To Asymmetry and Beyond!

Improving Social Connectedness by Increasing Designed Interdependence in Cooperative Play

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Figure 1: Simultaneous screenshots of (A) Scotty's interface and (B) Kirk's perspective during play. As Kirk attacks a wasp with her axe, Scotty uses the shock ability to stun it (white radius in A and blue lightning bolt effect in B) and the bomb ability on a distant enemy (yellow icon in A and red glow in B).

ABSTRACT

Social play can have numerous health benefits but research has shown that not all multiplayer games are effective at promoting social engagement. Asymmetric cooperative games have shown promise in this regard but the design and dynamics of this unique style of play is not yet well understood. To address this, we present the results of two player experience studies using our custom prototype game *Beam Me 'Round, Scotty! 2*: the first comparing symmetric cooperative play (e.g., where players have the same interface, goals, mechanics, etc.) to asymmetric cooperative play (e.g., where players have differing roles, abilities, interfaces, etc.) and the second comparing the effect of increasing degrees of interdependence between play partners. Our results not only indicate that asymmetric cooperative games may enhance players' perceptions of connectedness, social engagement, immersion, and comfort with a game's controls, but also demonstrate how to further improve these outcomes via deliberate mechanical design changes, such as changes in cooperative action timing and direction of dependence.

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CCS CONCEPTS

• Human-centered computing → Empirical studies in HCI; **• Applied computing → Computer games**.

KEYWORDS

Game design; Symmetric vs asymmetric play; Asymmetric games; Social presence; Games user research; Player experience.

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1 INTRODUCTION

Playing video games with others has been shown to have many pro-social benefits, including building trust between strangers [9] or promoting social interaction between the elderly and their caregivers [19]. Yet other games, even those we might expect to be hugely social experiences, such as the Massively Multiplayer Online game *World of Warcraft* [12] with its millions of players, can actually result in largely individualistic and egocentric player behaviour [10].

Recent research into how we might better design games that emphasize enriching social interaction have seen promising results by adopting a focus on asymmetric cooperative games [8, 11, 20]—games where multiple players cooperate, but each has unique abilities, information, feedback, rewards, or game mechanics, and therefore vastly different, though simultaneuos, play experiences—but it remains unclear what combination of elements are responsible for these games' uniquely engaging interdependent gameplay. What is increasingly clear, however, is that by employing various forms of asymmetry as a design tool, these types of games are able to develop unique forms of interdependence between players such that social interaction and reciprocity are not only advantageous, but become a natural part of the game.

In this paper, we dive deeper into this emerging research theme with a combination of two player experience studies that explore the spectrum of asymmetric play: the first compares symmetric and asymmetric play experiences, while the second examines different "degrees" of interdependence through more subtle, fine-grained mechanical manipulations of gameplay elements. In both cases, we employed our own prototype test bed game, *Beam Me 'Round, Scotty! 2*, to measure players' perceptions of social presence, connectedness, and individual experience.

Our research goal was the investigation of *mechanical* means of enhancing social connectedness, knowing that we would not cover all possible permutations or combinations of asymmetric elements. The specific narrative, visual, interface, and asymmetry choices made did not stem from a single, scientifically true/best choice (as, we would argue, no singular best choice exists for all purposes) but constitute a single point among a constellation of variations from which broader trends might be observed and leveraged to serve future design goals.

Our results indicate that players experience more social connectedness, behavioural engagement, immersion, and comfort with controls in asymmetric play than symmetric play, and, furthermore, increasing interdependence via deliberate design of low-level game mechanics can lead to a predicted increase in social connectedness, behavioural engagement, interest, and effort. We also uncovered several qualitative themes which underscore how designing asymmetry and interdependence into cooperative games can be a complex challenge. We discuss these complexities and reflect on our aspiration of enhancing players' social experiences during play using asymmetry as a design tool.

2 RELATED WORK

Work by Isbister [22] and Voida et al. [35] highlights how the nature of players' relationships with each other and the environmental context in which they play can have significant effects on players' enjoyment, behaviour, satisfaction, and participation. Indeed, the desire to play games with others is one of the primary motivations for modern digital game players [3], yet the challenge of finding games which appeal to pre-existing social circles while still engaging with the wide variety of player motivations [38] can be difficult. Theoretically, asymmetric games are uniquely positioned to not only provide deeply engaging social play experiences, but also bridge preference boundaries between different players by presenting multifaceted experiences to different types of players simultaneously. For example, work by Gerling et al. [18] demonstrates how asymmetry in game design can even be used to provide engaging experiences for players with different physical capabilities, such as the able-bodied and disabled playing together, not just by attempting to normalize differences between players through artificial balancing mechanisms, but by embracing players' differences and designing multifaceted games to suit each player's unique contributions.

Interdependence and Cooperation in Games

Research from sports psychology by Bruner et al. [13] demonstrated that positive interdependence between athletes led to better team performance, enhanced group cohesion, personal satisfaction, and closer relationships. Importantly, this effect was evident only in those sports where the entire team's success required group collaboration (e.g., soccer, relay races) and was not evident in sports where multiple athletes simply represented the same institution or trained together but competed as individuals (e.g., varsity marathon running). Bruner et al. attributed this effect to the presence of two factors: task interdependence (where athletes actions required collaboration with others) and outcome interdependence (where groups succeeded or failed collectively). These results mirror research from organization psychology by Saavedra et al. [29] that observed similar social benefits in workplace environments as a result of task, feedback, and goal interdependence.

