KickAR: Exploring Game Balancing Through Boosts and Handicaps in Augmented Reality Table Football

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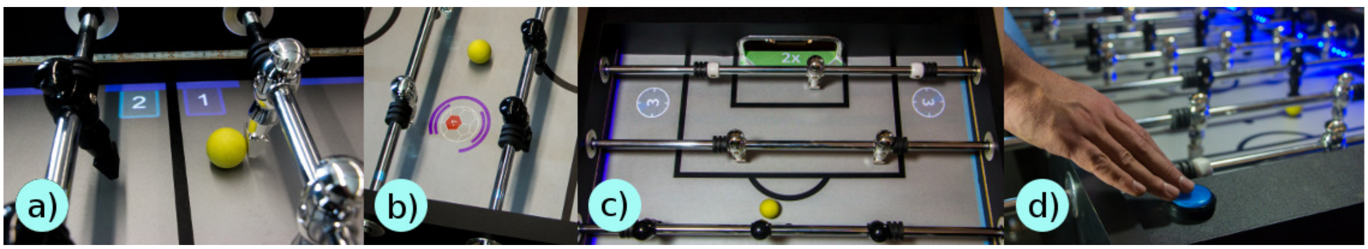

Figure 1: The KickAR system augments a foosball table with projection-based game data (a) and game balancing icons (b). When activated, these can either disadvantage stronger players, or favour weaker ones, for example by allowing their next goal (within a certain time frame) to count as two points (c). We investigated different triggering mechanisms of game balancing to compare *system-triggered* and *user-triggered* game balancing mechanisms; one of the latter involved pressing a button to trigger icons (d).

ABSTRACT

When player skill levels are not matched, games provide an unsatisfying player experience. Player balancing is used across many digital game genres to address this, but has not been studied for co-located augmented reality (AR) tabletop games, where using boosts and handicaps can adjust for different player skill levels. In the setting of an AR table football game, we studied the importance of game balancing being triggered by the game system or the players, and whether player skill should be required to trigger game balancing. We implemented projected icons to prominently display game balancing mechanics in the AR table football game. In a within-subjects study (N=24), we found players prefer skill-based control over game balancing and that different triggers are perceived as having different fairness. Further, the study showed that even game balancing that is perceived as unfair can provide enjoyable game experiences. Based on our findings, we provide suggestions for player balancing in AR tabletop games.

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INTRODUCTION

Social interaction is a core human need and driving motivational factor that facilitates our enjoyment of technology. Co-located, cooperative games, especially if they afford physicality, rely on social interaction and build social skills (e.g., trust, fairness, and cooperation) and social gameplay promotes bonding [45]. Playing with a co-located player increases fun, challenge, and perceived competence [17]. Given that physicality increases engagement and leads to stronger affective experiences [6], table games such as foosball, air hockey, or billiards enjoy widespread popularity in social settings [26].

However, players have divergent skill levels in common social and public settings [36] producing unbalanced game outcomes. This skill mismatch in games leads to a lack of suspense and less enjoyment [1]. For the weaker player, it can lead to anxiety [11]. On the contrary, when players' skill levels match, they experience greater flow and enjoyment [1]. Even when players disclose their skill assistance to one another, the benefits of the assistance outweigh any possible skill conceptions and do not harm player experience [15]. Game balancing comprises many mechanics that allow players to achieve narrower score margins, whether playing against another human player or against an AI opponent [**?**].

Unfortunately, there is little research on co-located social games involving physical movement that facilitates enjoyment and engagement [2]. Skill balancing for these games is particularly important because they are often played in public social settings, where matchmaking is unlikely to occur naturally. Thus, we wanted to investigate game balancing techniques for this particular co-located social setting using augmented reality (AR) technology for table games.

There are many ways to implement game balancing to equalize skill discrepancies. Single-player games adjust their own difficulty setting by modifying artificial intelligence (AI) behaviour or game item spawning [40]. Among games that field opposing human players, some employ match-making to assign players to opponents ranked at similar skill level, or skill assistance for weaker players [44]. Other ways of game balancing focus on disadvantaging stronger players (i.e., handicaps), and favouring weaker ones (i.e., boosts)—a common technique in racing games known as *rubber-banding* [33], specifically in the Mario Kart series [16] and has thus been called the *Mario Kart effect* [31]. Players sometimes also enforce handicaps on themselves in social settings; when playing against children or less experienced opponents, they “artificially construct a sense of equality” to increase enjoyment for all parties [45].

In this work, we focus on the boost/handicap game balancing techniques, and in particular, the catalyst of these game balancing mechanics. For instance, a research question that motivated us was: *Are boosts and handicaps accepted by players when they are triggered by the game system, or does it improve enjoyment and overall player experience when the players themselves have control?* Further, we explore whether it matters *how* players control the game balancing, that is, *whether user acceptance is increased if triggering game balancing mechanics requires game-related skills*.

To explore these research questions, we designed and developed *KickAR*, a custom-made AR foosball table featuring varying ways of triggering game balancing.

We contribute three important findings to user research on AR table games: (1) Players prefer skill-based control over game balancing triggers, more than control by the game system or player control that is not tied to skill. (2) Perceived fairness of game balancing does not necessarily affect player experience. (3) The appearance of game balancing challenges alone negatively affects players’ perceived competence, regardless of any game interference. Together, these findings provide a foundation for game developers to design their AR table games in a way that improves player experience and increases enjoyment in table games where skill disparity is common, such as those played in public social settings.

