Getting Hybridity Just Right: The Goldilocks Factor in Hybrid Digital Boardgames

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Abstract

Despite increasing interest in Hybrid Digital Boardgames (HDBs) that necessarily combine smart technology with a physical boardgame, little is known about how the design of hybrid functions impacts player experience (PX). Additionally, it is unclear whether existing, videogame-centric, PX measures apply to tabletop settings. We designed a mixed-methods study to examine the PX of a boardgame in both its published form and as a custom HDB. We learned that players' expectations of the "core" gameplay influence their perceptions of technology, highlighting a balance between the values and drawbacks of hybridity in relation to its impact on their sense of autonomy, fairness, and challenge in play. Our results also highlight methodological considerations for future tabletop PX studies, and suggest the existence of a Goldilocks Factor where the game offers "just right" hybridity that satisfies players without impacting core gameplay.

CCS Concepts

• **Human-centered computing** → *Empirical studies in HCI*; **HCI design and evaluation methods**; *HCI theory, concepts and models*; • **Software and its engineering** → **Interactive games**.

Keywords

Hybrid, Boardgames, Player Experience

ACM Reference Format:
Sasha Soraine and Melissa J. Rogerson. 2026. Getting Hybridity Just Right: The Goldilocks Factor in Hybrid Digital Boardgames. In *Proceedings of the 2026 CHI Conference on Human Factors in Computing Systems (CHI '26), April 13–17, 2026, Barcelona, Spain.* ACM, New York, NY, USA, 18 pages. https://doi.org/10.1145/3772318.3791963

1 Introduction

Recent growth in the number and breadth of published hybrid digital boardgames (HDBs)—games that necessarily combine a physical game with a smart digital tool [75]—has been mirrored by increased research attention to the design, implementation, and adoption of hybrid games more broadly. Researchers have examined hybrid games' use and potential for co-located and distanced play [20, 57, 74, 88], the ecosystems and frameworks of hybridity that surround them [43], the play of published hybrid games [2], the hybridisation of previously published boardgames [59, 60, 84] and design of novel hybrid games [19, 89], and the technologies that enable and facilitate hybrid play [47, 92]. Although several researchers have investigated players' attitudes towards the inclusion of hybrid tools in boardgames [27, 50] and other forms of tabletop games [58, 82], little attention has been paid to how such hybridity impacts the player experience and how— or perhaps whether —playing a hybrid game differs from playing a game that is purely physical.

We seek to build an understanding of how hybridity impacts a game's player experience (PX)—the personal experiences of playing a game [96] reflecting both the player-game interactions and the broader contexts of the game and player [62]. Designing enjoyable PX is the main goal of player-centric game design [3, pp. 30-31], so understanding the nuances of how to craft and evaluate PX is important to designers. However, reliably evaluating PX is difficult because its multi-dimensionality makes it hard to consistently operationalise and measure [13, 86]. Despite its unclear constructs, PX is engendered through game designs [80, p. 24]; the design of mechanics (or mechanisms) influences the resulting PX [38]. Ergo, designers could benefit from holistic insights on PX tailored to specific game designs.

Existing work has explored design patterns as an abstract language to describe and analyse common structures of gameplay for both videogames [9] and boardgames [25]. Rogerson et al. [75] effectively outlined HDB design patterns in their *Hybrid Digital Boardgame Model*(HDBM) by cataloguing common hybrid mechanisms from published HDBs and grouping these mechanisms into eight functional domains: Timing, Randomising, Housekeeping, Informing, Teaching, Calculating, Remembering, and Storytelling. As such, we can use the HDBM functions as a framework for systematically exploring the PX of specific HDB design patterns.

In this paper, we examine players' attitudes to and experiences of the use of hybridised Timing and Randomising functions in a boardgame. Leveraging our understanding of PX, game design, and hybridity, our specific research questions are:

- RQ1 How does the use of hybrid Timing and Randomising mechanisms impact the PX of a game?
- RQ2 How can we effectively study the PX of HDBs?

Building on A/B testing techniques [46], we conducted a reflexive mixed-methods study comparing the published boardgame *Spy Guy: Fantasy* [55] with a custom-developed hybrid variant. Existing HDB design literature suggests that digital components should provide added value to the gameplay [45, 74], particularly when

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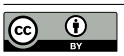


CHI '26, Barcelona, Spain

ACM ISBN 979-8-4007-2278-3/26/04
https://doi.org/10.1145/3772318.3791963

digital components replace physical ones [45]. Since we aim to directly compare the hybrid and non-hybrid game versions, we aimed to replicate the Timing function of the supplied sand timer and the Randomised draw of cards through a custom app without changing other elements of play. This study expands the body of literature on hybrid boardgames by contributing to the understanding of PX in HDBs. Our work also generates both broad insights into HDB design, as well as specific and detailed insights into the Timing and Randomising domains [75]. Moreover, our study acts as a prototype or pilot for future studies examining other functions in hybrid games, thus providing methodological insights to guide future work examining the PX of HDBs and of tabletop/boardgames more generally.

