Validating Test Chambers to Study Cooperative Communication Mechanics in *Portal 2*

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Abstract  
Cooperative communication mechanics, such as avatar gestures or in-game visual pointers, enable player collaboration directly through gameplay. There remain open questions about how players use cooperative communication mechanics, and whether they can effectively supplement or even supplant traditional voice and chat communication. This paper describes a future study to investigate player communication in *Portal 2*, and chronicles the design and validation of test chambers for the study.

Author Keywords  
Game analysis; cooperation; communication; experimentation.

ACM Classification Keywords  
H.5.3 [Group and Organization Interfaces]: Computer-supported cooperative play.

Introduction  
Cooperative communication mechanics (CCMs) enable players to exchange information and play together through interaction with the game, rather than voice or text chat [10]. In addition to common features such as voice chat [12], many games provide CCMs, which may support or even supplant their traditional counterparts. The co-op
mode of Portal 2 [11] features built-in CCMs: ping tools and avatar gestures. The ping tools allow players to point out specific locations within the virtual environment or synchronize activities through the use of an on-screen timer. Avatar gestures enable players to express themselves effectively, provided that they are within view of their teammate [4, 14].

Our future research will evaluate players’ use of CCMs in Portal 2. Our principal hypothesis is that players will perform best with access to a combination of voice communication and ping tools; and that when used in isolation, ping tools will outperform voice communication. A secondary hypothesis is that players who are more familiar with one another will perform better. This research will focus on understanding which communication methods (voice, CCMs) are most frequently used, how effective CCMs are in the absence of regular voice chat, and how players develop communication. The present paper discusses our planned study design; chronicles our design of custom cooperative levels, or test chambers; and evaluates their difficulty.

Background

Cooperative Communication Mechanics

Multiplayer games can be either competitive or cooperative. In competitive games, players work against each other, while in cooperative games, players create strategies together as a dyad or team [15]. Game mechanics are designed player decisions, structured by game rules, that advance the player(s) toward an outcome [6].

Many cooperative games offer the opportunity to use game mechanics to share information and coordinate action without using voice or text chat; these are cooperative communication mechanics [10]. Because they are game mechanics, players actively make decisions about when and how to engage CCMs to advance the game. The present research investigates what Terrell identifies as forced cooperation, where players are required to undertake interdependent actions to succeed [9], for which CCMs and voice communication should be essential for coordination.

Portal 2

In the cooperative mode of Portal 2 [11], two players work together to solve puzzles in a first-person perspective using the portal gun core mechanic. The portal gun allows a player to create two linked portals, openings through which players and objects can instantly pass. Players have to shoot at least twice, using each of two portal-firing triggers, to specify the two portal locations. A player can replace either portal by firing again with the same trigger at a new location. Players must avoid hazards and manipulate a growing number of puzzle elements and mechanics, such as moving blocks through portals to land on pressure plates, in order to find and reach the exit of each test chamber (level). Players coordinate their actions using ping tools, avatar gestures, and traditional voice and text chat.

Portal 2 CCM: Ping Tools

In Portal 2, the cooperative ping tools [5] are attention-focusing CCMs [10] that enable players to indicate a location in the virtual environment. There are two ping tools, the look ping (Figure 1) and the timer ping (Figure 2); these designs support Wong and Gutwin’s design implications for successful pointing in virtual environments [13].

The look ping (Figure 1), an unbound attention-focusing CCM, is used to direct the focus of one’s partner, serving to grab attention, provide instruction for portal placement, identify where an avatar should stand, or other purposes. Because it is unbound, it carries no information other than to direct the other player’s attention; further
disambiguation requires other means of communication or an established meaning.

Wong and Gutwin recommend that deictic pointing gestures be held long enough to establish mutual understanding [13]. The look ping design leverages this data: it persists for several seconds in the environment and players' head-up displays (HUDs) after being fired. If the ping is off-screen, an indicator appears at the edge of a player's screen to inform them of its relative location.

