

Best Practice for Co-op Puzzle Design

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Abstract – Co-op puzzle game is a game genre allowing two players to work together to solve puzzles. Both puzzle games and joint co-op games emphasize non-competitive gameplay, so this thesis discusses the best practices and methodologies to effectively design cooperation puzzle games. The artifact is described as a co-op level within Portal 2. This level contains some different solutions or methods for co-op puzzle design.

Key Words – Puzzle Design, Non-competitive Gameplay, Cooperation, Communication, Balance

I. INTRODUCTION

Puzzle game is challenging but not competitively hard for the players. It requires the player to stop, observe, think, and then make decisions. Joint co-op game is also a similar genre that both players are cooperating to defeat enemies, achieve challenges or solve puzzles. This does not include adversarial co-op titles where the players play together but have the option to compete for points and hinder each other, like *New Super Mario Brothers*. Neither does it include versus titles where players compete against each other, like *Street Fighter*, or other types of multiplayer titles.^[1]

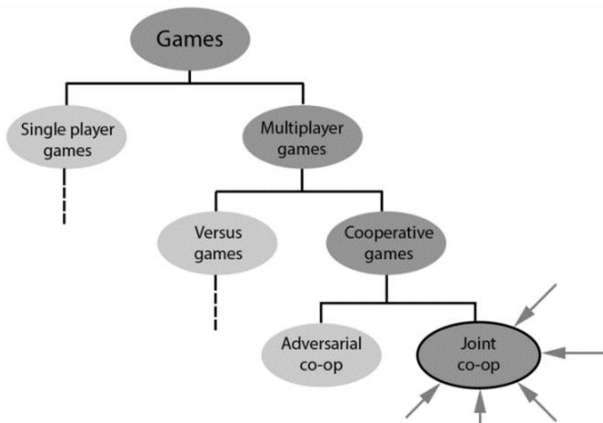


Figure 1-1 General Game Categories

It's difficult to craft an engaging experience for the players when designing a co-op puzzle game because good puzzles are usually logical and brain-burning, however, joint co-op games are more experiencing and relaxing. Therefore, to keep a balance of challenging and engaging for co-op puzzle games, a set of rules and best practices needs to be manipulated.

II. RESEARCH

A. Co-op Puzzle Game Examples

I started my research by playing some successful co-op puzzle games. I looked to see how they set up roles for both players, how they presented the objectives, and how they design the mechanics and puzzles. The four games used for research: *Brothers: A tale of two sons*, *Biped*, *Tick Tock: A tale for two*, and *Portal 2 Co-op Mode*.

Brothers: A Tale of Two Sons is a unique twin-stick adventure game with a suite of painfully personal and unique stories and dual-action puzzles.^[2] To complete various puzzles, the players progress by manipulating the two brothers either at the same time, which tests their trust and harmony or in a certain order, which tests their logical thinking.



Figure 2-1 Gameplay Moment in *Brothers: A Tale of Two Sons*

Biped is a cute and genuinely inventive physics-based co-op adventure that offers plenty of engaging and unique puzzles for those who can get a handle on the game's control scheme.^[3] The players control the robot's two legs using two and perform various moves—from simple walking and sliding to more advanced actions, like operating machinery or cutting wood. In this game, we find many puzzle scenes requiring the players to act at an exactly correct time. Communication and coordination to conquer challenges together play an important role in solving these puzzles, which is very different gameplay from *Brothers: A tale of two sons*.



Figure 2-2 Gameplay Moment in *Biped*

Unlike *Brothers: A Tale of Two Sons* and *Biped*, *Tick Tock: A tale for two* has a totally unique gameplay style because it contains two physically isolated scene scenes and requires the players to combine the information on both sides to understand the narrative and solve the puzzles.^[4] Communication becomes a must in this game.