2 Related Work

This study presents fundamental research on the PX of HDBs. Our review of existing literature both clarifies our understanding of the field and motivates our work. We first establish a theoretical grounding for hybridity in games, and then outline existing Human-Computer Interaction (HCI) work on hybrid games. We then define our understanding of PX, and cover the literature on PX measures both broadly and specifically for boardgames. Our review highlights how existing HDB design guidelines do not focus on PX, and how existing PX measures may not apply to boardgames.

2.1 Hybridity and Boardgames

In HCI, research on HDBs has tended to focus on their design and enabling technologies. Around the start of the millennium, particular interest was paid to the promise of digital tabletops [7, 33, 56]; more recently, attention has been paid to the design of commercial HDBs. Rogerson et al.'s HDBM systematically explored and modelled the functions that the technology element performs in HDBs [75] and developed design principles for HDBs based on in-depth interviews with game designers [74]. This work is influential in providing a standard vocabulary for hybrid functionality, but also capturing the current state-of-the-industry, thus allowing us to consider what existing HDBs see as possible for their role in games.

Perhaps inspired by the movement restrictions associated with the COVID-19 global pandemic [20], researchers have examined the context of *distanced play*, where players engage in a physical game despite not being co-located. While Maurer and Fuchsberger [57] and Sparrow and Rogerson [88] developed frameworks for this setting, Yuan et al. [99] explored this design space, and Rogerson et al. [73] developed a creativity support tool to assist in the design of HDBs for Distanced Play. In more specific explorations of this design context, Mills and colleagues reimplemented the tabletop games *Wavelength* [59] and *Letter Jam* [60] as hybrids for distanced play. Like Frey [29], Tu et al. [92] explored the integration of biofeedback into game design, focusing on how players' heart rates could be used during play. Other research has examined techniques and technologies for creating hybrid gameplay environments. Odenwald et al. [63] developed the Tabletop Teleporter, which allowed a game to be played simultaneously by two physically distanced players through a digital tabletop that merged the two play environments, and Kirshenbaum [47] developed a set of digital playing cards that respond to deformations such as bending. These have potential to be used for both co-located and distanced play, where they may solve problems associated with randomisation of materials across multiple sites. These works propose design guidelines for specific contexts that may nevertheless also be applicable to broader hybrid play. Similarly, Kankainen and Paavilainen [45] propose general design guidelines for HDBs based on workshops, interviews and surveys with various industry and academic stakeholders. These guidelines reflect the attitudes towards HDBs found by Rogerson et al. [74], and other hybrid game design insights (e.g. [18]). However, while this body of work creates new insights for game design and development, it focuses more on hybrid functionalities and design for user acceptance, and does not engage deeply with PX.

Taking a step back from the specifics of how hybrid play can be achieved, Kankainen stresses that hybridity exists as an ecosystem in which not just the games may be hybrid but also their environment and enablers [43]. In a similar abstract view, Arjoranta et al. [6] frame hybridity as the experience resulting from conceptual blending of domains. This approach effectively decouples hybridity from the game technology, and incorporates contextual player expectations about the game and intended experience. While our work focuses on HDBs as technological hybrids, this broader understanding of hybridity further demonstrates the importance of understanding the complex PX of specific gameplay conventions (i.e. design patterns) [44].

2.2 Player Experience and Boardgames

As well as the *design* of games, HCI is concerned with the *experience* of play. Player experience (PX) describes the personal experience of playing a game [96], encompassing both the player-game interactions and the broader context framing the game and player [62]. PX is often considered to comprise multiple experiential constructs, like immersion and flow, but there is no consensus on what these constructs are [13, 86]. Despite this, there have been several attempts to create quantitative measures of PX, such as the Player Experience of Need Satisfaction (PENS) [78], Player Experience Inventory (PXI) [1], Intrinsic Motivation Inventory (IMI) [76], and Game Experience Questionnaire (GEQ) [39].

While such quantitative surveys allow researchers to compare and contrast different games and game experiences with one another, there are some notable issues. In Games HCI, the GEQ has been criticised for not having undergone peer review, for undergoing undocumented changes over time with variably 33 [39] or 42 [66] items, and for its results not appearing to be replicable [53]. Johnson et al. [40] found that, for PENS and GEQ, some of the items may be valid although others lack empirical support and may overlap with other items on the instrument. In contrast, the PXI [1], a robust 30-item questionnaire developed by experts in Games UX, is validated across multiple studies [65] and populations [30]. Beyond validations, there is some debate about whether the theoretical foundations of these measures are appropriate for PX. Self-Determination Theory (SDT) [77], which underpins PENS and IMI and many other ad hoc games measures, has become synonymous with "good" PX but it is unclear whether its constructs actually measure PX [93] or if its underlying theories are suitable for all types of experiences [24]. Even the PXI, which is grounded in Means-End Theory [68] and presents as an alternative to PENS, still

measures SDT constructs (autonomy, and competence relabeled as mastery) [93]. Encapsulating these problems, Soraine and Carette note that "Without a consensus on the constructs that make up PX, it is hard to assess whether a tool's assumptions and measures are reasonable" [86].

