Exploring Patterns of Shared Control in Digital Multiplayer Games

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Abstract. This paper investigates the concept of shared control to design for innovative and enjoyable multiplayer experiences. More research on collective control over a single game character could support the design of compelling social experiences and provides insights in how the social context affects individual player experience. Hence, this paper addresses two perspectives: game design and game user research. First, a classification of possibilities to implement shared control is presented. As a proof of concept the shared control game *Shairit* was developed. Furthermore, we present an empirical study researching the impact of player interdependency on player experience induced by different forms of shared control implemented in *Shairit*. Results indicate that varying degrees of player interdependency in shared control do not provide fundamentally different player experiences in terms of need satisfaction, social presence and enjoyment. Further, findings suggest that a loss of individual control and feedback should not be associated with negative experiences per se, but should rather be acknowledged as legitimate mechanics to induce enjoyment in a multiplayer setting.

Keywords: Shared control · Distributed control
Collaborative games · Team play · Interaction design
Player experience · Need satisfaction · Game design

1 Introduction

In 2014, the implementation of *Twitch Plays Pokémon* (TPP)[1] led to a striking social phenomenon in the context of digital multiplayer gaming. TPP was an interactive gaming stream of the popular game *Pokémon Red* on the streaming platform *Twitch*[2], which allowed all viewers to simultaneously control a single game instance by typing game commands into the integrated chat system (i.e. "up", "a").

This form of shared control was a great success: In sum 1,165,140 individual players actively participated in the project, and 9+ million were spectating

[1] http://twitchplayspokemon.org/ - 2017/07/30.
[2] https://www.twitch.tv/ - 2017/07/30.

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with a peak of 121,000 individual comments being simultaneously entered.[3] The resulting gameplay was chaotic. A great number of conflicting commands was entered by players at every moment, whereas the game actually only processed and displayed one of them. Furthermore, the stream suffered from a delay of 30 s between the submission of a chat command and its eventual execution, thus probably preventing players from comprehending their contribution. The whole game design contradicts several basic game design principles regarding input processing and the provision of direct feedback (e.g. Chap. 8 in [1]).

Hence, the TPP phenomenon raises questions regarding the players' motivations and experiences. The sharing of control over a single game character constitutes an extreme situation in terms of interdependency between players. Thus, shared control could expand the list of interdependency subtypes recently examined by Borderie and Michinov in context of social flow experiences [4].

Common theories on player experience highlight the importance of feelings of competence, autonomy, and relatedness [20]. It can be assumed that sharing the control over a game leads to a reduced sense of autonomy and competence, thereby interfering with game enjoyment. However, the popularity of TPP implies the capability of shared control to induce highly interesting and motivating social experiences. This might be due to an increased feeling of relatedness. It is known that social aspects are a main motivation to play digital games [20,22] and that the social context of gaming affects the overall experience [5,6]. The social dynamics of shared control in TPP seem to be motivating enough for players to play a game that did not even react reliably on their input, indicating that social aspects may indeed suppress the impact of other player experience factors. Thus, an imbalance of player experience dimensions apparently does not necessarily impair game enjoyment. In general, more research on the interplay of social interaction and other dimensions is needed to explain which aspects are important for a positive experience. Hence, it is promising to further examine the concept of shared control in the context of digital games, player experience, and need satisfaction.

This paper contributes a systematic approach in this context. We provide a distinct terminology and a comprehensive classification to discuss different forms of shared control in digital games, revealing the wide range of design possibilities. Moreover, we present results of a study comparing different forms of shared control based on an exemplary implementation of a game with four different game modes. Those results provide insights into how shared control can influence need satisfaction and game enjoyment. Hence, our work informs researchers and game designers interested in designing compelling social experiences based on the shared control concept.

[3] https://blog.twitch.tv/tpp-victory-the-thundershock-heard-around-the-world-3128a5b1cdf5#.jkda9l2cm - 2017/07/30.

2 Game Enjoyment as Need Satisfaction

Ryan and colleagues [20] introduced a model that defines game motivation and enjoyment as the satisfaction of psychological needs based on their Self-Determination Theory (SDT). In the context of games, SDT assumes that players are intrinsically motivated to play games that provide satisfaction of their basic needs for competence, autonomy, and relatedness. In order to assess need satisfaction in games, they developed the Player Experience of Need Satisfaction questionnaire (PENS) [16]. Their approach was applied and validated in various studies [10,15,20,23], which account for its relevance in game research today. Recently, a review of the immersive experience questionnaire (IEQ), the game engagement questionnaire (GEQ), and the PENS was conducted, which are all three widely used and known instruments to assess player experience [7]. According to this recent analysis, PENS and other approaches are adequate to assess facets of player experience, even if they differ in advantages and disadvantages. After all, the trichotomy of competence, autonomy, and relatedness satisfaction is intuitively reflected in the discussion about TPP, as its shared control mechanic seems to impair competence and autonomy, but enhances relatedness satisfaction. Because of this intuitive matching, SDT and PENS are used in this paper to guide an initial investigation of player experience induced by shared control.

According to Ryan and colleagues [20] games provide feelings of competence, if players get opportunities to attain new skills by overcoming optimal challenges and receive positive feedback on their actions. Optimal challenges are difficult to overcome, but nevertheless possible to master. Additionally, they comprise a clear goal definition, thus players exactly know what they try to achieve. Games provide a feeling of autonomy, if they make players feels as they are acting volitionally, i.e. the in-game actions they conduct are in line with their inner selfs and values. This feeling is not necessarily based on the number of choices a game offers, but on its potential to generate commitment and volitional engagement for the actions a player can take [17]. To foster feelings of relatedness, games have to provide individual players with moments of relevance, in which they have the opportunity to acknowledge, support, and impact each other. Experience of relatedness is not only supposed to refer to human players, but can also be experienced during the interaction with single player games that provide non-player characters [17].