Conversely, work by van der Vegt et al. [34] observed how too much interdependence can lead to "process losses" and reduced task satisfaction due to frustration and cognitive overhead. Going further, work by Sherif et al. [32] demonstrated how interdependence could be deliberately employed to generate negative social behaviours such as bullying.

Significant effort has also been put into analyzing common patterns of play and effective mechanics for promoting beneficial social play in games. Work by Zagal et al. [39] surveyed successful board games and argued for the distinction between competitive, cooperative, and collaborative games, where players are increasingly tightly-coupled in both their actions and goals. Work by Beznosyk et al. [4] elaborated on this concept of "coupling" between players by defining "closely-coupled" games as those requiring "a lot of waiting or if the actions of one player directly affect the other player" [4, p. 7]. Conversely, "loosely coupled" games "did not require tight collaboration between players and allow more independent performance" [4, p. 7]. They found that closely-coupled games tended to be more exciting and identified several design patterns that encourage closely-coupled play, including limited resources, complementary roles, interaction with the same object, shared puzzles, shared goals, and abilities that can be used on other players.

Asymmetry & Interdependence as Design Tools. Work by Harris et al. [20] presented an alternative perspective on the concepts of "coupling" and "complimentary roles" by proposing asymmetry in a game's design as a means of introducing interdependence between players. Based on surveys of existing asymmetric cooperative video games, they presented a conceptual framework of several types of asymmetry, such as asymmetries of ability, interface, information, challenge, goals, team sizes, and investment in an attempt to bring a more coherent structure to the still nascent discussion of interdependence in cooperative game design. Although relatively new and not yet thoroughly tested across disparate genres by a larger body of practitioners, we have adopted it's vocabulary in our present work for the useful structure it affords when describing important features of asymmetric games in general and, as will be discussed later, for deliberately designing asymmetric dependencies between cooperating players.

For example, as demonstrated in work by Sajjadi et al. [30], asymmetries of information and perspective can be used to promote communication and coordination between players, though can also prove frustrating. Work by Depping et al. [9] demonstrated that asymmetries of abilities between players can be an effective tool for building trust between strangers. And work by Emmerich et al. [11] has explored how heightened interdependence can, perhaps counter to intuition, lead to *lessened* frustration between collaborating partners in games with time pressure.

We can also begin to describe the aesthetic strengths and weaknesses of commercial asymmetric cooperative games. For example, both *Star Fox Zero*'s [16] and *Clandestine*'s [2] cooperative modes create asymmetries of ability, information, and challenge by splitting each game's normal collection of single-player abilities between two play partners. However, the core design compromise of still accommodating single player play means that a second player is never strictly necessary and so the aesthetic experience of interdependence can suffer. In our experiences with *Clandestine*, for example, we found this accommodation resulted in a lock-step back-and-forth between the "agent" and "hacker" roles as one player/character was forced to wait for the other to complete a task before proceeding. In contrast, the bomb-defusing game *Keep Talking and Nobody Explodes* [17] *requires* two teams of players to cooperate simultaneously in order to succeed. By design, the game cannot be played any other way and the resultant aesthetic is a uniquely tense, collaborative rush.

Collectively, this previous work demonstrates the potential of leveraging asymmetry and interdependence as a means of enhancing social play experiences, yet highlights that there is still much to learn about the practical design and development of these types of games. It is at this intersection of player experience measurement and design then that we situate our current work and focus on the pursuit of a better understanding of not only the effects of asymmetry and interdependence in cooperative games but also how to design and develop novel asymmetric cooperative games more effectively.

3 EXPERIMENTAL TESTBED GAME

In order to explore our theories, we developed a new prototype game for use as an experimental test bed for two player experience studies. Our game, *Beam Me 'Round, Scotty! 2* (*BMRS2*), was inspired by the existing research prototype, *Beam Me 'Round, Scotty!* (*BMRS1*), used by Harris et al. [20] in their exploratory study of asymmetric cooperative play. Our rationale for this approach is twofold: First is the fine-grained control a custom prototype affords over mechanical, graphical, and interface manipulations. We can easily alter elements within the game to create contrasting control/manipulation comparisons while minimizing confounding influences such as changes in narrative or visual aesthetic. Second, redesigning and expanding upon the concepts presented in the original *Beam Me 'Round, Scotty!* allowed us to break new ground while still remaining rooted in the design insights, player study results, and conceptual framework established previously.

Original Game & New Questions

Beam Me 'Round, Scotty! 2 borrows it's essential premise from its predecessor: a two-player, co-located cooperative game in which players take on the roles of courageous spaceship captain Kirk and plucky engineer Scotty. Kirk, having crash-landed on a hostile alien planet, must find a means of escape. Meanwhile Scotty, still up in the orbiting starship, is able to use the ship's various abilities to help Kirk reach the exit.

Harris et al. [20] based the plot of their game on the science fiction series *Star Trek* [26] as a narrative convenience and, while we have adopted the same plot for *BMRS2*, prior knowledge of *Star Trek* is not necessary to play our game nor understand the player experience studies presented in this paper. Rather, the character names Kirk and Scotty are used here simply as shorthand labels for the specific gameplay archetypes being studied.