Apart from these design issues, our larger concern is that these measures are all designed around understanding PX for *videogames*, not *boardgames*. When considering tabletop play, there is some evidence that constructs like Immersion and Agency reasonably crossover [54], but that boardgame players experience these constructs differently than videogame players [28]. However, without boardgame-specific PX tools, these other measures have been adopted despite their shortcomings. Farkas and colleagues [26] used items from the IMI in their exploration of in-game enjoyment and tension. Barbara [8] used the Social Presence module of the GEQ to examine user experience in multiplayer boardgames, while Al Mahmud et al. [4] used it to examine the social play of older adults at a virtual tabletop. Johnson et al. [41] also used the GEQ, together with the Positive and Negative Affect Scale (PANAS) instrument. While Barbara's findings suggest that the GEQ may offer "a reliable and valid way to measure UX due to game mechanics and social interaction in rule-based board games such as RISK" [8], Johnson et al. note that "there are still some items in the GEQ that cannot be applied for board games" [41]. Liapis and Denisova [54] particularly highlight that terminology and experiences differ between the mediums, making wholesale adoption of videogame measures problematic. Particularly, these measures do not capture the importance of materiality [71] or the inherent sociality expected in boardgame play [97, p. 167].

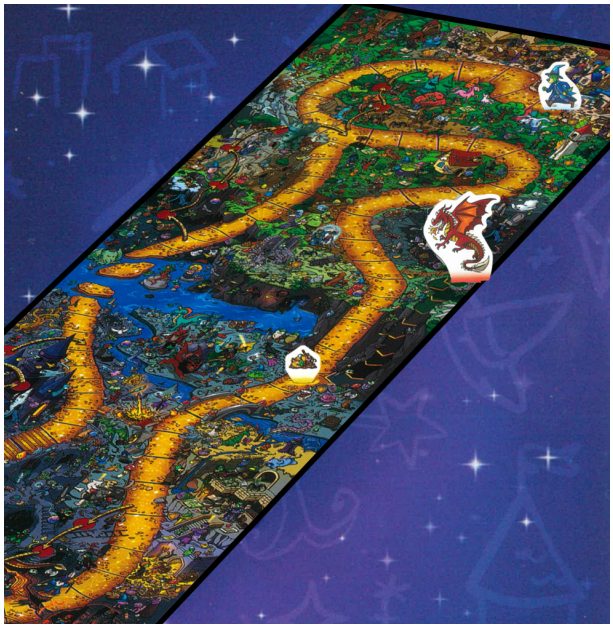
3 Hybridising Spy Guy: Fantasy

To understand the effect of hybrid mechanisms on PX in tabletop play, we chose to have players engage with the same game in a non-hybrid and hybrid format to effectively compare their PX measures. We chose *Spy Guy: Fantasy* [55] for this study because of its existing timing and randomisation mechanisms, its suitability for play in a lab environment, and its lack of prominence in Australia. It has a simple ruleset that is easy and fast to teach, while still being non-trivially challenging and entertaining for adult players.[1] We played the game several times and discussed and iterated what an app might do within the game context through several rounds of design and playtesting. These iterations included a pilot study with frequent and occasional boardgame players.

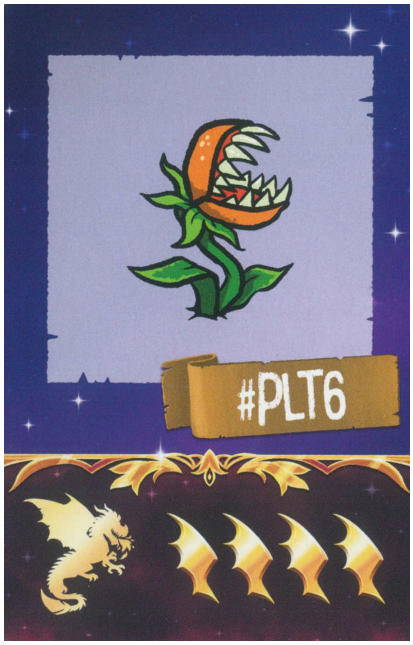
3.1 About the Game.

In *Spy Guy: Fantasy* [55], players play cooperatively as the eponymous hero, Spy Guy. Spy Guy races around the game board, attempting to rescue a village's treasure before the dragon Balasar captures it. To win the game, Spy Guy must retrieve the treasure and circumnavigate the board, returning to the village without being caught by Balasar. Fig. 1a shows the game board, with Spy Guy, Balasar, and the treasure in their starting positions on the track.