RELATED WORK

In this section, we synthesize prior research on the use of AR in leisure activities with a particular focus on AR table games. Concluding our synthesis is a review of related research on game balancing in video games.

AR Leisure Activities

Augmented reality has been used in many different areas related to gaming [39], and has been investigated in research through AR systems for a variety of traditional sports or leisure activities. For example, AR was used in a squash court to attract a new audience to the sport, provide enhanced training capabilities, and support a novel game experience within the context of squash [19]. Cooper et al. [12] presented a system using AR for Chinese checkers. In music-related scenarios, AR has been used to enhance karaoke [18], as well as instrument teaching systems, e.g. for piano or guitar [37, 28].

AR Table Games

AR has also been popular in the context of table games. Jebara et al. [23] augmented a billiards table with an HMD in order to present strategic shots to the player for training purposes. For the same purposes, a table tennis system was designed with AR [41]. The system was able to track play and present real-time visualization of data for trainers and players. Ohshima et al. [32] presented *AR*^{2}*Hockey*, an AR air hockey system, in which players used physical mallets while optical see-through head-mounted displays (HMD) were used to generate a virtual puck. Mueller et al. [30] presented a system that enabled playing air hockey against a remote opponent, with a physical puck and videoconferencing to show the opponent.

Table football has seen enhancement by technology in related work, for example through employing camera-based ball tracking and semi-automated rods to enable single-player gaming [21, 22]. AR has been used to re-envision table football for the PS Vita [27]. However, AR has not yet been employed for game balancing in table football games.

There has been little work on game balancing for AR-enhanced table games in general. The most prominent example is by Altimira et al. [2], who used AR to tackle the challenge of dissimilar player skill in table tennis. They used a digitally augmented table tennis table to balance different skill levels. The authors found that two approaches work well for the design of a balanced game: restricting the performance of more skilled players to encourage mistakes, and change their style of play to allow counteracting of the lower skilled players. In their approach, the authors matched a stronger against a weaker player, and adjusted the stronger player’s playing field to increase challenge. In further work [3], they studied other aspects of balancing such as dynamic vs. static adjustment with a similar system, i.e. adjustments to the difficulty after each point is scored or set as a constant. Participants preferred adjustment over no adjustment. Further, the authors found interesting effects regarding the interaction of player skill, and the presence and frequency of adjustments. For example, the difference in engagement between the dynamic and static adjustment was higher for more skilled players compared to less skilled players. In their studies, game balancing was always triggered externally, although participants explicitly asked for adjustments. This suggests a potential desire for user control over challenge-based balancing. With *KickAR*, we aim

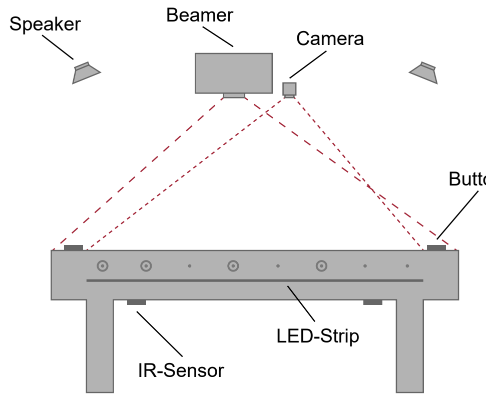


Figure 2: Architecture of the KickAR game table.

to build on this work by examining effects of different triggers of balancing mechanisms on player experience.

Research on Game Balancing

With regard to game balancing in general, the main goal is ensuring games that become neither too boring nor too frustrating. Van Lankveld et al. [42] use the incongruity theory as inspiration for game balancing to pursue this objective. They adapt the challenges of a game dynamically so that the incongruity (in the gaming context: difference between game difficulty and players' skill) stays at a constant level. They propose that keeping the incongruity level adaptively on a balanced value can uphold an entertaining gaming experience. Adjusting the difficulty level dynamically can also be called *dynamic difficulty adjustment* or *rubber-banding* [34]. Such techniques have been shown to positively influence player experience. Research by Denisova et al. [13] suggests that adaptive challenge can lead to increased immersion for players. Just telling players that a game has adaptive AI can improve their experience [14], even if that is not true. Further, player preferences regarding game balancing appear to differ based on game literacy. In a study exploring game balancing mechanics in racing games [10], some balancing mechanisms were rated as unfair by expert players, while there were no effects of balancing on subjective enjoyment for novices. It should be noted that game balancing in non-AR games often has to address effects of visibility and player perception of game balancing [5, 43]. In AR table games, these issues become less prevalent, as interference in the form of game balancing cannot be hidden as easily.

In summary, while the potential benefits of game balancing are apparent, effects on player experience differ with context, for example based on player composition (e.g., player vs. player, or player vs. non-player character), game context (e.g., video game or AR-enhanced real-world table game), or the manner in which balancing methods are implemented. With our work, we contribute to the research on game balancing using boosts and handicaps by studying how player experience is affected by user control over these mechanisms in an AR table game. Through this, we contribute to the burgeoning field of research on game balancing for AR table games.

KICKAR GAME DESIGN

With *KickAR*, we present a digitally augmented foosball table that automatically detects goal shots and provides sound effects. The system uses the table as a projection area, for example to display the current score (see Figure 1a) and visualize goal shots (see Figure 4). During games, it analyzes in-game events to detect mismatches in skill between players, and offers game balancing in the form of boosts and handicaps, which are also projected onto the table in the form of icons (see Figure 1b). The system provides different ways of triggering the game balancing mechanisms: control over triggering game balancing is held either by the system, or the player. Further, player-based control over game balancing is divided into skill-based control and non-game-related control.