3 Towards a Classification of Shared Control

Shared control can intuitively be understood as a game control mode, in which players collectively control one single game character. However, the possibilities to implement shared control are manifold. Therefore, we argue for a more precise definition and suggest a systematic categorization of shared control patterns based on the review of commercial games and related literature.

Shared Characters belong to design patterns for collaboration [21]. This game mechanic allows players to distribute control over several characters among each other. *Lego Star Wars*[4], for example, provides a pool of several characters, between which players can actively switch, as long as the desired character is not controlled by someone else. Thus, players have to collaboratively coordinate who should control which character. An example that illustrates how sharing a single character simultaneously can be realized is the game *Octodad: Deadliest Catch*[5]. It makes up to four players collectively control the main character of the game by distributing control over its extremities among players. In contrast, the more recent arcade racing game *Trackmania Turbo*[6] allows two players to control speed and direction of the same car simultaneously. Based on the latter two examples shared control can be related to the notion of *Concurrent Timing* by Harris et al. [8]. Thus it would be a subtype of synchronized actions that allows players to simultaneously control their respective in-game actions in context of an interdependent task. Although Harris et al.'s types of synchronized actions can be used to conceptually describe shared control, it seems not applicable to define distinctive forms of shared control, since it does not account for the different ways multiple players can be represented in the game (eg. sharing one representation vs. alternating between representations). In conclusion, shared control does not necessarily refer only to the sharing of control in terms of performed actions, but also to a sharing of a player representation, and how the two aspects relate to each other.

It is important to note that not all games are avatar-based like *Octodad* and represent players as a personalized entity like a character. *Trackmania Turbo* provides no character as player representation and games like *Tetris*[7] do not have any explicit player representation at all. Since it should not be important what type of player representation is collectively controlled, a neutral term should be used to prevent discussion on shared control from being biased against a specific type of player representation. In sum, a classification of shared control should account for aspects of player actions and player representations, and be independent from a specific type of player representation.

A term that ensures independence from types of representation is *Locus of Manipulation* (LoM). An LoM is defined as the "in-game position of the player's ability to assert control over the game-world" [2]. In other words, any perceptible in-game instance that proves a player's manipulation of the game world.

Regarding the aspect of sharing control over in-game actions Loparev et al.'s [11] work provides an initial distinction of basic shared control principles. With *WeGame* they introduced a middleware solution that allows players to play existing single player games collectively in a co-located setting [11]. It included an alternation of control corresponding to traditional gamepad passing, as well as simultaneous control that allows players to simultaneously control a shared character.

[4] (Traveller's Tales, 2011).
[5] (Young Horses Inc., 2014).
[6] (Nadeo, 2016).
[7] (Nintendo, 1985).

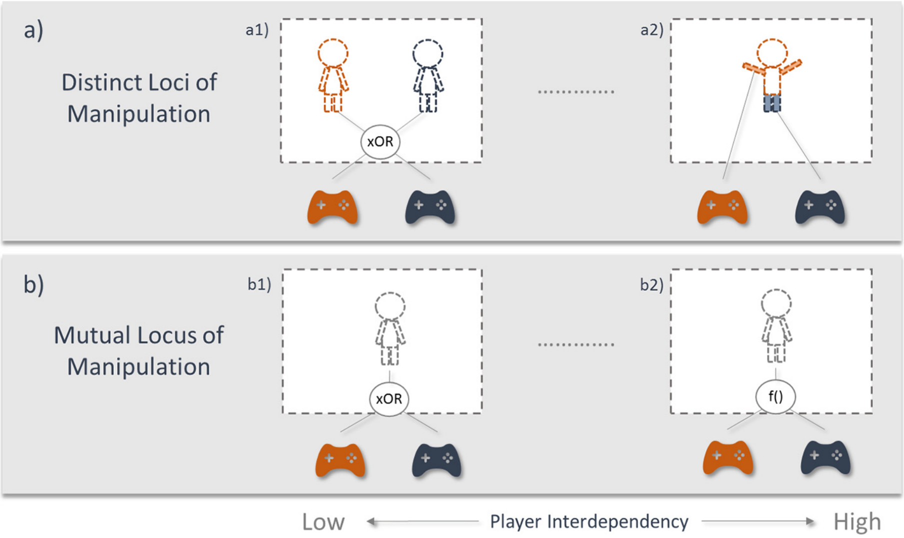

Fig. 1. Types of shared control: (a) Two players share two distinct LoM. (b) Two players share a mutual LoM. (a1) Sharing control of distinct LoM through control alternation. (a2) Sharing control of distinct LoM that establish a coherent entity. (b1) Sharing control of a mutual LoM by control alternation. (b2) Simultaneous control of a mutual LoM through input processing function.

Based on the distinction between alternating and simultaneous control and the concept of LoM, Fig. 1 illustrates a classification of shared control. Hence, shared control is basically defined either as the sharing of distinct LoM, or as the sharing of a mutual LoM (Fig. 1a, b). Within these two types, several variations are imaginable that differ in the degree of player interdependency (Fig. 1a1, a2, b1, b2). The classification is further described in the following.

3.1 Shared Control of Distinct Loci of Manipulation

Sharing the control of distinct LoM describes a pattern where each player of a multiplayer game controls at least one LoM that is not simultaneously controlled by another player at any point in time. At the same time players switch between those shared LoM, or are at least highly dependent from each other because they establish a coherent entity.