[1]On the review site BoardGameGeek, the average rating for Spy Guy: Fantasy is 7.6 out of 10, with a host of comments across the various Spy Guy titles which note the games' appeal to adults as well as to children.



(a) Game board, with Spy Guy, Balasar, and Treasure standees in their starting locations.



(b) Object card displaying object to find (here: the carnivorous plant); how many are on the board, indicated by the number at the end of the identifier (here: #PLT6 indicates that there are 6 carnivorous plants); and how fast Balasar moves when the treasure is taken (here: 4 steps).

Figure 1: Main components of Spy Guy: Fantasy.

Each turn has three phases. First, the *Search phase*, where players draw a card from the deck (See 1b), revealing an object that is hidden across the board. The players have 45 seconds (measured via sand

timer) to find as many images of this object as possible. The *Player movement phase* begins when the timer runs out. The players count the number of objects they found and move Spy Guy that number of spaces along the track. Finally, in the *Dragon movement phase*, the turn passes to Balasar. If the players have not yet reached the treasure, Balasar moves one space for his turn. If the treasure has been collected by the players, Balasar will move along the track by the number of wings on the drawn card (see bottom part of Fig. 1b). It is noteworthy that Balasar has the ability to fly; the dragon piece takes shortcuts to traverse the board more quickly than the Spy Guy.

We specifically are investigating the effects of digitising Timing and Randomising as defined by the HDBM [75]. Timing functions handle the timing and scheduling of gameplay, and Randomising ones handle the generation of randomised in-game elements. *Spy Guy: Fantasy* uses a sand timer to time the Search phase, and a deck of cards, which is shuffled before each game, to randomise the search gameplay. *Timing rounds* (Timing) and *ordering components* (Randomising) are recognised in the HDBM as common functions for digital tools in HDBs, and so it is reasonable for us to digitise these components to study the impacts of hybridity on PX.

3.2 Design Considerations for Hybridisation

Our study aims to specifically identify the effects of hybridity on PX, and so we were concerned about how player perceptions of both our custom app and HDBs in general would affect our results. Existing work shows mixed attitudes towards HDBs [50, 74], with particular concerns about the role of technology in the game weighed against the potentials for improved gameplay and enjoyment. Considering previous work on HDB design (see Sec. 2.1), beyond regular software usability, players expect technology to provide *added value* by expanding or extending functionality with processes like *automation* or *customisability* [45], but ultimately want the **technology to be integrated as just another component in the game** [74]. Given our aim is to trace PX changes to this modality shift, we made a conscious decision to **refrain from adding any new gameplay functionality to our hybrid implementation** which could interfere with that aim. However, we did not want a perceived "lack of value" to confound our PX measures.

Therefore we aimed to ensure that our implementation shared a **similar level of polish** to the original game such that players could feel like both games were *plausible* as commercial products and their PX could be compared reasonably. We leverage the concept of "juiciness"— the incorporation of large amounts of multisensory feedback in a way that is coherent with the game theme and mechanics to create a specific game feel [34]—as it is generally understood to contribute to perceived game polish [36]. Previous work on juicy design has shown that it increases audiovisual appeal [35] but has no consistent significant effect on player performance or other PX constructs, like perceived competence or perceived ease of use [35, 42]. As such, adding thematic audiovisual feedback to these functions should not inherently confound our study aim while still adding perceived value to the app such that players should not dismiss it as unpolished in a way that unfairly affects their PX.

3.3 Implementation

We built an Android application ("the app") using Unity 2023 to replace the sand timer (Timing function) and deck of object cards (Randomising function) for the game. The main game screen displays three buttons: Draw Card, Rules, and End Game (Fig. 2) During gameplay, players predominantly interact with the Draw Card button as it advances the game by initiating a new Search phase. Given our design goal to not add new gameplay features, we ensure our app's Timing and Randomising implementations are functionally identical to the originals—the timer counts down 45-seconds in 1 second increments, and the card deck has the same 56 unique cards.

We add polish through details in the visual and audio design of the app by drawing on elements from the physical boardgame. The Draw Card button is visually reminiscent of the top card of a deck, with the button looking like the back of the game's physical cards. When tapped, the search phase commences: a high-resolution scan of a random card from the deck appears on-screen and the timer begins (see Fig. 2a). The card's size on the screen has the same dimensions as the physical card to ensure that the images are the same size in both modes. The timer is where the most changes from the supplied materials (sand timer) are found: it starts automatically; provides clear information about time remaining through a decreasing circle and a numerical indicator; and provides audio feedback in the form of of a ticking sound, which increases in tempo and volume in the last ten seconds of searching before ending in a trumpeting sound effect. The sound effects were selected to reflect the fantasy theme of the game, invoking a medieval fanfare.