In the original *BMRS1*, both Kirk and Scotty players shared the same display and viewed the game world from an isometic perspective. Using a gamepad, Kirk players could move, aim, and shoot a medium-range blaster pistol but did not otherwise have any other abilities. Scotty players used a mouse and radial menu interface to deploy their special abilities by clicking directly onto the 3D game world terrain.

Scotty's five abilities included a Heal Beam that could replenish the health of the selected avatar, a Shock Beam that could electrocute and stun single objects/enemies, a Shield Wall that could be used to form impenetrable physical barriers that Kirk could shoot through but enemies could not, a Torpedo Strike which fell from the sky and exploded upon reaching the target point, and a Teleporter which could instantaneously transport Kirk a short distance. Use of these abilities required the expenditure of a limited pool of slowly regenerating energy which Scotty players would need to be mindful of lest their partner be left helpless in a dangerous situation.

Harris et al.'s initial study of *BMRS1* was exploratory in nature and, although it revealed several interesting themes for future research, it also raised several important questions which we address in our present work.

Symmetry vs. Asymmetry: Were players' sense of connectedness and harmonious collaboration a result of the inherent asymmetries between the Kirk and Scotty roles or was this merely a result of the particular visual and narrative trappings of a starship crew who must cooperate in order to escape their stranding? Would a hypothetical "symmetric version" of the same game elicit comparable perceptions of camaraderie and teamwork in its players through narrative alone?

Degrees of Interdependence: If specific mechanics of play contribute to players' perceptions of social connectedness, is it possible to design "increasingly asymmetric" versions of a cooperative game and do the resultant increases in interdependence increase social connectedness?

Beam Me 'Round, Scotty! 2

Though inspired by *BMRS1*'s initial explorations, *Beam Me 'Round, Scotty! 2* was designed and developed to address these new, more specific research questions and explore the hypothetical spectrum (Figure 2) of cooperative play via two player experience studies: the first comparing symmetric to asymmetric play and the second comparing increasing degrees of interdependence. Significant changes were made to the *Beam Me 'Round, Scotty!* concept as we designed our two player studies and developed our new prototype game to facilitate them.

One of the most significant changes introduced by *BMRS2* is that each player uses their own dedicated display (as a new channel for asymmetric information). Scotty's perspective (Figure 1A) shows the game world from a top-down, satellite view, and no longer shares a virtual camera with Kirk, so is free to pan their view around the game world independently. Similarly freed, Kirk's perspective into the 3D world (Figure 1B) was brought down from an elevated isometric view to an over-the-shoulder, third-person perspective which Kirk players could orbit around their avatar via the gamepad's right joystick (similar to many modern 3D action games). In *BMRS2*, Kirk's blaster pistol was replaced with a handheld axe; shifting Kirk's primary focus from ranged shooting and accuracy to melee combat and dodging/positioning. Also unique to *BMRS2*, Kirk could now make short-distance dodge rolls and activate a forearm-mounted energy shield (much like a medieval knight) that could block incoming attacks.

Further changes to the prototype game that are specific to each player study are described in more detail alongside each study's hypotheses, procedures, and results below.

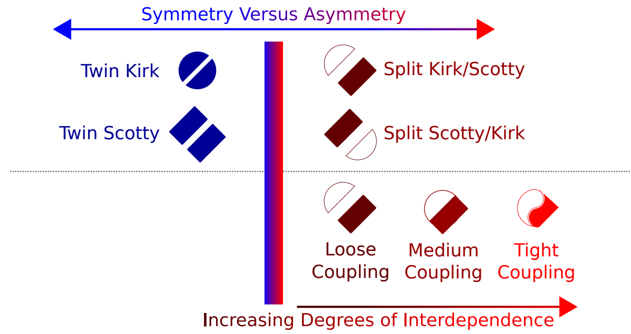

Figure 2: Visual representation of the conceptual relationship between study one (top), contrasting conditions on opposing sides of the symmetry/asymmetry divide, and study two (bottom), which contrasts conditions that are all asymmetric but exhibit increasing degrees of interdependence.

4 STUDY 1: SYMMETRY VS. ASYMMETRY

In order to facilitate the study of *asymmetric* versus *symmetric* play, we chose to contrast the traditional "Split" mode (where one player plays as Kirk and one player plays as Scotty) with two new gameplay modes titled "Twin Kirk" and "Twin Scotty". Rather than having each player play as different characters, with their associated asymmetries of ability, interface, and challenge, "Twin Kirk" and "Twin Scotty" allow us to study players' experiences when playing as the *same* characters but without changing the narrative, game world, or visual aesthetics of the base game.

While conceptually straight forward, implementation of these new symmetric modes presented several design challenges; foremost among them, the “Lonely Kirk” paradox. Numerous in-game obstacles existed that required collaboration between Kirk and Scotty’s asymmetric abilities to overcome. For example, without an attendant Scotty, how would two regular Kirk players traverse a chasm (an obstacle usually overcome with the help of Scotty’s teleportation ability) without either alterations to Kirk or to the chasm? Ultimately, we chose to give Kirk control over Scotty’s special abilities (i.e., Kirk could heal themselves, teleport themselves, etc.) in what we referred to as the “Super Kirk” solution. We felt this design alternative retained as many of the salient elements of the “Split” condition as possible. The narrative for this mode was tweaked so that Kirk players were requesting intervention from an A.I.-controlled “RoboScotty”.