System Architecture

The *KickAR* system consists of a foosball table, a ceiling-mounted projector, camera and loudspeakers. The projector and the camera are adjusted to the size of the foosball table through a calibration process, in order to accommodate foosball tables of different sizes. Through this calibration process, the game system learns the goal locations, and where it can position the display of icons without occlusion

In our prototype, we used standard hardware such as a camera with 60 frames per second to track the ball position at all times. The loudspeakers enable auditory feedback for in-game events in the form of cartoon-style sound effects. There are distinctive sounds for each event, for example to signify the beginning of the game, or that a goal has been scored. LED strips were embedded into the sides of the table alongside the playing field, and infrared (IR) sensors were attached to the undersides of the goals (eight sensors on each side). The IR sensors are used for precise goal detection (including the exact position where the ball crossed the goal line).

Whenever a goal is detected, the combined information from the camera and the IR sensors is used to visualize the precise course of the shot after a goal. The inlaid LED strips light up on the side of the scoring team, and a scoring animation traverses the table to update the score visualization.

Finally, buttons were embedded into both sides of the foosball table. The buttons are used for one of the game balancing modes, in which they are used as the non-game-related trigger for displayed game balancing icons (see Figure 1d). The complete setup is illustrated in Figure 2.

Designing for Balance in KickAR

Game balancing in *KickAR* is necessarily constrained by the fact that the game is an AR table game; being inherently situated in the physical space, game balancing cannot be hidden as well as in traditional video games. In the following, we describe which indicators our game balancing uses to detect skill mismatch in a game. The game system attempts to determine the skill level of each side based on the indicators below (prioritized on a scale of 1-10), and then compares the two. The first and main indicator is the game's current *goal difference* (priority: 8), as skill mismatch generally leads to a large score margin. Based on talks with professional and amateur players in a regional foosball team, we added *ball possession*

(2) and average *velocity of goal shots* (1). Ball possession is defined as percentage of the game duration thus far that they had the ball. We also added *number of pin-shots with sideways movement* (3), a particular technique that is widely used by experienced players [4]: a player pins the ball, then either moves it sideways (parallel to the bar) or passes it to another figure on the same bar, and then shoots at the goal (generally as a continuous movement at great speed). Finally, to avoid overcompensation, we incorporated knowledge of previous *help through game balancing* (1). If one side has received a lot of help during the game, this acts as a counterbalance and prevents further help.

When the system determines that a skill mismatch is prevalent, it randomly chooses a game balancing icon. The likelihood of the icon favouring the weaker side or disadvantaging the stronger side is thus determined by the number of icons of each category; this is described in more detail below. Depending on the mode of triggering game balancing, the icons either immediately take effect (triggered by the system), or must be activated by the player. In one player-triggered mode, icons are activated by rolling the ball over them (i.e. skill-based control); in the other, they are triggered through the buttons on the side of the table (non-game-related control).

Projected Icons & Mechanics
The *KickAR* system enables the prominent projection of game balancing icons and subsequent game balancing events directly onto the table without occlusion from the bars or playing figures through a calibration process. These icons are displayed within two open circles that rotate in opposite directions (see Figure 1b). The colour of these circles matches the colour of the team that will be favoured by this icon, that is, players generally attempt to activate icons of their colour. When the system detects a mismatch in the players' abilities, it determines which icons to display from a set of possible game balancing mechanisms (see Table 2). The icons representing these mechanisms can be seen in Figure 5.

The mechanisms can be categorized as either boosts (giving advantage to the weaker player) or handicaps (disadvantaging the stronger player). The icons can be further classified as those that cause immediate balancing, and challenges that have to be activated before it causes any difference in goals. Once a game balancing mechanism has been activated, the reaction is shown on the pitch. For example, immediate balancing adds or removes points from the current score. Immediate balancing is accompanied by animations and sound effects as points travel towards or away from the scoreboard visualization.

Challenges, on the other hand, add points or prohibit goals from counting only when the player activates them. The challenges are always accompanied by a spatial specification, that is, they apply to the whole goal or only half of it, or to half of the playing field (as scoring from the back half of the field is more difficult). When challenges are activated, their events are visualized for as long as they are valid, along with a timer. For example, Figure 1c shows a boost game balancing icon that has already been activated: any goal that is scored before the timer runs out (displayed twice to allow both players to read it right-side-up) counts as two points. Figure 3 shows an active handicap challenge: until the timer runs out, points can only be scored in the right half of the goal. The timer duration is set to either 10, 20, or 30 seconds according to the boost or handicap that was chosen (i.e., more stringent handicaps are accompanied by longer durations).

Imbalance Scores	**Degree of Interference**	**Game Balancing Mechanisms**
0–3	None	No game balancing.
4–8	Mild	No points for half field (back) for 10/20 sec; no points for half goal (left/right) for 10/20 sec.
9–13	Moderate	2x points for half field (back) for 10/20 sec; 2x points for half goal (left/right) for 10/20/30 sec; no points for half goal (left/right) for 20 sec.
14–23	High	2x points for half field (front) for 10/20 sec; 2x points / no points for half goal (left/right) for 30 sec; 2x points / no points for whole goal for 20/30 sec; add/remove one point.
24–50	Maximum	2x points for whole goal for 20/30s; no points on whole goal for 20/30s; add/remove one/two point(s).

Table 1: Based on playtesting, the imbalance scores were divided into four groups, each of which maps to specific GB mechanisms of varying degrees of potential interference. The GB system takes into account both the stringency of GB icons and the duration they are active.