Further, by varying player interdependency, two specific implementations of sharing distinct LoM are imaginable as the extremes of a continuous dimension. Figure 1(a1) illustrates the lower end of this continuum, a pattern that is implemented for example in *Lego Star Wars*, where each player controls a distinct character, with the possibility to switch between various shared characters. This reflects a low degree of player interdependency, since players are able to manipulate the game world rather autonomously through their individual LoM. Nevertheless they are not completely autonomous, because they cannot simply switch to an LoM that is controlled by another player. A high degree of player interdependency is illustrated in Fig. 1(a2), where each player indeed controls a distinct LoM, though their LoM establish a coherent entity that disables them from acting completely autonomously. This control pattern is for example implemented in *Octodad: Deadliest Catch*, where each player controls a limb of the protagonist and individual opportunities to manipulate the game world significantly depend on other player's actions.

3.2 Shared Control of a Mutual Locus of Manipulation

Sharing a mutual LoM describes a shared control pattern, where at least two players of a multiplayer game control the same main LoM at the same time.

Again, a variation of player interdependency could lead to two imaginable extreme implementations of this pattern: sharing a mutual LoM with low player interdependency as illustrated in Fig. 1(b1), where control alternates between two players, though the player not in control has no other LoM to control. This pattern is implemented for example in *WeGame's Sequential* mode [11]. Figure 1(b2) illustrates a high degree of player interdependency, where players simultaneously control a mutual LoM. Their collective manipulation depends on a specific processing function that defines how the individual parts of collective input are represented in the final manipulation. For example, in *Trackmania* the direction of player input is averaged, resulting in a combined direction. Actually, several combinations of input directions would then lead to no change of direction at all. In contrast, *WeGame's Legion* mode weighted individual player input based on similarity to other player's input. Hence, its processing function calculated a final command that does not equally represent all incoming inputs.

3.3 Player Interdependence in Shared Control

As visualized in Fig. 1, the degree of player interdependency allows for an unspecified number of variations to design shared control that are not further specified in this paper. Though, several examples of general approaches to vary player interdependency are provided. Generally, hybrid forms of sharing distinct and mutual LoM are imaginable and for example implemented in *WeGame's Legion* [11] mode which allows players to dynamically change the set of distinct LoM (distinct abilities of a character) they want to control. Thus, some players may collectively control for example the movement (mutually shared LoM), whereas others control the usage of a certain special ability (another mutually controlled LoM that is distinct from the movement). Additionally, certain features of shared control allow for further variation, as for example the alternation of control could be varied by the sequence (random vs. fixed, depending, or dynamic factors), the frequency of alternation, and the use of feedback mechanics (visualizing the duration of control). Correspondingly, simultaneous forms of shared control could differ between their input processing, transparency of individual contribution, and the enforcement of collective input.

4 Shairit - A Shared Control Game

The shared control game *Shairit* was developed to systematically evaluate shared control of a mutual LoM as it was implemented in TPP. Furthermore, it extends *WeGame* [11], by implementing variations of alternating and simultaneous control. *Shairit* includes four control modes, which can be categorized as sharing control over a mutual LoM with various degrees of player interdependency. It was developed to examine whether different implementations of shared control work as an entertaining game in a small group setting and to initially investigate player experience in terms of enjoyment, need satisfaction and facets of sociality.

Shairit is a four-player collaborative local multiplayer game, whereby its game modes mainly differ in the implemented control mechanic. Players share the control over a single LoM that is represented as a sphere (see Fig. 2). The four modes include two modes with alternating control and two modes with simultaneous control. Throughout 13 levels players have to collect several orbs by navigating the sphere. The source of conflict arises from different types of cubes that have to be used or bypassed to reach the orbs. Obstacle cubes are, as the name implies, obstacles players have to navigate around. They are static and can neither be moved, nor jumped on. Push cubes can be pushed by colliding with them. Jump cubes (Fig. 2) can be jumped on. Death cubes (see Fig. 2) are either static or patrol between waypoints. When players collide with them, the actual level's progress is reset and the LoM will respawn at the starting position. Death cubes can be moved by pushing push cubes against them. The game is controlled by *Xbox One/360* gamepads, utilizing only two or three input modalities of it, depending on the control mode. Players navigate the sphere with the left analog stick and jump by pressing "A". The shoulder button is used to conduct special actions in two of the four modes.

4.1 Alternating Control Modes

In the alternating control modes, LoM control alternates between players, what reflects the pattern shown in Fig. 1(b1).

Low Player Interdependency Mode. In the Alternating Control mode with low player interdependency (Alternating-Low), control over the sphere alternates every five seconds between players in a fixed sequence. To conduct a seamless transition, players could try to imitate the inputs of the active player. To indicate which player has control over the LoM, player-specific icons appear above the sphere (see Fig. 2). Interdependency is assumed to be low, because individual actions do not directly affect each other.

High Player Interdependency Mode. The Alternating Control mode with high player interdependency (Alternating-High) alternates control in randomized order every five seconds. Due to the randomizing, players cannot simply internalize control alternation and consequently should pay more attention to

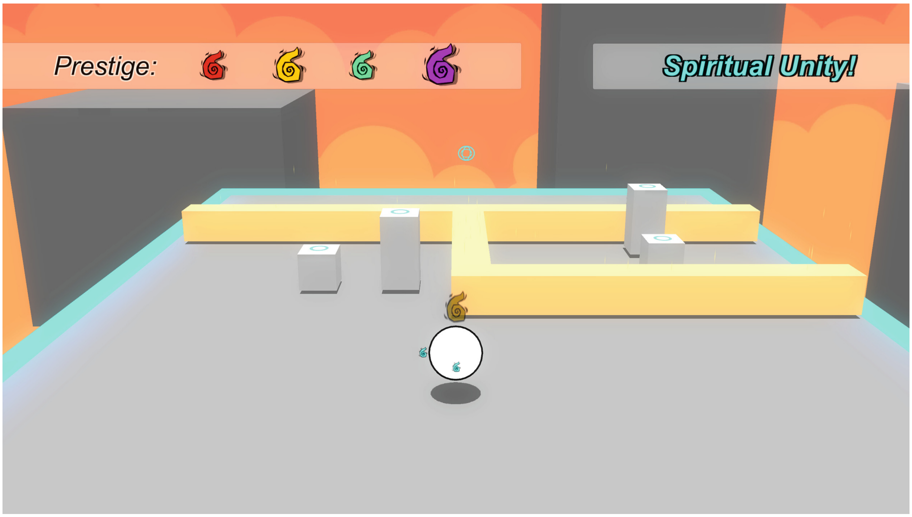

Fig. 2. In *Shairit* players have to collect turquoise orbs. Screenshot shows the Alternating Control mode with high player interdependency. To reach the orb in the back of this level players have to get over the yellow death cubes by jumping from jump cube to jump cube