The design of the “Twin Scotty” mode presented two design challenges. The first was a straightforward hardware/interface problem: as most modern PC operating systems do not easily support multiple pointers, the interface for controlling Scotty was transposed to use a multitouch tablet rather than a mouse. This was held consistent for all conditions where participants played as Scotty during this first study.

The second was a more subtle challenge of design: that of “Lonely Scottys”. With no Kirk, who would Scotty escort? Similar to the “Lonely Kirk” problem, we chose to have each human Scotty escort their own A.I.-controlled “RoboKirk” character; one that they could provide simply navigation commands to but that would not attack enemies nor defend themselves. This solution was preferred to either a more complex A.I. that would not easily be able to mimic the actions and behaviours of a live human Kirk player or a single RoboKirk, shared by two human Scotty players, which might introduce new forms of interdependence between players as they negotiated how and when to help their shared ward.

Having successful designed, developed, and pilot-tested three new gameplay modes, we set about conducting a 2 (character: Kirk vs. Scotty) × 2 (symmetry: asymmetric vs. symmetric) within-subjects player experience study.

Participants

We recruited 40 participants in 20 pairs (5 female/female, 4 female/male, 11 male/male) with a median age of 21 (range: 18-26) from the local university population. The majority (35 of 40) participants were students. Each pair was required to have a pre-existing social relationship (e.g., friends, classmates, family) but did not otherwise require any special qualifications (e.g., no prior game playing experience necessary). Participants were each compensated $15 for their time.

Equipment

In a private room within a university research lab, participants were seated in rolling office chairs in front of a table and Asus GL502VM gaming laptop (Intel Core i7 6700HQ CPU, 16GB RAM, NVIDIA GeForce GTX1060 GPU). The laptop display (15.6 inch, 1920×1080 pixels) was extended to an HP EliteDisplay E27i monitor (27 inch, 1920×1080 pixels). The larger 27 inch monitor was positioned approximately 40 cm further back on the table such that both displays took up the same proportion of the players’ field of view. Two Samsung Galaxy Tab S3 Android tablets, and two DualShock 4 gamepad controllers were connected to the laptop via 1.8 m long USB cables allowing players to pick up and manipulate the devices comfortably. A video camera positioned above and behind the main displays recorded participants verbal interactions, facial expressions, and non-verbal gestures. Participants’ in-game actions were recorded via screen capture on each of the four display screens (two PC monitors, two tablets).

Procedure

To begin each session, the experimenter explained the overall study procedure to the participant pair and described the basic plot of the game. Each participant would then play through the entire prototype game four times (i.e., the same sequence of levels), once for each condition. Thus each participant completed the game as Kirk twice, once with their partner as Kirk (Kirk, symmetric) and once with their partner as Scotty (Kirk, asymmetric), as well as Scotty twice, once with their partner as Scotty (Scotty, symmetric) and once with their partner as Kirk (Scotty, asymmetric). These four conditions were counterbalanced using a random Latin square of size four in order to accommodate for learning and fatigue effects.

Scotty conditions were played through the tablet, and Kirk conditions through the game controller, and when playing symmetrically (both Kirk or both Scotty), each character had access to the absent character’s “powers”, thus each combination required unique training (e.g., playing as Kirk with a Scotty partner that can beam you around was different than playing as two Kirks that each beam themselves around by commanding an artificial Scotty). Before each condition, participants were given a brief tutorial on how to use the new mechanics as well as five minutes to play and experiment with the new configuration in a shared sandbox level.

Measures. Recent work by Denisova et al. [7] comparing a number of commonly used player experience surveys demonstrated that each is acceptable for measuring player experience in general, but which survey to employ is best determined by the focus of the experimental study. For this work, we employ the Player Experience of Needs Satisfaction (PENS) [28] and Intrinsic Motivation Inventory questionnaires [27] to measure elements of players’ individual experiences.

We employ de Kort et al.'s Social Presence in Gaming Questionnaire (SQPG) [23] for its focus on empathy and behavioural engagement between players and because it avoids making explicit assumptions about team structures or cooperation versus competition—distinctions we wanted to avoid in our player study—as measures of inter-player experiences. We also employ the "Inclusion of the Other in the Self Scale" (IoS) [15] as it has been shown to be a particularly simple, effective, and easy-to-administer tool for gauging perceptions of "closeness" or "connectedness" in behavioural science literature.

Following each play condition, each participant completed a series of self-report surveys, providing the following dependent measures: *Connectedness* via IoS scale [15]; *Social Presence* via SPGQ [23] empathy, negative feelings, and behavioural engagement sub-scales; *Player Experience* via PENS [28] competence, autonomy, immersion, and intuitive controls sub-scales; and *Motivation* via IMI [27] interest, effort, and pressure sub-scales.

Finally, each participant completed a short demographic survey which included the BrainHex [24] survey. The experimental session concluded with a semi-structured interview. Each session lasted approximately 90 minutes.

Hypotheses

We proposed the following hypotheses for player study 1 as regards asymmetric play over symmetric play:

H1. Players would feel more connected to and perceive a greater sense of social presence with their play partners.

H2. Individual player experience metrics would be more positive.

H3. Players would be more motivated to play.

5 RESULTS

Due to a clerical error in copying the intended orders of conditions, our experimenter did not fully counterbalance the study sessions as expected and so a Latin square design was not accurately followed within each participant pair. However, the first condition was equally distributed between participants and thus, by excluding data from the second to fourth playthroughs, we analyzed each self-report measure using a between-participants factorial 2 (symmetry) × 2 (character) ANOVA. Post-hoc analyses used Bonferroni corrections.