The likelihood that the system will trigger a boost is equal to the likelihood of a handicap. There is however a slightly greater chance that the system will use a challenge, than that there will be immediate balancing.

Imbalance Detection & Scores
The imbalance detection occurred based on the prioritized indicators described previously (e.g., goal difference, ball possession, and whether previous game balancing had led to goal differences). These priority indicators were continuously re-calculated and used as factors to derive an overall imbalance score ranging from -50 to 50. A zero indicated exact balance between teams. The sign of the score indicated which team was stronger, and the difference of the score to zero indicated the strength of the imbalance.

Based on playtesting, the imbalance scores were divided into four groups (from low to maximum imbalance), each of which mapped to specific game balancing mechanisms of varying degrees of potential interference. For example, low imbalance scores (4–8) led to mild icons. Maximum imbalance scores (24–50) were required to lead to the more stringent icons, and immediate balancing did not occur before the second-highest imbalance score group. Thus *KickAR*'s game balancing takes into account the imbalance strength when choosing both the stringency of icons and the duration they are active (10, 20, or 30s). The mapping of imbalance scores to game balancing mechanisms is listed in Table 1.

Game Balancing Variants
KickAR was implemented to offer four different variants of game balancing, starting with:

	Challenges	Immediate Balancing
Boosts	2x points for half the goal 2x points for whole goal 2x points for half field	add point add two points
Handicaps	no points on whole goal no points for half the goal no points for half field	remove point remove two points

Table 2: KickAR offers a variety of game balancing mechanisms that favour weaker players or handicap stronger players. Some mechanisms are effected immediately, others have to be activated, and are then valid for a duration of 10–30 seconds.

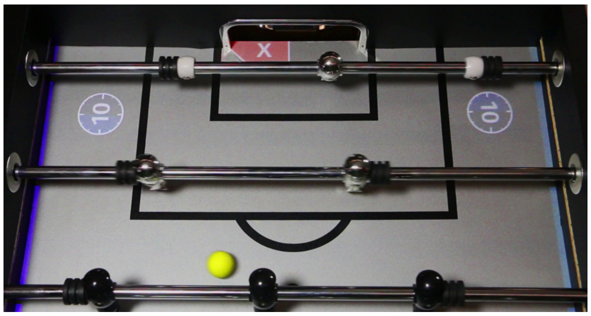


Figure 3: Projection of an activated game balancing handicap: until the timer runs out (displayed for both players), points can only be scored on the right half of the goal.

- the *baseline* version with AR but no game balancing, that is, regular foosball. The mode is augmented only by the dynamically-updated score visualization, and automatic goal detection along with the corresponding animations.

The other three variants all include AR-based game balancing based on the previously described imbalance detection, and all use the same mapping to game balancing mechanisms. The variants merely differ in *how* the game balancing mechanisms are activated:

- in the *system-triggered* condition, game balancing is triggered automatically by the game system. The appropriate balancing mechanism is then immediately activated[1] and displayed on the pitch. The players have no possibility to engage with the system's game balancing.

The final two conditions were player-triggered, i.e. icons are displayed but the corresponding game balancing mechanism is not enforced until players activate it:

- a *ball-triggered* condition, in which players have to roll the ball over the projected icons to activate the game balancing reaction. In this mode, the icon is randomly positioned on the pitch (while ensuring it is not projected onto the bars or players). This mode represents the skill-based version of player-triggered game balancing.

- a *button-triggered* condition, in which players activate displayed icons by hitting one of the buttons embedded into the table. In this mode, icons are always displayed in the middle of the field (mirrored, so that both players can view it right-side-up). The game balancing it represents is activated if any of the side buttons is pressed while the icon is displayed. This mode represents the non-game-related version of player-triggered game balancing.

[1] Players still need to meet the challenge (e.g. score in the valid half of the goal) to elicit benefits from challenge-based game balancing.

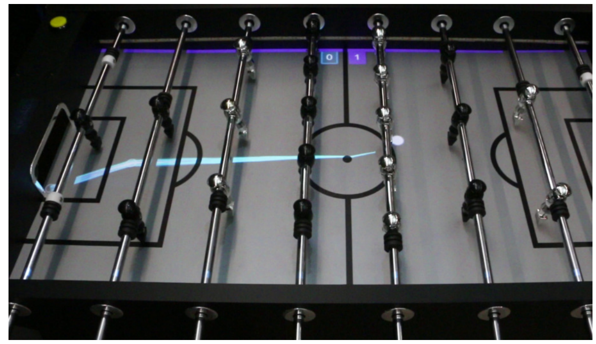


Figure 4: KickAR visualizes the path of the ball after goals.

KICKAR BALANCING STUDY

To compare the effects of these game balancing triggers on player experience, we conducted a within-subject experiment with 12 dyads[2] (N=24). Even though the system would enable team vs. team game play, we decided to let single players play against each other to avoid effects of inter-team behaviour and interaction. Each dyad experienced the three balancing variants *ball-triggered*, *button-triggered*, and *system-triggered*, as well as the *baseline* condition without a balancing mechanism, as described in the previous section.

Each session started with an brief introduction and consent forms. The participants then experienced the four conditions in counterbalanced order. They played seven minutes in each condition, and subsequently answered the questionnaires described below. On average, each session lasted 75 minutes. At the end of each session, participants were thanked and compensated with 10 EUR.