play the game seamlessly. Furthermore, interdependency is increased by a voting system. It allows players that are not in control, to vote for the currently controlling player by pressing the gamepad's shoulder button. If the active player receives votes from all others, he is granted another time frame of control, in which players can vote again. Thus, the mode allows players to manipulate the control sequence. As in Alternating-Low mode, icons above the sphere visualize which player currently has control. Additionally, it indicates the remaining control time by slowly vanishing (see Fig. 2). Furthermore, players are provided with individual and group feedback on the similarity between their inputs during a control alternation, which is called prestige. It shall enhance player communication and is visualized on the top border of Fig. 2, with individual prestige on the left and group prestige on the right side.

4.2 Simultaneous Control Modes

In the simultaneous control modes, players simultaneously control a shared LoM, what reflects the pattern shown in Fig. 1(b2).

Low Player Interdependency Mode. In the Simultaneous Control mode with low player interdependency (Simultaneous-Low), players can navigate the sphere simultaneously. Their input values are averaged each frame and processed into a combined movement direction. This input processing can lead to situations, where diametrical inputs do not result in movement at all. Player interdependency is assumed to be rather low (but higher than in the alternating control modes), because the mode does not require collective contribution to win the game. Theoretically a single player could play alone, without other players' contribution. Thus, collective input actually increases the difficulty.

High Player Interdependency Mode. Simultaneous Control mode with high player interdependency (Simultaneous-High) allows players to simultaneously navigate the sphere, but requires collective input to overcome certain obstacles in the game. This is caused by a certain input processing function that increases movement speed for each player that conducts input. Thus, if only one player is conducting input, the sphere is moving with just one fourth of its maximum speed. Consequently, this mechanic is assumed to induce high player interdependency. Further, players are provided with individual and group feedback as in Alternating-High mode (see Fig. 2). Here, the individual prestige increases or decreases based on similarity between player inputs. If a certain threshold is reached, pressing the shoulder button consumes individual prestige and grants exclusive control for five seconds, indicated by an icon above the sphere. This mechanics shall foster discussion on strategic use of prestige and thereby increase player interdependency.

5 Evaluation

The game *Shairit* was used to systematically evaluate player experience induced by different implementations of shared control. Additionally, we wanted to explore, if game enjoyment may be caused by different facets of player experience depending on the played mode. Therefore, our investigation was guided by the following two questions:

(1) Do various shared control modes induce different player experiences in terms of enjoyment, need satisfaction or social presence?
(2) Do various shared control modes cause different associations between game enjoyment and other facets of the player experience?

5.1 Study Design

To answer our research questions, we used a between-subject design with four study conditions in accordance with the four game modes of *Shairit*. Hence, the form of shared control serves as independent variable. As dependent variables, we assessed diverse dimensions of player experience including enjoyment, need satisfaction, and social presence.

Procedure and Measures. The study was conducted under controlled conditions in a laboratory at the university. As the game is designed for four players, participants were required to participate as groups of four people. Participants could either directly register as groups of acquainted people, or as singles that were organized to form a quartet by the examiner. All groups were randomly assigned to one of the four study conditions.

First, participants were asked to individually complete a pre-play questionnaire that assessed demographic data as well as their experience with digital games ("no experience at all" (1) to "highly experienced" (5)), and their familiarity ("stranger" (1) to "close friend" (5)) with each other as potential confounding variables. After that, the examiner explained the game's objective, rules and control principle. Then participants had to play all 13 levels successively. The game was projected on a wall via beamer and players sat on a sofa during play, using wireless *Xbox One* gamepads to control the game. As such, the laboratory provides a rather homelike atmosphere for the multiplayer setting. The examiner sat in the back and did not interfere in gameplay unless being asked direct questions. If progress in a level stagnated for more than five minutes, the examiner offered the opportunity to skip the current level. On average, the game was completed in about 20 min and only few groups had to skip the most difficult level. Conclusively, participants completed a post-play questionnaire that assessed their player experience in terms of enjoyment, need satisfaction, and social presence.

As a measure of enjoyment and intrinsic motivation the corresponding subscale of the Intrinsic Motivation Inventory (IMI) [19] was applied. The IMI was identified as a widely used instrument to measure game enjoyment [12]. Additionally, is was chosen because the notion of intrinsic motivation is directly linked to the satisfaction of psychological needs, i.e. need satisfaction leads to the emergence of intrinsic motivation to engage in playing games [3,13,14]. The sub-scale consists of seven items that have to be rated on a 7-point Likert scale (e.g. "I enjoyed playing *Shairit* very much"). PENS Accordingly, the PENS [16] was applied to assess levels of psychological need satisfaction. On three sub-scales it refers to the satisfaction of *competence* (PENS-C), *autonomy* (PENS-A), and *relatedness* (PENS-R). Furthermore, the sub-scale *intuitive control* (PENS-IC) was included in the study, because it seemed adequate to evaluate how far shared control as a control pattern is perceived as intuitive. The PENS asks participants to reflect on their player experience when playing *Shairit* and to rate all items on a 7-point Likert scale.