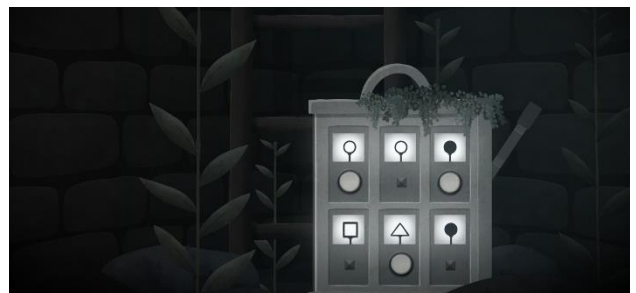


Figure 2-3 Gameplay Moment in *Tick Tock: A tale for two*

Portal 2' co-op mode is one of the best examples of co-op puzzle design because it provides various gameplay and contains all the three elements in the previous game examples. [5] In some levels which provide limited resources, the players must share their talent to manage such as cubes, portal walls to find the intended solution. However, in some levels which require a simulated acting moment, the gameplay varies from a puzzle-solving to a timing action.



Figure 2-4 Gameplay Moment in *Portal 2*'s Co-op Mode

Based on my discovery, *Portal 2* is the most flexible tool I can use to implement different co-op design patterns explore their success.

B. Theoretical Research

To make co-op gameplay engaging, we need to emphasize the balance between two players and encourage them to communicate, collaborate and build trust. In "Using Design Strategies to Create Engaging Co-op Puzzle-solving Gameplay"[6], Xiao Wei introduces 5 design patterns for co-op games. There is also a detailed explanation in the article "Game Design Patterns for Collaborative Player Interactions"[7]. Based on those research, three of those patterns are significantly important as the foundation of co-op puzzle gameplay. They are concurrency, parallelization, and separation.

Pattern	Description
Serialization	Operating one or more objects in a certain order that could not be operated by a single player alone
Parallelization	Operating one or more objects simultaneously that could not be operated by a single player alone
Separation	Forcing the players to split up and pushing them to go ahead without physical teammates nearby

However, there several common problems with co-op game design and possible solutions in this article. Tanya Short, a senior gameplay designer at Funcom, saw the five main problems facing cooperative game designers. [10] We will also address them and discuss possible solutions in our best practices.

The five problems she brought are:

- Knowledge Mismatch
- Skill Mismatch
- Public Humiliation
- No Protagonist
- Jerks

Meanwhile, to make it a good puzzle, we still need some theories from general puzzle design, Herman Tulleken claims a best practice for puzzle game games in the article "How Are Puzzle Games Designed". [8] In his theory, a good puzzle should own at least these three common features.

- has clear **rules**.
- has a clear **objective**.
- finds the **balance** between too easy and frustrating, to make an interesting challenge.

Combining the above research, we can come up with a four-staged best practice theory for co-op puzzle design. It is based on and integrates rules for puzzle design and contains the three co-op design patterns.

III. METHODOLOGY

Section A: Three design patterns for co-op puzzle

1 **Serialization gameplay requires players to take roles and test their skills in collaborative puzzle solving.**

In a serialization gameplay moment, the players are operating one or more objects in a certain order to make progressions step by step towards their final goal. They usually have clear role divisions on their tasks, such as the pitcher and the catcher in baseball sports. In the real world, it is also a serialization moment if person A is holding a door to ensure person B can walkthrough.



Figure 3-1 Serialization example in real life [11][12]

Serialization gameplay a classic and foundational method in co-op game moment design. To create a serialization moment, we divide the sequences into trunks and make sure they cannot be done by a single player. We also create good feedback and clear sub-goals for the progressions they achieve. In this way, both players are contributing to understanding the mechanics and solving the puzzle.

2 **Parallelization gameplay is a good way to test the consistency between players, which requires a huge amount of trust and chemistry.**

Parallelization gameplay usually refers to a condition that players work on solutions to speed up for the objectives, such as Canoe Double in the Olympic Games. The goal of this theory is to test the abilities of their working harmony.