Participants

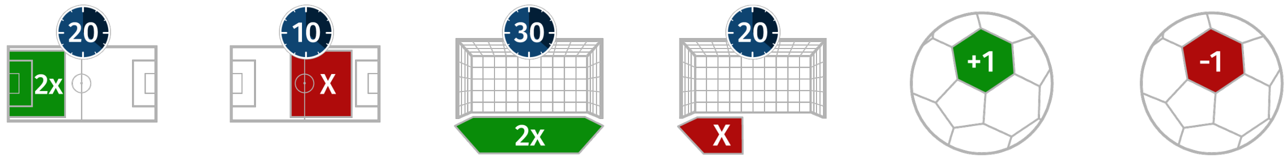
We recruited 24 students (14 male, 10 female) to participate as pairs to play against each other. On average, participants were aged 18–28 (*M*=23.08, *SD*=2.60). On a 5-point Likert scale (1=*strongly disagree*, 5=*strongly agree*), they reported a slight interest in (*M*=3.96, *SD*=1.08), and were not overly experienced in (*M*=3.33, *SD*=1.13), or skilled at (*M*=3.13, *SD*=1.30) playing foosball. Almost all dyads knew each other well (*M*=4.50, *SD*=.98).

Measures

The dependent variables measured after each gameplay session consisted of the following:

- participants' affective state: using the self-assessment manikin (SAM) measuring valence, arousal, and dominance on a 7-point semantic scale [8],

[2] Meaning pairs of participants



(a) (b) (c) (d) (e) (f)

Figure 5: A selection of KickAR's game balancing icons: a) goals scored from the back half of the field count as two points, b) goals from the front half are prohibited, c) any goal counts as two points, d) goals can only be scored on the right half of the goal, e) a point is added immediately, and f) a point is removed immediately.

- game engagement (GEngQ): 19 items on a 7-point Likert scale [9].

As physicality and body movement increases engagement and affective experience [6], we expected higher values for SAM and GEngQ for the *button-triggered* condition.

Further, as the effect of social gaming are mediated by social presence [17], we added:

- social presence module of the game experience questionnaire (GExpQ): 17 items on a 5-point Likert scale [20].

Finally, the players have different amounts of control over the game balancing between the conditions, which may affect enjoyment and feelings of agency, both of which are associated with motivation [35], leading us to add:

- several factors of the intrinsic motivation inventory (IMI): interest/enjoyment, pressure/tension, as well as perceived choice and competence (7-point Likert scales) [29, 38].

After each game, participants were also asked to what degree that game experience was exciting, fair, and fun on individual 7-point Likert scales. In addition, we assessed whether participants liked each of the individual game balancing mechanisms for that variant on a binomial scale. From this, we calculated the approval rating of mechanisms for comparison of specific boosts and handicaps overall, as well as separated by game balancing variant (see Figure 6 for an overview).

During each gameplay session, the system logged in-game events, such as the number of goals scored on either side, and whether a game was won or lost. These also included the difference in a match's end result: *match delta score*; a positive value indicates the game was won. It also counted the number of goals a player scored due to game balancing: *game balancing delta score*; a negative value indicates they lost more goals than they gained. Further, the logging also counted and distinguished between the number of game balancing icons displayed, triggered, and leading to gameplay interference. For clarification, in the *system-triggered* condition all icons are displayed and triggered simultaneously, while in the player-triggered conditions (*ball-triggered* and *button-triggered*), icons can be displayed but never triggered. Icons counted as leading to gameplay interference only if they led to additional or fewer goals being scored.

Finally, after all four gameplay sessions, participants were asked to rate their preferences regarding the conditions from greatest preference (ranking= 1) to lowest preference (ranking= 4). They were also asked open questions regarding their strategies for the player-triggered conditions, as well as general likes and dislikes.

RESULTS

In the *ball-triggered* and *button-triggered* conditions, game balancing icons were displayed 15 times in each game on average (M=15.33, SD=4.82). (There was no game balancing in the *baseline* condition, and in the *system-triggered* condition game balancing was triggered and employed immediately.) For the individual players, this translates to M=7.67, SD=7.40 game balancing instances in their favour. In the same two conditions, roughly half of these icons were then activated (M=8.92, SD=2.93) in each match. Over all conditions with game balancing (*ball-triggered*, *button-triggered*, and *system-triggered*), game balancing was then employed (i.e., interfered with the game) M=8.75 (SD=7.74) times in each match. A Friedman's ANOVA showed that there was no significant difference in the number of times game balancing was employed per match among the three conditions, $\chi^2(2)$=0.55, *ns*. The average match delta score was 3 (M=5.08, SD=4.30). A Friedman's ANOVA over all four conditions (including the baseline without game balancing) showed that there was no significant difference in match delta score, $\chi^2(3)$=3.24, *ns*. The effect of game balancing on the final score differences was subtle; the average number of goals that occurred due to game balancing in the conditions that used game balancing was M=1.67 (SD=1.53).

Individual Game Icons

There were clear differences in how well participants liked individual game balancing reactions (see Figure 6). Adding points for achieving a challenge (*2 points on half goal*, *2 points on whole goal*, and *2 points from half field*) led to high approval ratings. The comments revealed that the challenge aspect was what caused this. Immediate reactions that added points were not well received, although this effect decreased for the *ball-triggered* condition. The user comments emphasised that immediate reactions were percevied as "unearned", and that this impression was lessened for the *ball-triggered* condition due to the skill potentially involved in triggering the icons: "*With ball-triggered you have to earn any gifted goals, with button-triggered you get it as a present. I didn't like the latter*" (P8-2) and "*While pushing the button you feel a bit bad, to burden the other due to one's own incompetency—ball-triggered feels better, because skill is involved*" (P8-1).