Finally, the experience of social presence and the perceived quality of the social interaction between team mates was assessed by the Cooperative Social Presence (CSP) sub-scale of the Competitive and Cooperative Presence in Gaming Questionnaire (CCPIG) [9][8]. It is designed for the evaluation of collaborative digital games and is divided into the two dimensions *perceived team cohesion* and *team involvement*. Team cohesion represents the level of perceived effectiveness and successful collaboration of the team. Team involvement refers to the degree of involvement, investment and dependency in a team. The questionnaire asks respondents to indicate their agreement with each statement on a 5-point Likert scale.

[8] The CCPIG can be found at: https://www.sites.google.com/site/ccpigq/downloads - 2017/07/30.

Table 1. Mean values and standard deviations regarding age, gender, familiarity, and game expertise among condition groups.

	Alternating-Low ($N = 24$) M (SD)	Alternating-High ($N = 32$) M (SD)	Simultaneous-Low ($N = 19$) M (SD)	Simultaneous-High ($N = 19$) M (SD)
Age	25.38 (3.29)	21.03 (2.62)	22.11 (3.07)	25.32 (3.73)
Gender	14 male 8 female	4 male 27 female	8 male 11 female	14 male 5 female
Familiarity	2.83 (1.53)	3.56 (1.31)	2.79 (1.44)	2.95 (1.25)
Expertise*	3.71 (1.04)	2.31 (0.93)	2.95 (1.18)	4.00 (1.00)

* Significant differences between certain groups were found.

5.2 Results

In sum 96 subjects (24 groups) participated in the study. However, data of two participants was excluded from the analysis due to incomplete data sets. Hence, the final sample includes 94 participants (40 male, 52 female, 2 prefer not to say). Age of participants ranges from 18 to 33 years ($M = 23.22,\ SD = 3.67$). Participants were students recruited at the university, who received certification of participating required for certain lectures. The distribution of participants among groups and corresponding mean scores of their attributes age, gender, game expertise, and familiarity is presented in Table 1. The distribution of male and female participants among the conditions is notably unequal and will be considered when controlling for potential confounding effects of game expertise and familiarity. For all following analyses, preconditions for parametric procedures were tested in advance. In case of violated assumptions of normality or homogeneity of variances, corresponding non-parametric tests were applied. If relevant, further assumptions of methods are specified in the following.

Differences Between Conditions. In order to test if groups differ in terms of player experience (research question 1), analyses were conducted to compare mean values regarding enjoyment, need satisfaction, and social presence. Mean values can be found in Table 2.

In general, scores for enjoyment (IMI) tend to be rather high in all groups. A Kruskal-Wallis test shows no significant difference between groups ($\chi^2(3, N = 94) = 5.017,\ p = .16$).

Mean scores for perceived competence are all moderately high and highest in the Simultaneous-High condition. Autonomy means are also moderately high except for a medium score in the Alternating-Low condition. Scores for relatedness are rather moderate, and high in Simultaneous-High mode. To test the significance of these group differences in need satisfaction, analyses of variance were conducted. Results indicate that the type of game mode had no main effect on perceived competence ($F(3, 90) = 1.36,\ p = .26$), autonomy ($F(3, 90) = 1.94,\ p = .13$), or relatedness ($F(3, 90) = 1.48,\ p = .23$).

Table 2. Mean values and standard deviations regarding all investigated dependent variables in the four study conditions.

	Alternating-Low ($N = 24$) M (SD)	Alternating-High ($N = 32$) M (SD)	Simultaneous-Low ($N = 19$) M (SD)	Simultaneous-High ($N = 19$) M (SD)
IMI	5.35 (1.19)	5.208 (1.29)	4.63 (1.60)	5.58 (1.20)
PENS-C	4.46 (1.56)	4.13 (1.68)	4.25 (1.49)	5.00 (1.35)
PENS-A	3.43 (1.19)	4.08 (1.23)	4.02 (1.45)	4.32 (1.34)
PENS-R	3.96 (0.97)	3.98 (1.15)	3.40 (1.35)	4.12 (1.16)
PENS-IC*	6.01 (1.12)	5.76 (1.04)	6.18 (0.75)	6.53 (0.60)
CSP-TC*	4.10 (0.57)	4.28 (0.63)	3.73 (0.82)	4.31 (0.47)
CSP-TI	4.23 (0.49)	4.27 (0.44)	3.66 (0.93)	4.23 (0.45)

* Significant differences between certain groups were found.

Social aspects were investigated by comparing scores for perceived team cohesion and team involvement. Mean scores for both are lowest in the Simultaneous-Low condition, as compared to rather high means in the other three conditions. A Kruskal-Wallis test partly validates this descriptive impression and reveals a significant difference between groups in terms of team cohesion ($\chi^2(3, N = 94) = 8.34,\ p = .04$). Based on a Bonferroni post hoc analysis participants perceived a significantly lower degree of team cohesion in the Simultaneous-Low condition compared to the Alternating-High condition ($z = -2.674,\ p = .045$). Contrarily, a Welch ANOVA shows no main effect of game mode on perceived team involvement ($F(3, 43.55) = 2.37,\ p = .084$).

Control was perceived as highly intuitive in each mode, as illustrated in Table 2. Only control of the Alternating-High mode tended to be rated as less intuitive compared to other modes. A Kruskal-Wallis test was calculated to compare measures of intuitive control between groups. The test indicates that there is an overall significant difference ($\chi^2(3, N = 94) = 9.21,\ p = .027$). Post hoc Dunn-Bonferroni tests reveal that players experienced higher intuitive controls in Simultaneous-High condition than in Alternating-High ($z = 3.02,\ p = .015$). All other pairwise comparisons are not significant.