Figure 3-2 Parallelization example in real life [13]

To do this, we must have a very clear goal that allows the players to make efforts on acting but not on thinking. For example, both operate buttons /switches at the same time or move/ jump on a movable platform, it is an accomplishment only when they act at the correct time. The better they consistent, the closer they achieve the goals.

3 Separation gameplay tests the complementary between players, which allows them to take roles, share information, and think independently.



Figure 3-3 Separation example in real life [14][15]

Separation gameplay is a very effective way of getting rid of knowledge mismatch problems. By splitting the resources and separating the two players into different physical spaces, we provide a chance for them to take different roles. They are aimed to find clues by themselves and share unique information. Like the coordinator and the ambulance driver in 911 emergency assistance, each takes advantage of their resources and abilities to contribute to their final goal.

Section B: Four Staged Best Practice Theory

Stage 1. Create a serialization gameplay moment.

- Divide the puzzles into chunks and make them impossible for one player.
- Set clear goals and feedback for each step.

Stage 2. Use spaces and tasks to create multiple gameplay.

- Separate tasks to create parallelization gameplay which requires the players to work well consistently.
- Separate spaces to create separation gameplay which requires the players to communicate well in a complementary way.

Stage 3. Design "wow" moments

- Create puzzle catches in serialization gameplay.
- Add puzzle challenges in parallelization gameplay.
- Design reunion moments after players being separated for a period.

Stage 4. Balance the gaming experience.

- Split tasks for players, do not let them wait.
- Split information for players, let them talk.
- Have engaging cooperative tasks for players.

IV. LEVEL DESIGN PROCESS

We experienced two major milestones in this project, pre-production, and final artifact production. During the pre-production stage, we aimed to discover potential puzzle mechanics which match the design patterns.



Figure 4-1 Preproduction Pipeline

By playing and researching relevant games, we have discovered solutions of three design patterns according to similar mechanics. For example, here is a light bridge moment in Portal 2. To create a serialization moment for this action block, we duplicated the steps and assigned different tasks for players. The main challenge came from how to create restrictions and prevent the sequence

from being accomplishable for a single player. However, to create a parallelization moment, we simply duplicated the goals which required them to operate simultaneously. Figuring out a reasonable difficulty for the challenge was the main challenge we met during action block design.

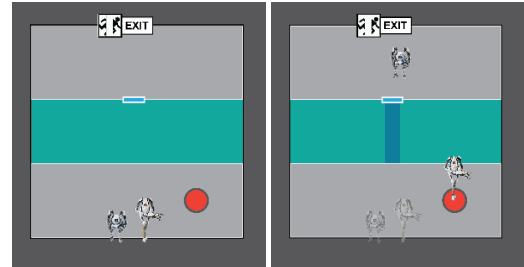


Figure 4-2 Light bridge mechanics in Portal 2 co-op mode

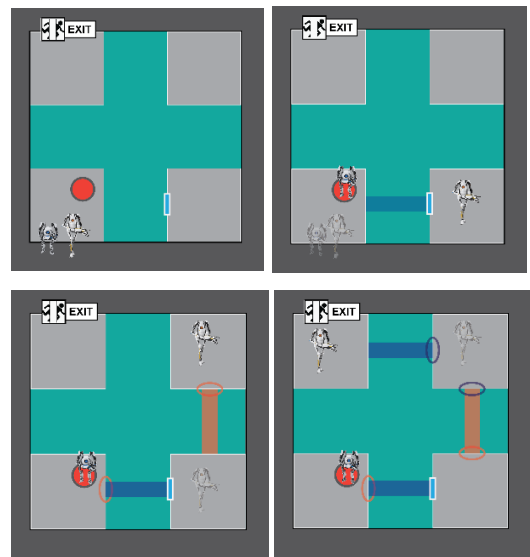


Figure 4-3 Serialization gameplay with light bridge mechanics in Portal 2 co-op mode