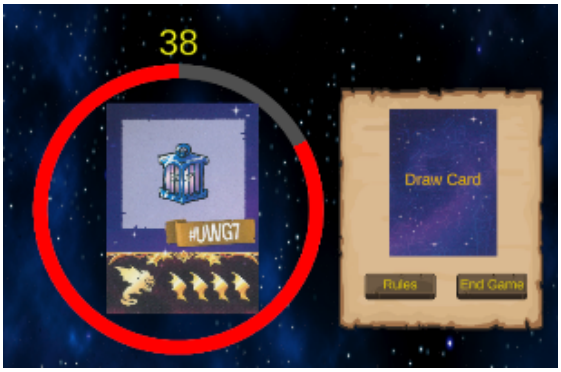
While the timer is counting down, the Draw Card button is disabled so players cannot draw multiple cards at once. If they interact with the Rules button, the timer pauses and a screen with the gameplay sections of the rulebook pops up. The timer remains paused until the players have closed the rules. While this may seem different from regular sand timers, it is possible to pause a sand timer by laying it on its side.

After the trumpet fanfare marks the end of the Search phase, the screen transitions to trigger the Player and Dragon movement phases, instructing the player to move Spy Guy and Balasar (Fig. 2b). This remains on-screen as a visual reminder of the next step in the process for 3 seconds. Once it disappears, players are able to tap on the Draw Card button again to start the next search.

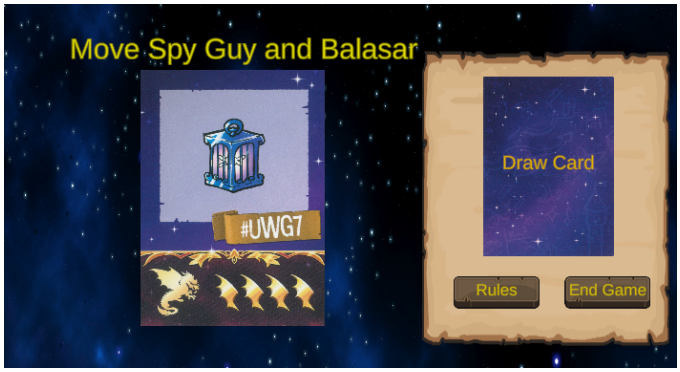
At any time, players can end the game with the End Game button. When the End Game button is hit, the timer is paused and a confirmation screen is displayed. If they player confirms they want to end the game, they are shown how many cards they have drawn in this session and are then taken back to the home screen.

4 Methods

We conduct this research under a reflexive paradigm, and so provide significant detail about our design choices in this work. We start this section by outlining our positionality as background context to our research design. We then explain our rationale for the study design, particularly explaining how our initial within-subjects study design shifted to a between-subjects study in response to our data. We then describe the study's participants and procedures, before explaining our data analysis process. This work is constructionist [10] and is rooted in symbolic interactionism [85], in that it



(a) Main gameplay screen displaying controls (Draw Card, End Game and Rules), Card and Timer.



(b) Secondary gameplay screen after timer runs out, triggering player and dragon movement phases.

Figure 2: Custom Spy Guy: Fantasy Android application to replace deck of cards and sand timer.

sees meaning as socially constructed and dynamic. Thus, we aim to reflect participants' views and sense-making through our own reflexive processes. We acknowledge that the quantitative element of our mixed-methods approach comes from a positivist paradigm, but reconcile this clash by treating it as secondary data supporting our primary qualitative interview data.

4.1 Positionality statements

This paper represents a pivot in our research as HCI academics from investigating the design and adoption of HDBs to examining the nuances of their PX. This prior work has informed our knowledge and understanding of HDBs and guided us to articulate the detailed design goals presented in 3.2.

Our recreational enjoyment of boardgames also has meaningful input to this study. For example, one of us purchased *Spy Guy: Fantasy* [55] at a game fair not with the intention to use it for research but simply because it looked like an interesting game. This deep genre familiarity and knowledge allows us to identify and select appropriate games and hybridisation approaches for these studies; our extensive experience over many years as game teachers guided us in developing a teaching script for the game to allow participants to quickly get started playing.

Finally, it would be remiss not to note our interest in HDBs as a research area. While neither of us would necessarily reach first for an HDB during a casual game night with friends, our interest in the genre is strong and likely exceeds the interest of many of our participants.

4.2 Study Design

Our study is a mixed-methods A/B testing study with a between-subject design. For transparency around our research practice, we explore here the reasons behind our study design. We focus on why mixed-methods, A/B testing fits our research aims, and then explain how we arrived at a between-subjects design from an initial within-subjects study (published as [87]).

4.2.1 Why Mixed-Methods A/B Testing. We want to understand the differences in PX between hybrid and physical play for the same game. Effectively, this is a comparison between the experience of the same system with two different interfaces, thus A/B Testing seemed an appropriate paradigm.