Controlling for Game Expertise and Familiarity. Game expertise and familiarity of players might have affected perceived need satisfaction and the social experience. To investigate whether these aspects have influenced the analysis of group differences, we included them in our analysis as potential confounding variables. Hence, we tested for preconditions and assumptions of an analysis of covariance. For both variables, we analyzed group differences and associations with dependent variables in each group.

In terms of mean familiarity, differences between groups are not significant according to a Kruskall-Wallis test ($\chi^2(3, N = 94) = 5.204,\ p = .16$). To check for a potential confounding effect, associations between familiarity and the dependent variables were investigated based on scatterplots and Pearson's r. We assumed a linear relationship, if scatterplots and correlation coefficients indicated a linear association. Familiarity is only significantly correlated with relatedness in the Simultaneous-High condition ($r = .486, n = 19,\ p = .035$) and with team cohesion in the Alternating-Low condition ($r = .623, n = 24,\ p = .001$). Since a systematic linear relationship between familiarity and the dependent variables in all conditions is a main precondition for the analysis of covariance, it can be concluded that familiarity seems to have no general confounding effect on the dependent variables in our study.

The distribution of gender and game expertise among the four study groups is rather uneven as indicated by mean values (cf. Table 2). Both aspects seem to be closely related. An independent samples T-test reveals a significant difference between male and female participants in terms of game expertise ($t(90) = 8.61\ p < .001$), indicating that men had more experience with digital games ($M = 4.05, SD = .845$) than women ($M = 2.4, SD = .955$) in our sample. Correspondingly, a one-way analysis of variances shows a general significant difference between the four study conditions regarding the reported expertise ($F(3, 90) = 14.06,\ p < .001$). Dunn-Bonferroni post hoc tests indicate that participants in the Alternating-High condition, which also is the group with the smallest number of male players (4 males, 27 females), reported significantly less game expertise ($M = 2.31$) than participants in the Alternating-Low ($M = 3.71,\ p < .001$) and in the Simultaneous-High condition ($M = 4,\ p < .001$), which are the two groups that contained considerably more male than female players. To control for potential confounding effects of game experience on our dependent variables, correlations between game expertise and those variables were examined. Pearson's r values and scatterplots show only two significant correlations: game expertise is positively correlated with competence in the Alternating-High ($r = .381, n = 32,\ p = .032$) and the Simultaneous-Low condition ($r = .545, n = 19,\ p = .016$). Thus, the assumption of a linear relationship between the potential covariate game expertise and the dependent variables in each condition is violated. Accordingly, no further analysis of covariance for game expertise was conducted, as no confounding effect is indicated.

Associations Between Enjoyment and Facets of Player Experience. To address our second research question, we calculated correlations between IMI scores and the other dependent variables in order to gain insights into what specific dimensions of game experience account for the degree of enjoyment.

For reasons of clarity Table 3 summarizes Pearson's r coefficients of relationships between IMI scores and the other dependent variables for each condition. The perceived level of need satisfaction was positively associated with enjoyment in almost every combination. Only in the Simultaneous-High condition relatedness was not correlated with the IMI scores. Measures for social presence were positively associated with enjoyment in the Simultaneous-Low condition. Additionally, team cohesion was found to be positively correlated with IMI scores in the Alternating-Low, and Team Involvement in the Simultaneous-High condition.

Table 3. Significant Associations between IMI and other Dimensions of Player Experience for each Mode

	Alternating-Low ($N = 24$)	Alternating-High ($N = 32$)	Simultaneous-Low ($N = 19$)	Simultaneous-High ($N = 19$)
IMI with	r	r	r	r
PENS-C	.709**	.538*	.535*	.719**
PENS-A	.651**	.352*	.785**	.81**
PENS-R	.656**	.391*	.538*	.306
CSP-TC	.455*	.048	.622**	.321
CSP-TI	.402	-.047	.640**	.576**

* Correlation is significant at the .05 level (2-tailed)
** Correlation is significant at the .01 level (2-tailed).

6 Discussion

Generally, playing *Shairit* proved to be an entertaining experience. This conclusion is justified by the reported high enjoyment scores as well as by observations made during gameplay. Consequently, shared control can provide an enjoyable experience not only as an extension for existing single player games [11], but also as a core mechanic.

6.1 Differences in Player Experience

The shared control modes of *Shairit* provide high levels of enjoyment and, furthermore, do not differ significantly from each other in terms of player experience. Therefore, the implemented patterns of shared control seem to induce an entertaining player experience equally well, what qualifies each of them as a recommendable multiplayer game mechanic. Further, we suppose, that the entertainment value of *Shairit* is indeed based on the interdependency between players introduced by the sharing of control, as *Shairit*'s entire game design is focused on the requirement of coordinating the collective control or the alternation of individual control. Hence, there are no other game mechanics that could be additional sources of game enjoyment (e.g., special abilities, story, customizing). Even the prestige and voting systems in two of the modes are tightly bound to the shared control mechanic.

Surprisingly, players reported high perceived intuitiveness of control for all game modes. This is surprising, because we assumed, that especially in the simultaneous modes players could be confused by the input processing, as these modes reduce comprehensibility of individual influence. However, perceived intuitiveness was not lower compared to alternating control. Hence, the loss of individual control did not impair ease of control, but rather seems to be acknowledged as an essential part of the game challenge by players, as intended. Moreover, it has to be noted that—despite the novel input processing—*Shairit* features a rather simple input interface that only requires players to control the analog stick and one or two buttons. Differences regarding perceived intuitiveness of control between Alternating-High and Simultaneous-High are probably caused by differences in game expertise: Simultaneous-High had higher values in both, game expertise and intuitive control. Participants who are used to video game controls may have had less struggle to adapt to the novel input scheme compared to rather inexperienced participants.