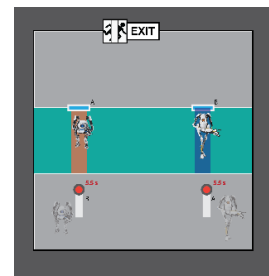
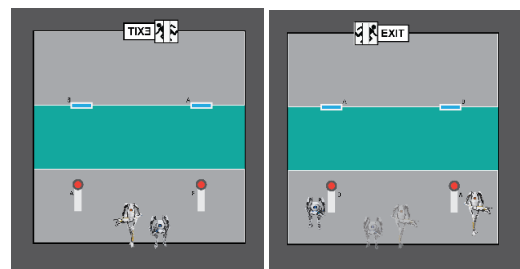


Figure 4-4 Parallelization gameplay with light bridge mechanics in Portal 2 co-op mode

To create a separation moment, we split the resources from the goals and requested players to take roles. The main challenge came from how to provide efficient ways of communication.

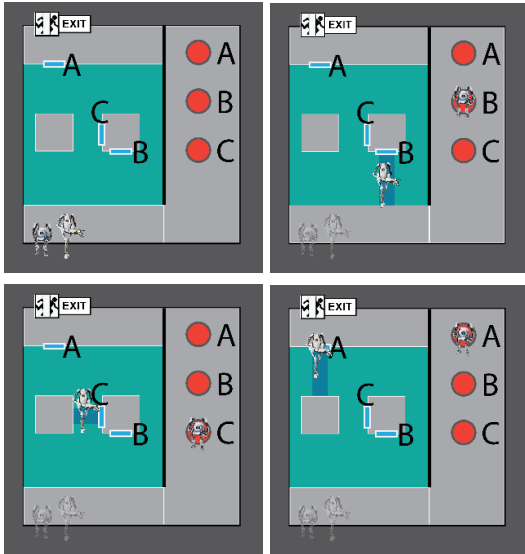


Figure 4-5 Separation gameplay with light bridge mechanics in Portal 2 co-op mode

Using this idea generation, we were able to design many action blocks with raw ideas presenting potential gameplay before starting the final artifact, which benefited the future mechanics related to each design pattern. Following Jolie Menzel’s theory of puzzle design^[8], we designed 9 gameplay chunks and asked 12 players to take a first-pass to playtest. Here is a list of the action blocks and the core mechanics.

ID	PATTERN	MECHANICS / FOCUS
1	serialization	Dual-player puzzle sequences Share space, share information
2	serialization	Dual-player puzzle sequences Multiple spaces, information split
3	serialization	Dual-player puzzle sequences Multiple spaces, share information
4	parallelization	Timing mechanics One time communication
5	parallelization	Timing mechanics A lot of communication
6	parallelization	Timing mechanics Continuous communication
7	separation	Single-player puzzles Some communication required
8	separation	Dual-player puzzles A lot of communication required
9	separation	Dual-player puzzles with different roles A lot of communication required

Figure 4-6 Action Block Design List

We started the production phase after collecting data from the player testers. We recognized both the advantages and disadvantages of certain mechanics implementation and decided to use buttons, laser emitters, beams, and light bridges as our primary mechanics because they fit three patterns well.

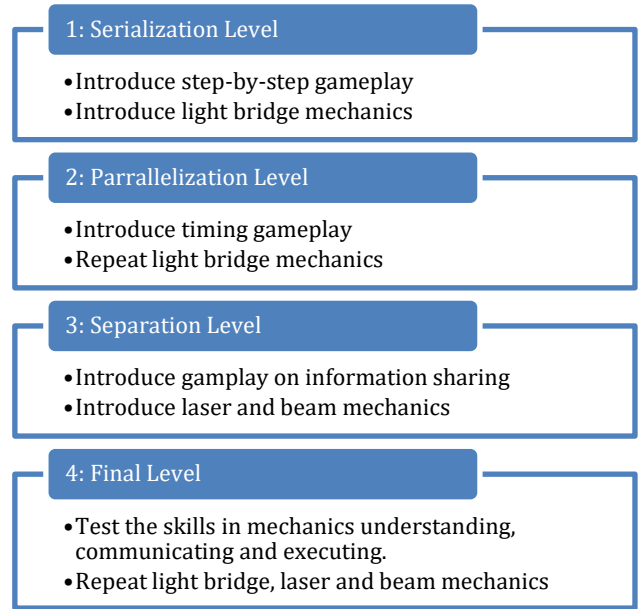


Figure 4-7 Production Level Design Plan

To design the final level, we implemented the four-stage theory into practice. We designed gameplay mainly based on the serialization design pattern. Then we twisted some gameplay and added more exciting moments as shown below.