A/B testing is a method which compares two minimally different versions of a website or product through controlled studies [46]. A/B tests are typically performed online as a between-subjects controlled experiments that rely on the statistical power of large- (or large-enough-) scale quantitative data [81]. Although our method is neither online nor purely—or even primarily—quantitative, we have adopted the language and style of A/B testing due to its specificity and focus on careful and detailed comparison of two variants of a specific product. We share the position that A/B testing is at its most useful and insightful when the objects compared are minimally different, lacking even "subtle errors that are not easy to anticipate or detect" [48], hence our position on the importance of polish in our app.

While A/B testing typically focuses on the comparison of quantitative measures, abstracting fuzzy experience data to interval values alone reduces our ability to understand the specifics of an experience and *why* a player may feel that way. Increasingly, researchers are recognising the value of mixed-methods in A/B testing. Data triangulation through surveys and interviews offers insights into the possible causes of observed differences in response to variants and opportunities to more deeply understand the outcomes of even a small study [46, 49]. By taking a mixed-methods approach, we can holistically capture information about this experience, and use the different types of data to question each other and triangulate our findings.

4.2.2 Within- and Between- Subjects. We initially explored a within-subjects design to examine differences between hybrid and physical play in *Spy Guy: Fantasy*, published as [87]. This meant that our initial procedure had participants play both versions of the game, with groups counterbalanced to address ordering effects. We ran 16 participants through this process and analysed their results. In doing so, we found that participants assessed their second play experience in comparison to the first experience, not on its own. While the semi-structured interview data was able to accommodate

this kind of reflexive comparison through follow up questions, the second play survey data appeared heavily skewed.

After reflecting on this methodological consideration, we proposed that a between-subject design might be more appropriate in this case. We recruited another 16 participants, who played the game in a single variant. We combined data from this group with the first plays from the within-subjects group. This gave us two sets of data from 32 games each: a 16-person within-Subjects cohort who each played both variants of the game (16 hybrid, 16 physical games), and a 32-participant between-subjects cohort who each played a single version of the game (16 hybrid, 16 physical games). This is shown in Fig. 3, where the vertical boxes represent the between-subject configuration, horizontal boxes represent the within-subjects configuration, and coloured arrows map our data to the underlying configuration it is drawn from. While we report on qualitative data from both cohorts, the quantitative data analysis below is based on the between-subjects study – that is, on "first play" data.

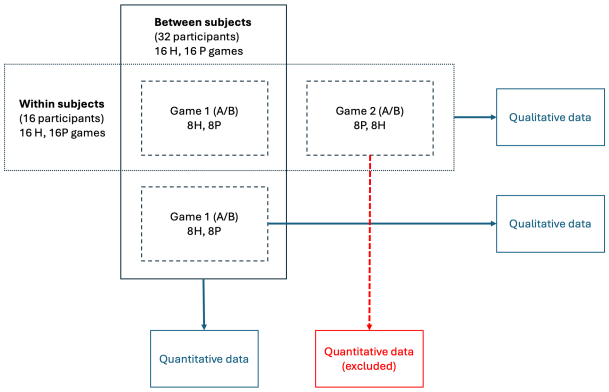


Figure 3: Participant Groups for the Within and Between Subjects Conditions. Within-subject structure denoted by horizontal boxes, and between-subject structure denoted by vertical boxes.

4.3 Study Participants and Procedures

We first describe the participants, and then we outline the study's apparati and procedures. The study, in both within and between-subjects form, had ethics approval from The University of Melbourne (Ethics ID 29470).

4.3.1 Participants. 32 participants (16 women, 15 men, 1 non-binary; $\overline{\text{Age}}$: 33.16 ± 11.68 years) completed our study. Participants were recruited from the Melbourne area, with particular effort to capture a mix of novice players and knowledgeable hobbyists from local game groups. Based on self-reported game history, we categorized participants as either (**K**)nowledgeable (N_K = 20)—indicating they regularly play modern games—or (**N**)ovice (N_N = 12)—indicating inconsistent game playing or only familiarity with mass-market games (e.g. Monopoly). We used this information to understand and question the data, but not for significant analysis. Participants were divided into two groups, (**P**)hysical or (**H**)ybrid, based on the game variant they played. There were 16 participants in each group; 8 from the initial within-subjects setup, supplemented with an additional 8 for the between-subjects setup, as indicated in Fig. 3. The groups were fairly similar in age and gender distributions. Of note, the Hybrid group had more Knowledgeable players (12/16) than the Physical group (8/16).

4.3.2 Apparatus. In this study, participants interacted with a designed game and app, and their experiences were measured via survey and group interview. We discuss all of these here.