We did not find any significant differences regarding need satisfaction between game modes. Hence, the variation of the shared control pattern (alternating control vs. simultaneous control) does not affect the overall player experience induced by the game in terms of need satisfaction. Given that the alternating control modes allow for individual exclusive control like common games without shared control do, our findings invalidate our initial concern that loosing exclusivity of control automatically undermines perceived autonomy and competence experiences. On the contrary, a detailed look at the results reveals that *Shairit* tends to provide moderately high levels of competence and autonomy satisfaction, independent of the control pattern. Maybe these needs were not primarily addressed by the game itself, but rather by the social processes induced by it. For instance, it can be a source of competence and autonomy satisfaction if a player takes on a leading role in team coordination, something that was previously reported by Rozendaal et al. [18].

Thus, a lack of in-game mechanics that foster individual feelings of competence and autonomy might be compensated by social processes. Additionally, team success and the impression of team competence is supposed to influence the individual experience of competence. Thus, being successful as a team in a highly interdependent task may contribute to the impression of one's own competence. Interestingly, scores of relatedness satisfaction tended to be lower than scores of competence and autonomy. This contradicts the initial assumption, that the social experience plays a more essential role in shared control than individual feelings of competence or autonomy.

For a more in-depth investigation of the social dynamics during gameplay we also compared feelings of cooperative social presence. In sum, the scores for team cohesion and team involvement were high in all groups and support the assumption that team related experiences are an essential part of the player experience in shared control games. Nevertheless, team cohesion was significantly lower in the Simultaneous-Low mode than in the Alternating-High mode. This difference can be explained by looking at the items of the corresponding team cohesion scale. Team cohesion includes aspects of effective team communication, goal-sharing, commitment to work together, and feeling like a part of a team. By comparing the control mechanics of the two modes, it becomes apparent that the Simultaneous-Low mode does not require players to work together, or to participate at all. Players do not have to communicate with each other or be equally committed to the game's goal in order to succeed. In contrast, in all other game modes progress is negatively affected if individual players decide against participation. Given that team cohesion was rather high in all other modes, we assumed that the Simultaneous-Low mode in general tended to foster less feelings of team cohesion. Although no significant difference was found regarding the degree of team involvement, a detailed look at the means and standard deviations of team cohesion and involvement reveals that both dimensions tend to be experienced in a similar manner. Probably, issues of the data distribution (violations of normality and variance homogeneity assumptions) and the resultant use of different tests caused one dimension to differ significantly and the other not. This inconsistency should be addressed in future evaluations of the modes, especially because the difference in team involvement would have been significant at the .10 level. Support for assuming that team involvement could actually differ in the same way as team cohesion may be found in its operationalization. Since it reflects the individually experienced cognitive investment to and dependency from one's team mates, we would again argue, that the Simultaneous-Low mode failed to foster such experience as sufficiently as the other modes, due to the fact that it does not enforce cooperation at all. In conclusion, comparing items for relatedness and the CSP scales indicates, that they represent different qualities of sociality in games. Relatedness is supposed to assess the building of emotional relationships. In contrast, CSP scales focus more on the functional aspects of relationship building with regard to the game's goals and challenges. Consequently, we suggest to consider both instruments to gain a more comprehensive insight into the social dynamics during gameplay.

Although the variation of control mode did not lead to statistically significant differences in the majority of assessed player experience dimensions, mean score tendencies offer interesting starting points for further research. In the Simultaneous-High mode players experienced a high degree of competence. Whereas competence could be intuitively expected to be satisfied in modes with individual control that allows players to easily comprehend their contribution and success, one may ask what aspects may induce such high competence satisfaction during simultaneous control. One potential source was already described above in reference to Rozendaal and colleagues [18]. In addition one could also ask why competence satisfaction is not higher in modes of alternating control. An initial assumption is that competence satisfaction could have been partly impaired in these modes because not only individual success, but also failure is recognizable for each player. This could lead to reprehensive behavior among player, as observed by Loparev and colleagues [11]: Their *WeGame* offered a mechanic that visualizes individual input during collective control and occasionally caused more experienced players blaming others. Similarly, it seems suspicious that players of the Alternating-Low mode tended to experience less autonomy compared to the other modes.

We expected it to provide more autonomy satisfaction than modes with simultaneous control due to its opportunities for individual goal achievement. Thus, the question is, why does it not? One initial thought is that an enforced loss of exclusive control (every time control alternates) has significant negative consequences for autonomy satisfaction that other beneficial aspects of the mode can not compensate. Further, in this mode players know that they are responsible for progress on a regular basis. Thus, inexperienced players may anticipate feelings of guilt on a regular basis, because they know to be confronted with situations they fear. In contrast, the voting system in the Alternating-High mode maybe compensated those negative consequences by allowing players to influence the control alternation.

In sum it is notable that the Simultaneous-High mode tended to induce the highest scores regarding nearly every examined facet, indicating that it may be well balanced in terms of potential advantages and disadvantages for either sociality aspects or individual-centric experiences. Additionally, compared to the other modes it probably represents the most consequent implementation of shared control. Thus, results validate the value of this interaction pattern, even if it seems unintuitive at first glance. In conclusion we emphasize that the complex interplay of specific degrees of input enforcement, exclusivity of control, and visibility of individual contribution is supposed to shape the social player experience and is worthwhile to be investigated in future analyses.

6.2 Familiarity and Game Expertise

In our evaluation we controlled for degrees of familiarity and game expertise. We were interested in whether they systematically influence potential main effects of our experimental manipulation on player experience. Since the degree of familiarity probably determines the quality of social interaction between players, we expected familiarity to impact the extent to which our game fosters social player experience. Interestingly, our results did not indicate a systematic confounding effect of familiarity. However, significant correlations between familiarity and relatedness, as well as familiarity and team cohesion in some modes indicate that strangers and friends may experience different qualities of sociality in certain control modes.