- Section 1: Serialization with parallelization moment
- Section 2: Parallelization with reunion “wow” moment
- Section 3: Combination of separation gameplay, puzzle catches, and timing mechanics

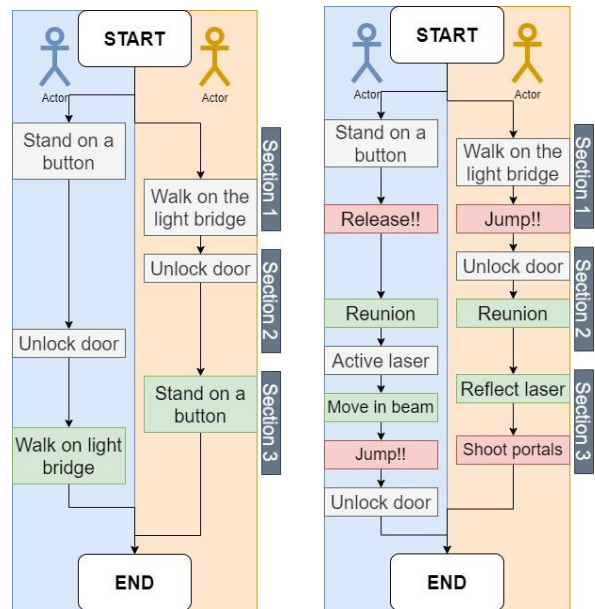


Figure 4-8 Four-stage Best Practice Example

V. RESULTS AND DATA ANALYSIS

Pre-production: Action Block Playtest

1. Serialization Action Blocks

ID	Focus	Rate
1	Dual-player puzzle Share space, share information	7.5
2	Dual-player puzzle Multiple spaces, share information	7.5
3	Dual-player puzzle Multiple spaces, information split	5

Figure 5-1 Serialization Action Block Playtest Result

The rate came from playtesting surveys within 0-10, representing how much the players enjoyed the action blocks. From the data, we discovered that people cared about how much information they could get from the process, so having clear goals and enough feedback are both important in this game pattern.

2. Parallelization Action Blocks

ID	Focus	Rate
1	Timing mechanics Requires continuous communication	8.3
2	Timing mechanics Requires a lot of communication	7.5
3	Timing mechanics Require communication once	5.8

Figure 5-2 Parallelization Action Block Playtest Result

Communication helped the player gain fun game experience in parallelization gameplay moments. Puzzle mechanics that are easy to understand and hard to execute fits this pattern because it provides chances of communicating.

3. Separation Action Blocks

ID	Focus	Rate
1	Dual-player puzzles with different roles A lot of communication	8.2
2	Dual-player puzzles A lot of communication required	6.5
3	Single-player puzzles Some communication required	5.7

Figure 5-3 Separation Action Block Playtest Result

Based on our observation, we realized that single-player puzzles were not an ideal way to design co-op moments because players did not like waiting with nothing to do. Splitting the sequences into small chunks and assigning tasks for both players could solve this problem. Besides, having clear role division also contributed to separation gameplay since players were having clear goals on what they were responsible for.

Production: Final level artifact

We had two main questions to answer from the playtest data: could we design a good puzzle using the four-stage theory? And could we provide a cool co-op gameplay moment for the players?

The answers were reflected how difficult the players thought and how important they were in the role. Here are the answers.