The timer ping (Figure 2), a semantically imbued attention-focusing CCM, enables players to synchronize their actions. Many puzzles require this level of precision, for example, simultaneously pressing a pair of buttons to open a door. The timer ping functions similarly to the look ping, except that the indicator is imbued with semantics: a three-second countdown shown on the indicator that concludes with “GO”. The exact nature of the action taken at the end of the countdown must be otherwise coordinated by the players, although it is frequently obvious when directed at specific game elements that afford synchronized action.

**Portal 2 CCM: Gestures.** In co-op mode, Portal 2 includes several expressive CCMs [10]: individual and cooperative gestures (Figure 3), such as facepalm, thumbs-up, dance moves, or a cooperative high five. These can be used to grab a player’s attention, convey information about the outcome of an event, or express emotion.

**Future CCM User Study**
The goal of the present research is to understand the effectiveness of CCMs. The study aims to examine the use of available CCMs and analyze participant data to understand the impact of CCMs in gameplay. This work will also help to understand how CCMs enhance playability, and which CCMs are the most effective and efficient. We will also investigate the effect of players’ relationships on communication and gameplay. We will study any appearance of emergent CCMs [10], new ways in which players use their avatars to communicate.

There exist a number of CCMs across many games. Prior research has investigated player performance and enjoyment in cooperative games that lack communication ability, finding that the structure of game mechanics can enable coordination without explicit communication [1]. The collaboration and coordination of multiplayer teams, where performance is critical, has also been studied extensively [2, 8, 12].

We have chosen Portal 2 for this study for two reasons: its cooperative game mode and its CCM UI. Portal 2 features a forced cooperation game mode, in which players are required to collaborate and play together through intimately intertwined game mechanics. In many situations, all four portals (two portals for each player) must be placed in specific places, with players using them at precise times. To collaboratively enact a successful strategy, it is essential that players inform each other regarding portal location and timing. Portal 2 also incorporates CCMs directly into its controls. As we have noted earlier, the CCMs are well-designed in accordance with current research in virtual environments.

To understand player use of CCMs, we will undertake an observational study of Portal 2 gameplay with custom levels in which we manipulate access to CCMs and voice communication. The study will be a 3 × 3 within-subjects design, varying test chambers and access to CCMs (voice and CCMs, voice only, CCMs only). The study will involve audio and video recording, from which we will extract data.
including level completion time, number of portal gun uses, and how players communicate with each other. We will also use Seif El-Nasr et al.'s video coding scheme [7] to understand cooperative performance.

Since Portal 2 is an exceedingly popular title, we have developed custom test chambers to ensure that players have not previously experienced the puzzles in the study. According to Linehan, the pace at which challenges are introduced impacts enjoyment, apparent difficulty, and players' ability to learn from gameplay [3]. Thus, the presented levels are designed to be of overall moderate difficulty, which we test in the present validation study. This is intended to prevent overwhelming novice players, while still providing interesting content to more experienced individuals.

Test Chamber Design and Validation
The goal of the project is to understand the impact of CCMs on player performance. The original levels in Portal 2 are designed to slowly increase in complexity; for our purposes, it is necessary to design puzzles that are accessible to beginners but are complex enough to inspire communication between players. Control over the content of the levels is necessary to create a consistent stimulus for hypothesis testing. Further, many potential test subjects will have already solved puzzles present in the original levels, necessitating the creation of custom test chambers. Thus, the present validation study uses the hypothesis that, for good, moderate-difficulty test chambers, perception of difficulty should be inversely proportional to player skill; that is, beginner players should find the designed test chambers hard and expert players should find them easy. Further, valid test chambers will engage players in communication with one another.

Designing and Selecting the Test Chambers
The Portal 2 test chambers used for this study are designed by our team, specifically for use in the study. Before designing the levels, we evaluated the numerous game mechanics from Portal 2, assessing their suitability for moderate-difficulty levels. For example, gel mechanics that require players “paint” the game environment for various effects were eliminated, due to their use requiring a deeper understanding of game physics, while mechanics involving moving blocks onto pressure plates were included.