Probably most surprising is the lack of association between familiarity and enjoyment, which emphasizes that shared control sufficiently induces an entertaining experience independent of group composition in terms of interpersonal relationships.

Besides familiarity, we assessed game expertise because we expected it to represent players' experience with diverse game mechanics. We assumed that it may determine to what extent they are able and willing to adapt to novel interaction patterns. Hence, participants with more expertise are supposed to adapt faster to the game context than inexperienced players, allowing them to experience higher need satisfaction, particularly in terms of competence.

Game expertise significantly differed between some groups. This may be related to the unequal distribution of male and female participants, who differed in their reported game expertise. Nevertheless, inconsistent associations between game expertise and player experience contradict a systematic influence of game expertise on potential main effects of our experimental manipulation. In fact, game expertise was only found to be positively associated with competence satisfaction in the Alternating-High and the Simultaneous-Low condition. Those correlations can be intuitively interpreted. Since in the Alternating-High mode players could vote for other players, it is reasonable to expect less experienced players voting for more experienced players in order to overcome difficult passages. Accordingly, more experienced players would have increased time of control and thus more opportunities to feel competent. Similarly, in the Simultaneous-Low mode experienced players could simply take over control if a challenge becomes too hard (while the other players do not provide any input). Hence, despite not systematically influencing need satisfaction in our different shared control settings, associations between game expertise and competence in certain modes indicate that game expertise may influence competence satisfaction if opportunities to withdraw from or to overtake control are provided. Since game expertise was not associated with enjoyment, neither, the evaluated shared control patterns seem to be enjoyable for experienced and inexperienced players likewise.

6.3 Associations Between Enjoyment and Facets of Player Experience

In accordance with SDT [20], psychological need satisfaction was associated with enjoyment in almost every mode of *Shairit*. This implies that individual experiences of competence and autonomy may be essential for a positive player experience, even if a game is intended to rely mainly on sociality aspects. Interestingly, facets of sociality were inconsistently associated with game enjoyment across conditions in our study, indicating that game enjoyment of shared control may not depend on qualities of social interactions per se. This is surprising, as we expected that the experience of a game that heavily relies on team coordination and communication would automatically benefit from emotional, cognitive, and behavioral engagement of team members. The Simultaneous-Low mode, which does not require players to work together, was the only mode in which variables of sociality were associated with enjoyment. This indicates that players enjoy this mode, if they explicitly decide to work together, despite not being forced to do so. The lower the experience of mutual engagement in this mode, the less enjoyable is the experience. Independence of enjoyment from team cohesion or team involvement in other modes may reflect that even if the team is not working together in a cohesive and effective way, the experience of *Shairit* is still enjoyable for the individual. Indeed, observations of gameplay indicate that an essential part of the fun arises from moments of failed team coordination. Nevertheless, a comprehensive analysis of predictors for enjoyment of shared control is needed to adequately interpret associations between facets of player experience.

6.4 Limitations

Some limitations have to be mentioned regarding the experimental evaluation of *Shairit*. Since our study groups were unequal in size, the validity of our statistical analysis may not be optimal. We accounted for that in specific cases by choosing adequate test statistics, but lastly analysis would benefit from equal sample sizes.

Though familiarity and expertise did not have a confounding effect in our study, we still suggest to consider them as potential influences that have to be controlled for and further examined in future studies. Studies focusing their effects should include a systematic manipulation of those variables by deliberately assembling player groups beforehand to test different constellations of players and compare their experiences and interactions. Moreover, we recommend to think about more sophisticated ways of assessing players' familiarity and expertise. As it was not the focus of our study, we measured both aspects by simply asking players to rate their game expertise and familiarity with their co-players on a custom scale. These subjective scales may have been interpreted very differently by participants (e.g., "close friend" might mean different things to different people). In sum, subjective assessment and unsystematic distribution of experienced and inexperienced as well as familiar and unfamiliar participants could have affected our findings.

Regarding the conceptualization of *Shairit* it has to be noted that the game design is based on intuitive considerations and, thus, still has to be further validated in terms of induced experience of interdependency. Moreover, we investigated shared control in just one game. Whereas this bespoke setting allowed us to implement different types of shared control and investigate them under controlled conditions, findings are limited to similar game concepts. It has to be considered that other game genres may trigger different forms of social interaction and offer distinct design spaces that require other implementations of shared control to create a good game. Given the fundamental differences between shared control and traditional game control, we decided not to include a control condition in our analysis (comparing shared control to a common individual control pattern). Nevertheless, comparability of the two concepts can be further examined.

7 Conclusion

Sharing the control of interactive environments is an experience people seldom have in reality. As the evaluation of our shared control game *Shairit* has proven, it sufficiently provides an entertaining experience. Hence, our work illustrates the potential of shared control patterns for developing innovative, compelling, and highly social games. To support game designers and researchers alike, we additionally provided a comprehensive classification of types of shared control, that is supposed to guide and expand game design approaches of future collaborative multiplayer games.

The different implementations of shared control evaluated in our study provided equally high levels of enjoyment and need satisfaction.

Furthermore, not only sociality aspects but also more individual experiences like perceived competence and autonomy were identified as essential aspects of enjoying local shared control. Nevertheless, future research is needed to investigate the interrelation between enforced interdependencies and the comprehensibility of individual contributions, as well as their impact on player experience. Insights will help to better understand how shared control can benefit or harm individual enjoyment. This paper contributes to this research by presenting interesting findings of a comprehensive multiplayer study. Conclusively, understanding the experience of shared control not only informs game designers interested in designing compelling social experiences but also contributes to the fundamental understanding of how people enjoy playing together in groups.

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