Connectedness. There was a significant main effect of symmetry on connectedness ($F_{1,36} = 4.5, p = .04, \eta_p^2 = .11$), where participants playing as different characters reported being more connected to their play partner ($M = 4.0, SE = 0.3$) than participants playing as the same character ($M = 3.0, SE = 0.3$). This finding confirms our primary hypothesis (H1).

There was also a significant main effect of character on connectedness ($F_{1,36} = 7.6, p < .01, \eta_p^2 = .17$), where participants playing as Kirk reported feeling more connected to their play partner ($M = 4.2, SE = 0.3$) than participants playing as Scotty ($M = 2.9, SE = 0.3$). This was a more surprising result, but players commented that, because Kirk used an over-the-shoulder perspective, they felt more connected to their play partner and their actions, as if they were "right there".

These main effects can be further explained by a significant interaction between character and symmetry on the connectedness measure ($F_{1,36} = 7.6, p < .01, \eta_p^2 = .17$). Post-hoc analysis revealed that for Kirk, participants rated themselves as feeling significantly more connected in the asymmetric condition (i.e., when their partner played as Scotty), than the symmetric condition, when playing with another Kirk ($p = .001$), but when playing as Scotty this difference was not significant ($p = .66$). Moreover, the ratings of connectedness for Scotty when playing with either Kirk or another Scotty were as low as when playing as Kirk with another Kirk. This finding illustrates that, while asymmetric play *can* lead to feeling more connected to one's play partner, the role a player takes on can have a significant impact on these feelings. When playing asymmetrically in our study, it was the Kirk player that felt more connected to their partner, not the Scotty player.

Social Presence. There was a significant main effect of symmetry on behavioural engagement ($F_{1,36} = 6.0, p = .02, \eta_p^2 = .14$), where participants rated asymmetric play as more engaging ($M = 5.8, SE = 0.2$) than symmetric play ($M = 5.2, SE = 0.2$). This finding again reinforces our primary hypothesis (H1) that when players take on asymmetric roles in play, they will feel more socially engaged. However, it should be noted that players in all conditions rated levels of social engagement quite highly ($M \geq 5.2$). There were no other main effects or interactions involving engagement, empathy or negative feelings ($F_{1,36} < 1.7, p > .20$).

Individual Player Experience. There were significant main effects of asymmetry on immersion ($F_{1,36} = 7.7, p < .01, \eta_p^2 = .18$) and intuitive controls ($F_{1,36} = 5.8, p = .02, \eta_p^2 = .14$). Participants rated asymmetric play as being both more immersive (asym.: $M = 4.7, SE = 0.2$; sym.: $M = 4.0, SE = 0.2$) and having more intuitive controls (asym.: $M = 6.0, SE = 0.2$; sym.: $M = 5.2, SE = 0.2$), confirming H2. There were no other main effects or interactions involving competence, autonomy, immersion, or intuitive controls ($F_{1,36} < 2.1, p > .16$).

Motivation. There were no significant main effects or interactions involving interest, effort, or pressure ($F_{1,36} < 2.2, p > .15$). We therefore cannot confirm our remaining hypothesis (H3) that players will be more motivated in asymmetric play.

Ranking of Game Modes. When we asked participants to rank the three game modes (two symmetric and the one asymmetric played in two ways) in order of personal preference we found a significant main effect of game mode on preference ($F_{1,36}$ = 37.471, p < .000, η_p^2 = .490). The Twin Scotty condition (M = 2.8, SE = 0.073) was ranked significantly less favourably than both the Twin Kirk (M = 1.7, SE = .109) and Split (M = 1.5, SE = .095) conditions however there was no significant difference between the ranking of the Twin Kirk and Split conditions themselves.

The quantitative results of our first study showed clear benefits of asymmetric play over symmetric play in terms of connectedness, social presence, immersion, and intuitive controls. Our qualitative observations of gameplay recordings and semi-structured interview responses, however, invited more nuanced questions around what *characteristics* of asymmetric play could magnify these effect and prompted our second player study.

6 STUDY 2: DEGREES OF INTERDEPENDENCE

Our first study demonstrated that asymmetric play could generate higher social connectedness than symmetric play, but observations and interview data indicated that the asymmetries alone (ability, interface, and information) did not fully explain these feelings; there was something about way the asymmetries interacted and how players were often forced to collaborate because of their differences that prompted feelings of improved social connectedness in some scenarios yet not in others. Where our first player experience study compared symmetric and asymmetric cooperation, our second study explored the more subtle characteristics of interdependence *within* asymmetric cooperative play.

Based on Saavedra et al.'s [29] conceptualization of "task interdependence" and Harris et al.'s [20] nascent framework for asymmetric game design, we chose to manipulate the degree of interdependence between participants via mechanical changes to Scotty's five abilities; specifically whether and how Kirk would need to collaborate with Scotty in order for the powers to be effective.

Study Factor: Degree of Interdependence

Starting with the "Split" (asymmetric) *BMRS2* configuration of playing with one normal Kirk (without special powers) and one Scotty (escorting a single human Kirk player), the mechanical behaviour of Scotty's abilities were manipulated to create three distinct *degrees of interdependence* between the Kirk and Scotty players: loose, medium, and tight coupling.