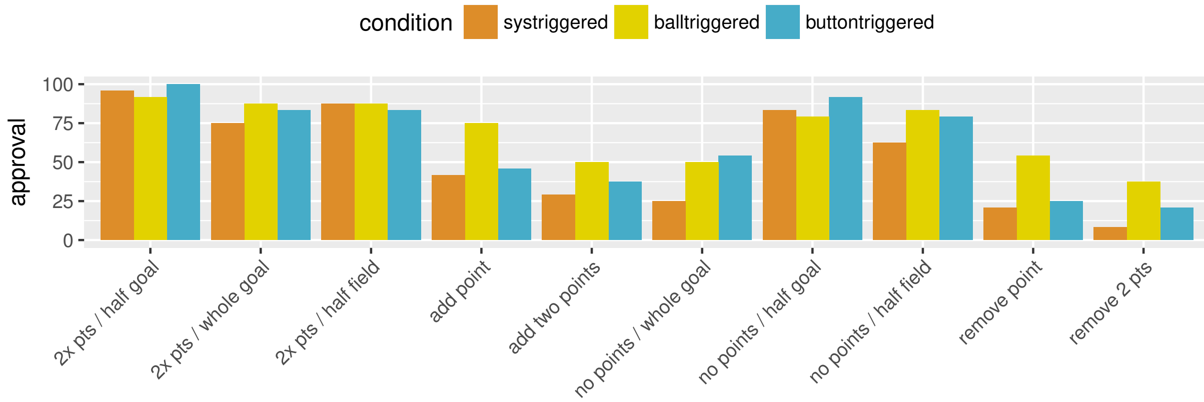


Figure 6: Approval ratings of the individual game balancing mechanisms separated by condition. The approval rating consists of the percentage of participants that voted for that mechanism to be included in a specific game balancing variant (as rated after playing in that condition).

However, the *button-triggered* condition felt "*more conscious / active*" and led to a greater desire to trigger icons (P11-2).

Removing points yielded low approval ratings. Participants commented that this was "*heavy punishment*" (P8-1) and "*unfair*" (P6-2), and "*didn't really feel earned*" (P7-1). Prohibiting points from scored goals was disliked when applied to the entire goal, but largely approved of when applied only to the half goal, or to half the field.

Strategies and Open Feedback

In the open questions, three participants stated that they had not employed any strategies for the player-triggered conditions. One participant mentioned that they had only started to trigger icons disadvantageous to their opponent, because their opponent had already started it. Another participant reported triggering icons disadvantaging themselves to even out the score. In contrast, another seemed to resent the fact that they had never had the opportunity to trigger icons on purpose, because their opponent was always weaker. The remaining players were approximately equally divided between trying to trigger icons in their favour, icons that would disadvantage their opponent, or both.

Condition Preferences

Regarding the preference rankings, the *button-triggered* condition received ranks indicating the greatest preference (i.e. the lowest mean, M=1.83, SD=0.85). The other conditions all had higher but similar means: *ball-triggered* (M=2.5, SD=1.20), *system-triggered* (M=2.79, SD=1.00), and *baseline* (M=2.88, SD=1.10). A Friedman's ANOVA showed that there was a significant difference in the mean rankings, $\chi^2(3)=38.6$, $p<0.001$. Post-hoc tests were applied with Bonferroni corrections, showing that the *button-triggered* condition differed significantly from all other conditions (*difference*=100 for *baseline*, *difference*=92 for *system-triggered*, and *difference*=64 for *ball-triggered*) with a critical difference of 47.19.

Affective State

Participants' affective state in terms of dominance was overall high (M=5.54, SD=1.58). The mean values for dominance were higher for the *baseline* (M=5.79, SD=1.67) and *system-triggered* (M=5.75, SD=1.11) conditions than for the *ball-triggered* (M=5.38, SD=1.71) and *button-triggered* (M=5.25, SD=1.75) conditions. The valence mean was similarly high overall (M=5.41, SD=1.78). The values were again highest for the *baseline* (M=5.5, SD=1.64), but closely followed by the *system-triggered* (M=5.42, SD=1.79), *ball-triggered* (M=5.38, SD=1.69), and *button-triggered* (M=5.33, SD=2.08) conditions. Arousal was also overall positive (M=4.36, SD=2.28). The values were highest for the *button-triggered* (M=4.63, SD=1.56) condition, and followed by similar values for the *baseline* (M=4.38, SD=1.44), *ball-triggered* (M=4.33, SD=1.58), and *system-triggered* (M=4.63, SD=1.56) conditions.

A logistic regression using the valence, dominance and arousal factors to predict the game balancing condition yielded no significant model over the null model, $\chi^2(9)=4.44$, *ns.* A linear regession was conducted to investigate the effect of valence, dominance, and arousal on the game balancing delta score. The dominance factor was a significant predictor (β=-0.36, $p<0.05$), R^2=0.12, adjusted R^2=0.09, $F(3,92)=4.07$, $p<0.01$. The dominance factor showed a significant negative correlation with the game balancing delta score, r_τ=-0.28, $p<0.001$. Finally, valence was a significant predictor for the match delta score (β=1.50, $p<0.001$), R^2=0.28, adjusted R^2=0.26, $F(3,92)=12.21$, $p<0.001$. Valence was positively correlated with the match delta score, r_τ=0.36, $p<0.001$.