Game and Technology: We described the base game, *Spy Guy: Fantasy*, and our custom hybrid app in Section 3. The game was set up on a long table in an observation room (Fig. 4). For participants playing the hybrid version, we provided an Android tablet with our app pre-installed and running. The tablet was propped up on the table using a phone/tablet holder at one end of the table.

PX Survey: Our post-game survey consisted of twenty-eight 7-point Likert-scale questions, and two open-ended questions. We used the **miniPXI** [31] as the survey's base. This is a shortened version of the PXI [1], covering its ten constructs (Ease of Control, Challenge, Progress feedback, Audiovisual appeal, Goals, Meaning, Mastery, Immersion, Autonomy, and Curiosity) and a meta-construct (Enjoyment). Like the validated PXI, the miniPXI measures each construct via a 7-point Likert scale measured from -3 (strongly disagree) to +3 (strongly agree). While the miniPXI may be less reliable than the PXI, in that measures of some constructs may be less consistent [32], it is nevertheless faster and more efficient to administer than the full PXI. While the designers of the PXI are at pains to stress that the entire questionnaire (whether the full PXI or miniPXI) must be administered in order for results to be valid, they acknowledge that there may be times when the PXI might be extended [1]. This was important for this study, as work on the PXI and miniPXI focuses exclusively on digital games and not on the specific experiences of tabletop board or HDB gameplay. We extended the miniPXI to include **seventeen additional 7-point Likert items** examining sociality, materiality, and (for the **H** cohort) hybridity in the game. These ideas do not comprise formal constructs of PX for boardgames, but represent well-established elements of player motivations and experience (e.g. [21, 51, 71]). We also added **two open-ended questions** on players' likes and dislikes about the experience.

Semi-structured interviews: Our interviews focused on the experience of playing the game. Participants were asked about elements of the play experience they found engaging, challenging, and/or frustrating. As well, we asked them to reflect on their other gaming experiences and how those compare to this game. The 16 participants from the within-study paradigm were then asked to compare their experiences between the two versions. The 16 participants who only played one version were instead shown the other variant of the game (e.g. physical players were shown the app) and asked to speculate on how they think that experience would differ. All of our interviews were video recorded.

(a) Setup of physical game variant

(b) Setup of hybrid game variant.

Figure 4: Experimental setups for the physical (4a) and hybrid (4b) variants.

4.3.3 Procedure. Participants began their session by providing their consent to participate, and completing a survey about their demographics, recent gaming history, and familiarity with *Spy Guy*. Participants were then paired up; pairs were assigned either (**P**)hysical or (**H**)ybrid, indicating the version of the game they would play. This ensured an even division of participants between conditions ($N_P = N_H = 16$).

Participant pairs were led to an observation room, where the game was set up on a table. For the Hybrid condition, the sand timer and deck of cards were replaced with an Android tablet. Participants were taught how to play the game by one of the researchers via a teaching script, but were told to refer to the rules (via the app or printed rulebook depending on the condition) if they need further clarification during the game. The participants played until they either won (by returning Spy Guy and the treasure to the starting location) or lost (were caught by Balasar).

After the game finished, participants completed a short survey about their experience (see Sec. 4.3.2). Following this, the Within-subjects cohort (see Sec. 4.2.2) re-played the game using the other variant before completing the survey again.

When surveys were complete, the researchers facilitated semi-structured group interviews with all available participants. As we were able to run up to two study sessions concurrently, group interviews were at minimum two people (i.e. the pair of participants) and maximum four people (i.e. two pairs of participants).

4.4 Data Analysis Process

In this study, our primary empirical data source is our qualitative group interviews. The interview data provides direct and nuanced insight into players' perceptions of their own experience. We consider this data in dialogue with the quantitative miniPXI survey results to get a deeper understanding of how players reflect on their game experience in different forms. This decision also helps us to consider the efficacy of these different types of data in studying PX of boardgames.

Notably, data from 16 participants (9 women, 7 men; $\overline{Age}$: 34.50 ± 8.5 years) comes from our original within-subjects study protocol. Given our study design change, we chose to eliminate the PXI data from their second playthrough; this ensures that our data consistently captures the participants' first experience with the game, and that we maintain an even number of group members. We left the interview data from these 16 participants intact, as their reflections on their gaming experience provide valuable and informed insight into the experiential differences between the two variants.

4.4.1 PXI Data Analysis. Following the guidelines for analysis of the PXI and mini-PXI [1, 31], we analysed the Likert data using IBM SPSS v29 to calculate descriptive statistics and perform non-parametric tests. Data were segmented according to whether participants were in the **(P)**hysical or **(H)**ybrid variant group and whether, based on their description of the types of games they generally play, they were classified as a (**N**)ovice player or a (**K**)nowledgeable player. We use N/K with the participant numbers to indicate this in subsequent discussion, although the Novice/Knowledgeable assignment was not a significant factor in our analysis. As anticipated, no participants had previously played a *Spy Guy* title.