We consider Scotty's Bomb ability as an example. In the Loose Coupling condition, with a single click Scotty players could deploy a bomb into the 3D world and, after a short countdown, the bomb would explode and clear a path for Kirk; a one-time, unilateral action on Scotty's part with no necessary action from Kirk. In the Medium Coupling condition, after Scotty deployed the bomb, Kirk would first need to approach and manually activate it before the countdown would begin; in this case, both Scotty and Kirk participated in the use of the bomb via their respective one-time actions. Finally, in the Tight Coupling condition, Scotty's click would instead deploy an volatile "bomb rift" which could only be triggered by physically attacking it. As the rift would disappear after a short time, Kirk and Scotty players would need to coordinate closely on timing and positioning in order for Kirk players to be able to skillfully throw their axe at the rift in time and for this version of Scotty's bomb ability to be effective.

For brevity's sake we omit detailed descriptions of how each of the five abilities were changed over each of the three degrees of interdependence but provide Table 1 for succinct reference. In general, as the level of interdependence advanced from loose, to medium, to tight coupling, Scotty and Kirk would both need to pay more continuous attention, coordinate in more detail, and execute more numerous, more skillful, and more bilateral actions in order to successfully utilize all of Scotty's five abilities. All other mechanical details, such as the speed at which Kirk was healed, the explosive range and power of the bombs, or the maximum distance travelled with each teleport remained the same across conditions.

Participants and Equipment

Expecting to encounter more subtle effect sizes than in our first study, we increased the number of participants in our second study. We recruited 72 participants in 36 pairs (14 female/female, 18 female/male, 40 male/male) with a median age of 23 (range: 18-33) from the local university population. Again, the majority (67 of 72) of participants were undergraduate students. Our recruitment criteria and compensation were the same as the first study. The hardware and room layout were also the same as before with one exception: while Kirk players continued to use a dual-joystick gamepad as before, Scotty players used a mouse and keyboard on a second 27 inch, 1920×1080 pixel display for their input, rather than a multi-touch tablet. This was done for simplicity and reliability reasons as, with only a single Scotty in play throughout this experiment, there was no longer a need to accommodate multiple Scotty interfaces simultaneously.

Procedure & Measures

This second player study examined a single experimental factor (degree of interdependence) with three levels (loose, medium, and tight coupling). The general procedure of this "degrees of interdependence" study followed the same "play, survey, play, survey" pattern as the previous study with all of the associated introduction, training, practice, and closing demographic/interview steps as before. New to this study however was a series of questions at the end of the three experimental conditions asking participants to rank the different variations of Scotty's five abilities (heal, shield, shock, bomb, teleport) according to four criteria (most powerful, easiest to

Table 1: Brief descriptions of how Scotty's and Kirk's interactions changed as the mechanics of Scotty's abilities were manipulated between the Loose, Medium, and Tight Coupling conditions in Study 2.

		Heal	Shield	Shock	Bomb	Teleport
Loose	S	Click on Kirk	Click on Kirk	Click near enemy	Click near enemy	Click at destination
	K	No action required				
Medium	S	Click near Kirk to engage, monitor energy, click to disengage	Click drag to draw wall	Click near enemy to engage, monitor energy, click to disengage	Click near enemy	Click drag to place two endpoints
	K	Stand nearby	Maneuver around	Attack shocked enemy	Approach, press button to arm bomb	Walk into endpoint
Tight	S	Hold button, track Kirk, monitor energy	Hold button, track Kirk, aim toward enemies	Await Kirk's signal, shock enemy	Click to place bomb	Click to ready destination, monitor energy
	K	Walk slowly	Coordinate attack and personal shield with Scotty	Throw and embed axe in enemy, notify Scotty	Hit bomb with thrown axe to detonate	Press button to trigger teleport

use, made participant feel most connected to their partner, and favourite) as well as ranking the three play modes overall (loose, medium, tight coupling).

At the outset of each study session, the plot of the game and the controls for each character were explained to both participants before they were given the opportunity to decide which role each partner wanted to play. Once chosen, each participant played the same character for all three conditions. The sequence of conditions was fully counterbalanced to account for learning and fatigue effects (every permutation of 3 conditions, cycled 6 times).

Hypotheses

We proposed the following hypotheses for this study:

H4. As the degree of interdependence increased between players, participants would perceive a greater sense of connectedness and social presence with their play partners.

H5. Individual player experience metrics will be more positive for the tightly coupled condition than for low coupling.

H6. Highly skilled players would most prefer tightly coupled play while low skilled players would prefer low coupling.

Results

Social Connectedness & Engagement. There was a significant main effect of interdependence on connectedness ($F_{2,142} = 5.8$, $p = .004$, $\eta_p^2 = .076$), where participants felt significantly more connected to their play partner under the tight coupling condition ($M = 5.81$, $SE = 0.12$) than the loose coupling condition ($M = 5.26$, $SE = 0.16$), $p = .002$. Although there was a consistent trend across all three conditions (medium coupling $M = 5.51$, $SE = 0.14$) and the differences between medium-tight coupling was marginally significant ($p = .054$), loose-medium was were not statistically significant ($p > 0.12$).