Social Game Experience and Game Engagement

The GEQ social factor yielded a fairly neutral mean value overall (M=3.12, SD=0.56), as did the game engagement means (M=3.68, SD=1.00). The social presence factor was highest for *ball-triggered* (M=3.23, SD=0.53) and *button-triggered* (M=3.11, SD=0.49) game balancing, followed by *baseline* (M=3.08, SD=0.66) and *system-triggered* (M=3.05, SD=0.56). Game engagement was highest for *button-triggered* (M=3.79, SD=1.09) and then *system-triggered* (M=3.75, SD=0.92) game balancing, compared to *baseline* (M=3.60, SD=1.09) and then *ball-triggered* (M=3.59, SD=0.91) game balancing.

A logistic regression using these two factors as predictors for condition showed no significance, $\chi^2(6)$=2.50, *ns.* The factors also proved nonsignificant predictors in a linear regression for the game balancing delta score, R^2=0.00, adjusted R^2=-0.02, $F(2,93)$=0.20, *ns.*, and the match delta score, R^2=0.01, adjusted R^2=-0.01, $F(2,93)$=0.42, *ns.*

Intrinsic Motivation Factors

The mean values for interest/enjoyment were positive (M=5.86, SD=1.20). They were highest for the *button-triggered* (M=5.99, SD=1.15) condition, but closely followed by the *system-triggered* (M=5.85, SD=1.20), *baseline* (M=5.82, SD=1.22), and *ball-triggered* (M=5.77, SD=1.30) conditions. The perceived choice factor had positive mean values overall (M=5.11, SD=1.16), while perceived competence had a lower but still positive mean (M=4.05, SD=1.78). The IMI's pressure/tension factor was highest for the *button-triggered* (M=3.73, SD=1.38) condition. The means for *baseline* (M=3.48, SD=1.50) and *ball-triggered* (M=3.48, SD=1.34) conditions followed, while it was lowest for the *system-triggered* (M=3.08, SD=1.41) condition.

We conducted a logistic regression using the four measured IEQ factors: interest/enjoyment, perceived choice, perceived competence, and pressure/tension, to attempt to predict the game balancing condition. The model showed no significant predictors, $\chi^2(12)$=8.23, *ns.* However, using these factors with the game balancing delta score as the outcome in a linear regression showed that interest/enjoyment (β=0.44, $p<0.05$) and perceived competence (β=-0.54, $p<0.001$) were significant predictors, with an overall model fit of R^2=0.24, adjusted R^2=0.21, $F(4,91)$=7.24, $p<0.001$. Interest/enjoyment and the game balancing delta score showed a significant negative correlation, r_τ=-0.15, $p<0.05$, as did perceived competence, r_τ=-0.37, $p<0.001$. A final linear regression showed that perceived competence (β=1.81, $p<0.001$) was a significant predictor of the match delta score, R^2=0.36, adjusted R^2=0.33, $F(4,91)$=12.54, $p<0.001$.

Exciting, Fun, Fair

The mean values for the item rating the game as exciting were high (M=6.06, SD=1.58). The mean values for fun were similarly high (M=6.06, SD=1.58). The values for the game being fair were also overall positive (M=5.15, SD=1.83). We conducted a logistic regression for these three items in relation to the game condition, $\chi^2(9)$=20.72, $p<0.05$. Fairness was the significant predictor for the game balancing condition, $\chi^2(3)$=14.49, $p<0.01$. The *baseline* condition had the highest mean fairness value (M=6.25, SD=1.07), while the *system-triggered* (M=4.92, SD=1.61), *ball-triggered* (M=4.88, SD=2.09) and *button-triggered* (M=4.54, SD=1.98) conditions had lower means. A Friedman's ANOVA showed these differences to be statistically significant, $\chi^2(3)$=11.60, $p<0.01$. Post-hoc tests with Bonferroni correction applied yielded no significant differences, although the difference between the *baseline* and *button-triggered* conditions (*difference*=23) almost reached the critical difference of 23.59.

Display of Game Balancing Icons

To determine whether the display of icons alone (disregarding whether they were activated) had an effect on the dependent variables, we calculated how often game balancing icons in the participants' favour were displayed (negative values thus indicated a majority of icons were to their disadvantage). Linear regression showed that this value could not be significantly predicted by participants' dominance, valence, and arousal, R^2=0.10, adjusted R^2=0.07, $F(3,92)$=3.42, *ns.*, nor by their game engagement and social game experience, R^2=0.01, adjusted R^2=-0.02, $F(2,93)$=0.24, *ns.*

Of the intrinsic motivation factors, however, perceived competence proved to be a significant predictor (β=-2.20, $p<0.01$), R^2=0.20, adjusted R^2=0.17, $F(4,91)$=5.80, $p<0.001$. Kendall's tau showed a significant negative correlation of perceived competence and the number of boosts displayed for individual participantshow often icons in the participants' favour had been displayed, r_τ=-0.28, $p<0.001$.

DISCUSSION

Overall, the players enjoyed the game and the game balancing mechanisms, as evidenced by positive values for their affective state and their comments. When asked to rank the game variants, the players showed a preference for the *button-triggered* game balancing condition, which we attribute to the greater physicality involved in hitting the button. Body movement increases engagement and affective experience [6]—although these were not significant predictors, *button-triggered* did hold the highest arousal mean, and had the second highest for social presence.