Initially, a total of nine test chambers, three per designer, were created. Test chambers were made using the Level Editor tool available in the Portal 2 game package.

All nine levels were played and tested by the team members, all of whom possess at least intermediate Portal 2 skill (see Table 1), to provide elementary screening of playability, communication requirements, and bug-testing. The primary criteria for selecting the levels was based on a level’s ability to generate conversation between players. Out of the nine levels, the team shortlisted three levels, shown in Figure 4, which were considered to be of moderate difficulty and required communication for success. These levels were used in the validation study.

Participant Selection
The validation study was conducted with three pairs of players, one pair each of beginners, intermediates, and experts in playing Portal 2. While in the CCM study, we expect a range of expertise levels, for the validation study, participants were actively recruited with these expertise levels. Expertise was differentiated on the basis of familiarity with the game, described in Table 1.

Participants selected for validation of the levels were all over 18 years of age. Three pairs of players were invited to

| Beginner | never seen nor played Portal 2. |
| Intermediate | has played Portal 2, but not all levels. |
| Experts | has played all official levels of Portal 2. |

Table 1: Portal 2 levels of expertise.
participate. The first pair were beginners, one female (age 35) and male (age 37). The couple is married, and have known each other for over 18 years. The intermediate pair were two males, both age 27, and have known each other for less than a year. The advanced group were two friends one male and other female, age 24, who have known each other for two years.

Validation Methodology
Each pair of players played each of the three levels in the order A, B, then C (Figure 4), and played in the same room. The pairs were given a maximum of 40 minutes to complete each test chamber. All CCMs were made available to players during the study. We observed players’ interactions during the game and noted the amount of time they needed to complete the test chambers. At the conclusion, we asked the players to rate the difficulty of the levels on a scale of 1 to 10 (10 being the most difficult).

Validation Results
While the expert and intermediate teams finished all test chambers; the beginners were only able to complete Test Chamber A, they ran out of time for B and C. Table 2 describes the ratings provided by each player of each test chamber, split out by expertise.

<table>
<thead>
<tr>
<th>Test Chamber: Expertise</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginner</td>
<td>(8, 9)</td>
<td>(7, 10)*</td>
<td>(9, 10)*</td>
</tr>
<tr>
<td>Intermediate</td>
<td>(5, 6)</td>
<td>(6, 7)</td>
<td>(5, 6)</td>
</tr>
<tr>
<td>Experts</td>
<td>(1, 1)</td>
<td>(4, 3)</td>
<td>(2, 2)</td>
</tr>
</tbody>
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Table 2: Player ratings of test chamber difficulty by expertise level. Participants of lower skill found the test chambers harder than experts, as expected. Starred entries indicate that the team was unable to complete the test chamber in 40 minutes.

Per the data shown in Table 2, the beginner-level players found all three custom levels to be extremely difficult. The intermediate-level players rated the three levels as moderately difficult, whereas the expert-level players rated the levels as very easy. These results are in tune with our initial hypothesis, where we assumed that level-rating is a function of player experience levels.

In the observations of the validation study, it was also noted that players in all three tests made extensive use of communication tools, primarily speaking to one another. Use of the ping tool was also frequent. Therefore, we conclude that the designed test chambers will require a good amount of communication between the partners, making them suitable for the later CCM user study.

Conclusion
We are working to advance an understanding of players’ in-game use of cooperative communication mechanics to support more engaging game design, as well as learning through gameplay. Open questions remain about exactly how CCMs support play, and how they can support or even supplant voice communication. The present research describes a future study of CCMs in Portal 2 and our development and validation of custom Portal 2 test chambers. For the study to work, it is essential to provide interesting and new test chambers that will challenge players without overwhelming them.

As future work, we will perform the described study on analyzing and understanding the use of CCMs in Portal 2. We aim to identify the most effective, fun, and expressive ways in which players communicate in-game by observing and analyzing how players handle the challenges under specific communication conditions. It will be also interesting to see if players develop their own emergent
CCMs. We expect the outcome of the present research agenda to be useful for both researchers and game designers.

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