There was also a significant main effect of interdependence on behavioural engagement ($F_{2,142} = 7.6$, $p = .001$, $\eta_p^2 = .097$) as measured by the SPGQ survey [23] where players reported feeling less engaged under the loose coupling condition ($M = 2.549$, $SE = 0.11$) than under both the tight ($M = 2.19$, $SE = 0.08$, $p = .002$) and medium ($M = 2.24$, $SE = 0.08$, $p = .006$) coupling conditions. (Lower scores indicate perceptions of stronger behavioural engagement.) These findings partially confirm our primary hypothesis (H4).

Individual Player Experience. There were significant main effects of interdependence on interest ($F_{2,142} = 5.68$, $p = .004$, $\eta_p^2 = .074$), where participants felt more interested in the game under both the tight coupling ($M = 2.64$, $SE = .112$, $p < .007$) and medium coupling ($M = 2.77$, $SE = .112$, $p < .015$) than under the loose coupling condition ($M = 3.09$, $SE = .147$). There was no significant difference in interest between the tight and medium coupling conditions however ($p = 0.27$).

There were significant main effects of interdependence on effort/importance ($F_{2,142} = 11.5$, $p = .000$, $\eta_p^2 = .140$), where participants placed significantly more importance and effort in both the tight ($M = 3.64$, $SE = .143$, $p = .001$) and medium coupling ($M = 3.50$, $SE = .135$, $p < .000$) conditions than in the loose ($M = 4.09$, $SE = .146$) coupling condition. There was no significant difference in perceived importance between the tight and medium coupling conditions ($p = 0.25$).

Mode Ranking. There were significant main effects of interdependence on overall mode preference ($F_{2,142} = 10.5$, $p < .001$, $\eta_p^2 = .129$) with participants ranking tight coupling higher ($M = 1.61$, $SE = .085$) than both medium ($M = 2.32$, $SE = .086$, $p = .000$) and loose ($M = 2.07$, $SE = .100$, $p = .007$) coupling.

There was a slight but significant correlation between participant pairs' combined skill ratings and their overall mode preferences as well, with higher skilled pairs tending to prefer tight coupling ($R = -.240$, $p = .0.43$) and lower skilled pairs tending to prefer loose coupling ($R = .300$, $p = .002$); partially confirming our hypothesis (H6).

Generally, our player experience metrics indicated a trend towards improved perceptions of social connectedness as we manipulated our prototype's mechanics to increase asymmetry and interdependence. As we generated those mechanical manipulations based on the conceptual design primitives described by Harris et. al. [20] (e.g. frequency/direction of dependence), our results thus lend some credence to the utility of their framework for design as well.

7 DISCUSSION

In the following discussion section, we reflect on our qualitative observations and a thematic analysis [5] of our two player studies based on participants' gameplay recordings and interview responses. We highlight the numerous subtle complexities we encountered in both the design and play experiences of our two prototype variations.

Emergent Cooperation vs. Designed Interdependence

Even in our first study's symmetric condition, we observed participants discovering ways to be dependent on one another and thus create spontaneous asymmetry. For example, participants would heal each other in the Twin Kirk condition or help each other to complete levels by having the more skilled player trigger level transitions for both players. On the other hand, some participants (e.g., some particularly skilled dyads) would leverage these spontaneous asymmetries within the symmetric condition to "compete", for example by "rushing" to the end and preventing the other symmetric player from completing the level on their own.

Thus we further refine Zagal et al.'s conception of collaborative games [39] by highlighting how cooperation can be designed to be either required or optional. Consider Super Kirk's "heal" ability specifically: because of its area of effect, there was nothing mechanically preventing one Super Kirk player from using their ability to heal their partner Super Kirk. In this way, the two Super Kirks could *choose* to cooperate but their symmetric abilities did not *require* that they do so. Compare this to an earlier iteration of the Super Kirk character (not used in our present studies) that saw a Super Kirk's heal ability affect only herself. As such, it was mechanically impossible for one Super Kirk to heal another. By leaving the mechanical possibility for one Super Kirk to aid another but not require it, designers can leave space open for "emergent cooperation". Contrast this with the "Split" condition where only Scotty can heal Kirk and this can be viewed as a form of "designed interdependence" between the two players as regards Kirk's health and survival.

The Rhythm of Interdependence

When queried as to their overall preference of play modes, participants expressed clear favourites but many also described how they would most prefer to be able to shift and alter their interdependence with their partner over the course of play. They were cautious about being locked into a single dynamic over the course of a hypothetical full game (e.g., dozens of hours of play). As one participant described, "Shake it up from level to level, don't have the same style of dependence every time." [S2, P129] suggesting that sometimes both the direction and intensity of dependence should vary over time throughout play.

This mirrors the concept of "interest curves" from both game and film literature [31] wherein it is actually counter to overall audience enjoyment to present a sustained level of high excitement/interest over the full course of an experience. Rather than providing "more of a good thing", audiences eventually become bored and fatigued without being provided opportunities to relax and process the moments of intensity during complementary periods of calm. We would expect to encounter similarly ideal "rhythms of interdependence" in the design of more full-fledged asymmetric cooperative games.

