: (Top) Selecting a block; (Middle) Moving a selected block out of the tower; and (Bottom) Placing it on top of the tower

and distribute the actions in ways that enabled them to see more details more easily and naturally.

Participants in both the tablet and large display versions had almost the same number of moves. However, they differed in terms of selection and movement times.

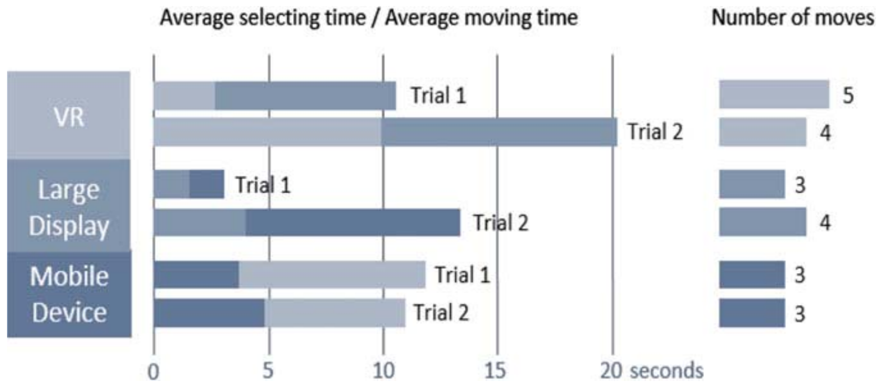


Fig. 12 The results of our study showing the number of moves and the average time taken for each move

In the tablet version, these two times were similar. We observed that given the small size of the display, participants had to spend more time looking carefully at which block to select and (once selected) where to place it so that the tower remained stable. Participants said they liked the variety of gestures and that they felt the gestures were natural to use. However, they also said that the gestures were not very precise and that at times they were not able to manipulate the blocks in the ways they wanted. On the other hand, they mentioned that the tablets allowed them to sit and move around freely, and players felt relaxed when playing. They also said that it was fun to see how the other player interacted with the game and find out their thoughts and strategies. Players said that at times they shared laughs and talked with each other about what the outcome of a move would be and did not feel that they wanted to compete with each other. When we showed them the VR version, they said that it would not be possible to see the facial and body expressions of the other player and this would not be as '*fun*'. They also said that it would result in them being more competitive. On the other hand, they said that they liked how the VR version allowed players change perspectives easily by walking around and/or moving their heads to get a closer look at the tower.

Participants liked the large display platform because of the single shared view and the ability to play while sitting next to the other player—this increased their enjoyment of playing. We observed this group of participants laughing the most and were actually trying to participate in the other player's turns as all the controls were taken over by one participant at a time. In comparison, in the VR and mobile versions, participants were able to view the blocks from different angles and think about their next move during the other person's turn, since the players had separate game displays. Like for the tablet platform, respondents desired greater flexibility in how they could change viewing perspectives—changing of perspectives was easier with the VR HMD where users only needed to turn or move their heads back-and-forth.

When playing the game wearing the VR HMD, participants appeared to be more focused on the game than the players in the other groups. This was another reason VR participants were able to make more moves, as they were competing and wanted to win. In fact, they barely talked with each other, though this was understandable as it was not possible for the VR participants to see each other. The other two groups (mobile and large screen) felt that they were playing the game more for pleasure than competition.

4 Summary and Future Work

In this project, we explored the usability issues and gameplay experiences of a multi-user casual, competitive game across three platforms: VR HMD, mobile tablets, and a large display. To this end, we developed a game based on the Jenga game but increased its complexity to make it more engaging and tested the game on 12 participants. We found that although all participants found the game engaging, they highlighted some positive affordances and features of each platform as well as elements that could be improved. In the future, we will use this feedback to improve the game's elements and expand its possibilities. For example, the current version can only be played by two players at a time, but this can be increased to a larger number of players. We intend to run more comparative studies to discover further ways of making these types of games enjoyable and engaging, specific to the various platforms available.

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