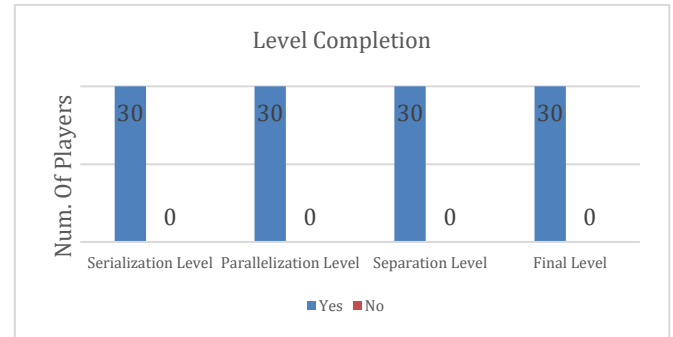


Figure 5-4 Level Completion Chart

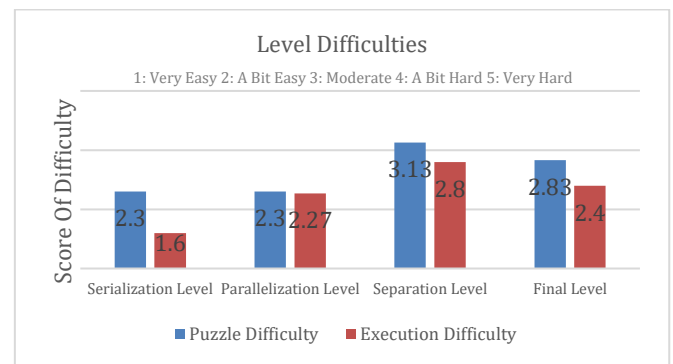


Figure 5-5 Level Difficulty Chart

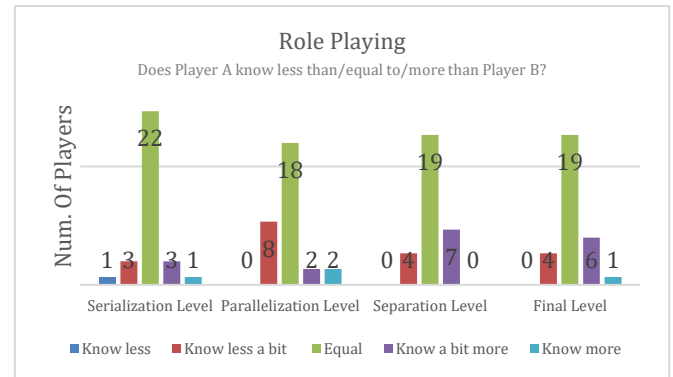


Figure 5-6 Role Playing Result

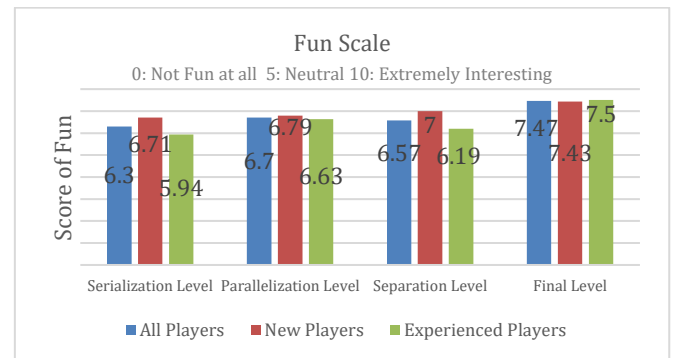


Figure 5-7 Fun Scale Result

According to the chart, 100% of players were able to complete the puzzle levels among 30 playtesters (14 people never played portal 2 co-op mode). Puzzle difficulties were increasing in a moderate range and they were all easy to execute, which partly indicated the success of puzzle mechanics. More than 93.33% of players believed that they were equally important as their partners or only a bit less/more important, which proved the co-op game experience was also a success.

Besides, the final level had the highest average score for both new players and experienced players. Though in the first three levels the experienced players had less fun compared with new players, they had increasing fun in the final level, which followed the four-stage co-op puzzle design theory.