Tedious Reliance vs. Thoughtful Contributions

From our observations, it is not necessarily enough to simply have players "wait on others' actions" (as described by Beznosyk [4]). Rather, a partner's action is better received when that partner overcomes their own challenges in order to make a meaningful contribution to the team. For example, having Scotty wait for Kirk to bark "Shock!" once her axe was embedded in an enemy during the tight coupling condition was viewed as frustrating. As one participant described, "This isn't a challenge. It's just tedious." [S2 P135]. Yet Scotty calling out navigation directions (e.g. "left, right, straight") for Kirk after using their unique perspective to plot a course was much better received despite the similar pattern of command/action. During interviews, participants highlighted the distinction of Scotty having to put thought into their contribution rather than just the rote response of pressing a button when mindlessly commanded to.

In this vein, participants were also queried about *BMRS2*'s support of their shared situational awareness by proposing two hypothetical design changes: one which improved support by adding more cues (e.g. edge-of-screen position indicators when Scotty's deployed abilities outside Kirk's field of view) and another which reduced support (e.g. by preventing Scotty and Kirk players from seeing each others' screens at all). Despite significant prior research studying the utility and design of such cues [1, 33, 36, 37], responses were split with some pairs anticipating reduced frustration but others viewing such cues as thwarting the need for tight verbal communication; which they viewed as the core appeal of *BMRS2*.

The Tangled Web of Ability Tuning

For each condition in study 2, the specific timing and directions of coordination between participants was varied for Scotty's five abilities in order to manipulate the degree of coupling between the two players. However, in order to maintain a degree of experimental control, the theme of each ability (i.e. heal, shield, shock, beam, and teleport) and their other factors such as energy costs, damage, and duration were held constant. Yet it is important to note that the *combination* of these (non-)changes could still potentially alter the overall efficacy of each ability. That is, in the loose coupling condition, Scotty players could typically deploy their abilities unilaterally but in the tight coupling condition, Kirk players would typically have to intervene in some way before Scotty players' abilities could be fully utilized. In terms of balance/tuning, it could be argued that this made Scotty's abilities more cumbersome to use in the tight coupling condition and potentially less powerful for participants unable to coordinate smoothly. In a more realistic design scenario then, the need to balance or tune the different abilities becomes important in addition to considerations of asymmetry and interdependence: if tightly coupled abilities are more difficult for player pairs to deploy, these more difficult to use abilities should be comparatively more powerful/effective in order to compensate and to ensure every choice of coupling degree is viable, interesting, and worthwhile.

Design Recommendations

As both game designers and experimenters, we argue that the tension between thoughtful interdependence and frustrating tedium is one of the most important challenges in the design of asymmetric cooperative games. Simply making the constraints of collaborative actions faster, more frequent, or multi-directional is not guaranteed to have the intended aesthetic effect depending on both the low-level game mechanics and higher-level social context in question.

The flexibility in choices available to players is also a difficult balance to strike in asymmetric game design. Generally, games which allow players to tailor the difficulty and combination of mechanics in play might be able to appeal to a wider range of player tastes. However, as our participant feedback has highlighted repeatedly, the constraints imposed on players via asymmetry and the deliberate interdependence asymmetry creates between players is one of the core strengths and appeals of asymmetric cooperative play. The "Super Kirk" condition of our first player study sums up this challenge cleanly: able to deploy all of Scotty's abilities on their own, Super Kirk is clearly more powerful and Scotty becomes unnecessary. But is that power (and independence) something play partners actually want? And should the game's designers even give players the choice of playing as Super Kirk?

We are faced with a vastly multi-dimensional space that must incorporate challenge, player aptitude, autonomy, asymmetry, social context, and many other variables in order to map out a "sweet spot" for interdependence à la Csikszentmihalyi's [6] more tractable challenge vs. aptitude concept space popularized in "flow theory". As any single mechanical detail is tweaked, it is likely to have numerous follow-on effects on seemingly unrelated game elements. In our experience, while conceptual/design frameworks can assist in this endeavour, there are few more effective substitutes than in-depth design practice, concrete prototyping, repeated iteration, and hands-on player feedback.

8 LIMITATIONS AND FUTURE WORK

Just as player experience phenomena observed in *Tetris* [25] do not necessarily generalize to experiences playing *Dark Souls* [14], our explorations are necessarily limited by the particular game being investigated. Many of the changes made to *BMRS2* in pursuit of our player studies' specific scientific goals had numerous unanticipated repercussions on other elements of the game's mechanics, dynamics, and aesthetics. As Hunicke et al.'s [21] MDA framework discusses, it is important to be mindful that each game is a unique amalgam of design and social context that is as much steered by their designers' vision as they are their players' input. Even in *BMRS2*, the introduction of a second Kirk-style avatar in certain conditions, rather than just a case of "adding more or the same", had the unanticipated effect of making level transitions an interaction mechanic: with faster players alternately helping/hindering their partners based on when they triggered each exit.

We intend to investigate the impact of varying the intensity of interdependence over a play session for future work. It remains unclear how different rhythms of interdependence (i.e. variability in pacing and intensity of play, given the same interdependence mechanics) may alter players' social experiences.

9 CONCLUSION

In this paper, we present the findings of a pair of player experience studies that compared asymmetric play to symmetric play, and within asymmetric play, the degrees of designed interdependence. We found that social presence and perceptions of connectedness were higher in asymmetric play than symmetric play, and higher in tightly-coupled asymmetric play than loosely-coupled asymmetric play. These same trends were also found for immersion, behavioural engagement, and even understanding and comfort with the game's controls. We also reflect on several themes that emerged, including the need for designers to consider both emergent cooperation vs. designed interdependence as well as whether, how, and when to provide flexibility in the degree of interdependence.

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