Frame Game Balancing As A Challenge

Their comments and the approval ratings for individual game balancing icons showed a clear preference for the challenge-based game balancing as opposed to immediate game balancing. This difference seemed to occur because of feelings of achievement that were missing when points were simply added or removed. The mechanism of adding points received better ratings from players than removing them, even though the weaker player receiving points is essentially the same as the stronger player losing points, in terms of the resulting scores. This is likely explained through loss aversion [25].

Players' approval of immediate balancing was improved for the *ball-triggered* condition: it appears that giving players control over the game balancing increases their preference for it. For example, allowing players to get a sense of skill by triggering a balancing mechanism. In addition, this could give other players the perception of being skilled and attribute an intent to their action (an attribution issue of balancing that has come up in related work [15]). As approval of immediate balancing was still low for the *button-triggered* game balancing, it seems that framing it as an in-game challenge that involves skill is important for player acceptance. However, it seems that the *button-triggered* game balancing condition was overall favoured among participants compared to the other conditions because of the physicality involved in pushing the button.

It should also be noted that – although this was not mentioned in player comments – players' preference for challenge-based balancing over immediate balancing could also arise from a preference for outcome uncertainty and increased suspense [1]. With our current study, we cannot untangle how much of or whether the player's enjoyment occurred due to uncertainty, or how it affected perceived fairness. Qualitative measures may be better suited to explore this in future work.

Overall, this leads us to our first contribution: players of AR table games prefer skill-based player control over the game balancing triggers compared to non-skill-based player control, or game system control over the triggers. AR table game developers should consider designing their game balancing mechanisms either as challenges, or allowing players a degree of skill-based control over immediate game balancing techniques. Additionally, it is possible that the affordances of the triggering mechanism can facilitate physical engagement and that this could lead to improved player experience.

Regarding player experience, few of the expected differences between the conditions manifested, not even for the no game balancing *baseline*. It would be interesting to investigate a comparison of the results for a "traditional" foosball game with neither game balancing nor AR. However we argue that our study's baseline condition is valid for exploring the effects of game balancing, as it represents precisely *system-triggered*, *ball-triggered*, and *button-triggered* conditions without game balancing. As the game balancing only rarely led to score interference, the effect may have simply been too subtle or the recruited participants may have been too close in skill. As mentioned, the subtlety of the *KickAR*'s game balancing is partly by design, to allow for comparison between the *system-triggered* and player-triggered modes. Otherwise the *system-triggered* modes could have had significantly more interferences, because all game balancing is immediately activated.

Game Balancing Can Diminish Achievement

As expected, the game balancing delta score had a significant negative correlation with players' dominance, interest/enjoyment, and perceived competence. This means that, if a game system favours a player too much, it can impact their experience negatively, because they feel less in control of game actions and their own successes in the game. While game balancing can affect perceived player achievements, this did not impact their overall player experience, which could suggest that player experience is decoupled from the achievements in AR table games. Previous work in the literature has indicated that noticeable game balancing can result in achievements lacking meaning [7, 31]. With our study, we confirm these previous results for the application of game balancing through boosts and handicaps in AR table games. Game developers that target the area of AR table games should therefore be careful not to depend too heavily on game balancing mechanisms to enhance the social engagement in these publicly played games.

The Myth of Fairness

While the post-hoc tests showed a lack of significance, there was a significant difference in perceived fairness of the game conditions. From this perspective, the game balancing had a noticeable effect. Unexpectedly, this did not lead to any significant differences in player experience. Affective state, social presence, game engagement, and most IMI factors did not differ significantly. This constitutes another contribution for the design of game balancing for AR table games: perceived fairness is not a significant factor influencing player experience. This indicates that AR table game developers and researchers need not always consider perceived fairness of game balancing mechanisms, as this does not necessarily lead to decreased enjoyment or negative emotions, which is in line with related work in video games [15].

Appearances Matter

Finally, we discuss our last contribution: the results showed that the favour delta held a significant negative correlation with perceived competence. This means that the mere appearance of game balancing icons correlated with players feeling less competence, regardless of whether this led to any difference in the scores. A possible explanation for this could be either the lack of player skill or a strategic decision in the game not to trigger the balancing mechanism. Additionally, it is also possible that the game provided enough engagement or possibly engrossment [24] to distract players from balancing triggers outside of the immediate game space.

Game designers should thus be careful not to rely too much on game balancing. If the system indicates through game balancing projections in the game space that one player is considered weaker, this may cause negative affect for that particular player. Future work will investigate whether this can be caused regardless of actual performance.

CONCLUSION

Co-located social games involving physical movement facilitate enjoyment and engagement. Due to their frequent occurrence in diverse social settings, game balancing for skill mismatch is particularly important for these games.

In this paper, we presented KickAR, a custom-made AR-enhanced foosball table, to explore game balancing with boosts and handicaps. With this game table, we explored our research question on different triggers for this kind of game balancing, and their effects on player experience. In a within-subjects study, we compared system-based control to player-based control over the game balancing triggers, as well as the importance of designing for different types of player control: skill-based as opposed to non-game-related.

In summary, our contribution consists of three main findings regarding the use of game balancing for AR table games:

- Players clearly prefer skill-based control over the game balancing triggers, rather than control by the game system or player control that is not tied to skill.
- Perceived fairness of game balancing does not necessarily impact the player experience.

- The appearance of game balancing challenges alone already negatively affects players' perceived competence, regardless of game interference.

With these results in mind, AR table game designers can improve player experience and increase enjoyment in games that feature a disparity in skill levels. While these findings are particularly important for table games, future work will explore to what degree these findings generalize to team-vs-team gameplay, and video games with players that are not co-located.

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