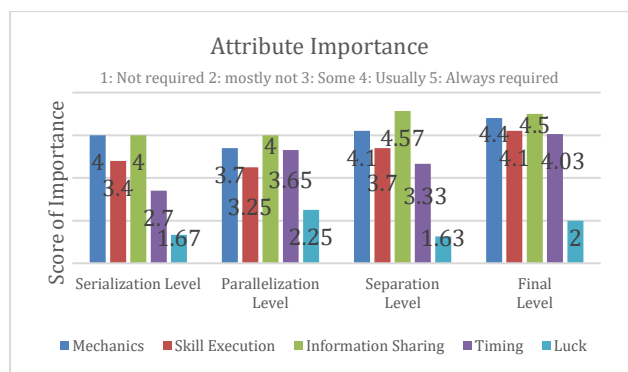


Figure 5-8 Co-op Attributes Importance Result

For a better understanding of how three design patterns work, we also collected data for the attribute importance from the most common co-op skillsets. The data shows that information sharing is always the most important value, with mechanic understanding ranking the second. Good timing skill is usually required in parallelization and separation game moments, but it is not necessary for serialization gameplay. From another aspect, we could see how the four-stage theory contributes to co-op puzzle design because the final level requires all the skillsets except good luck, which is never a key attribute to interesting gameplay.

VI. CONCLUSIONS

A. Challenges and Feedback

The biggest challenge I ever met in this project was mechanic idea generation. At the early stage, I did not have a clear idea of how the three patterns would work and experienced some failure in action block design. However, I received a better understanding after the early playtest from my players, who were all level designers. They provided me very helpful feedback and suggestion, which inspired me in my final level construction.

Another challenge I found was from my final playtest. Due to COVID-19, it was hard for me to find playtesters who could locally play together. Some testers could not smoothly experience the whole level because of an internet issue. To solve this issue, I invited classmates, friends, and even people who I

did not know to participate in the playtest in order to get a good amount of data.

The final challenge I experienced was the different gaming experiences between experienced players and new players. Experienced were those who had played original Portal 2 co-op mode, and they were expecting more since they had been familiar with the mechanics. They also did not accept my twist of using the light bridge because it was not common in the original game. Beyond that, I accidentally discovered that they disliked the separation level (Experienced Player Rate 6.19, New Player Rate 7, Average Rate 6.57). After talking with them, I recognized the huge amount of information to share at that level frustrated them, so I added windows between spaces and put on symbols on the devices to make communication easier.

B. Best Practice Takeaways

- The audience enjoyed fun moments more than good puzzles.
- Information sharing is always important in all patterns.
- They held high tolerance for serialization puzzles because they can hardly solve them on their own.
- Communication plays an important role in co-op puzzles, especially for parallelization and separation gameplay.
- Serialization and separation gameplay have advantages in increasing puzzle difficulties, however, parallelization has advantages in increasing challenges and fun.
- Clear feedback is a key to success for serialization and separation puzzles as timing is the key for parallelization.
- Effective ways of balancing gameplay: divide the sequence into small pieces if one player is always waiting, ask if the puzzle is possible for one player, ask if the challenge is hard/easy, and ask if the information is too much or not enough.

C. Continuation

Though I started this topic based on previous students' research, there is still a long way to go to establish a comprehensive theory for good co-op puzzle design because design patterns have so many differences. If I had more time, I would like to do more practice for each pattern systematically. I would be also glad to see if someone could take this topic as a start and make a progression for further study.

D. Conclusion

Given the data from playtesting, I am able to conclude that the four-stage practice theory is a very helpful and practical way for starters to create engaged collaborative puzzle gameplay. Specifically, it provides various gameplay and avoids common problems in co-op games. With the knowledge, I have learned about different co-op game patterns and my practice in puzzle design through the whole process, I believe I have demonstrated my ability to bring designs from concept to completion.

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