4.4.2 Qualitative Data analysis. We use reflexive thematic analysis [15, 16] to analyse the interview data. We visualise our process of familiarisation, coding, and iterative theme generation in Fig. 5.

Automated transcripts of each interview session were generated by the rev.com AI service. We post-edited these [37, 61] while watching the video recordings to generate fit-for-purpose, "good enough" transcripts [11] suitable for our own use.[2] Through this active editorial process, coupled with conducting the interviews and observing the play sessions, we became sufficiently familiarised with the data.

[2]This is equivalent to "inbound" translation – "the process of translating to understand" [5] rather than "outbound" translation – "translating to communicate" or share with others [5]

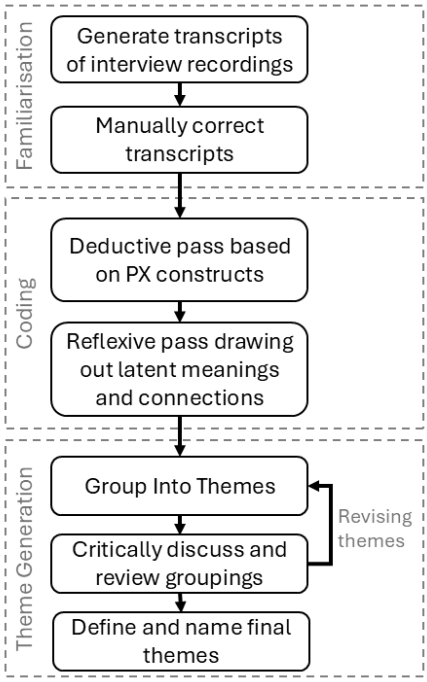


Figure 5: Our reflexive thematic analysis process, highlighting our steps for data familiarisation, coding, and iterative theme generation.

We took two coding passes through the data: a preliminary, deductive, codebook-like pass [91] using constructs from the PXI [1] and our custom PXI-style questions (see Table 1) to cover broad strokes and preliminary codes that examine these specific constructs, followed by a reflexive, abductive pass to develop deeper understandings of the players' experiences and connections between them. During the initial deductive 'codebook-like' pass, we looked for implicit and explicit discussions that reflected the PXI constructs (e.g. autonomy) and survey-specific ideas (eg. effect of hybrid technology). Construct definitions from the original PXI paper were used as a major touchpoint in coding these implicit discussions. For example, *Challenge* describes "the extent to which the specific challenges in the game match the player's skill level" [1], and so explicit conversations about *difficulty* fall under this code alongside more nuanced reflections on how *game design elements influence difficulty* ("that coin one was particularly hard 'cause they're so tiny", K13) or the effect of different *strategies to mitigate difficulty* ("what if I do, like a police search, and do it in a grid?", K28). Simple connections between constructs were also captured in this pass, such as the connection between *Challenge* and *Immersion* ("A sense of immersion and cognitive absorption, experienced by the player"), through (**P**)hysical participants finding it "annoying keeping track of the sand timer" (K03) since they needed to divide their attention between the timer and board, interrupting their concentration while searching for items.

For the reflexive pass, we abductively re-examined the data for latent concepts and connections. We drew from our experience as designers, gamers, and researchers to understand how certain constructs, like *Ease of Control* ("the extent to which a player finds the actions to control the game clear and intuitive") manifest in boardgame and HDB contexts. For example, multiple participants took issue with the fact that "from the card itself, you cannot tell what size the item is [on the game board]" (K24). Superficially, this seems to be an issue with *Clarity of Goals and Rules* ("The extent to which the overall objective and rules are clear to the player") and *Ease of Control*, as the card design is making it difficult for the player to know what they are looking for. However, underlying this conversation is an issue of *player expectations about this type of game*, as participants felt that *Spy Guy: Fantasy* would be "a relaxing sort of game because it doesn't require much brain power" (N26). These conversations further reflect participants' expectations of game *Mastery* due to the perceived simplicity of the game rules and their experience with other forms of hidden object games ("this is gonna be really fun 'cause I used to really like, Where's Wally? And I haven't played it since I was a kid", K29). This foregrounds the complicated relationship between design decisions that create *Challenge* in a game and players' expectations of *Clarity* and *Ease of Control*.

We generated themes by grouping codes and then we critically discussed the resulting themes in an iterative refinement process until we developed our final set. Keeping in line with rigour in RTA (see [15]), our themes are neither topic summaries, nor direct responses to our interview or research questions. Rather, they reflect our interpretations of phenomena relating to the PX of the game. We discuss how we understand the relationships between these themes to answer our research questions in Sec. 6.

5 Findings

In this section we present key findings from our analysis of this study. We first report on the quantitative survey and then explore the qualitative interview data. While our primary data comes from our interviews, we present the survey results first in order to contextualise our findings.

5.1 miniPXI and Survey Findings

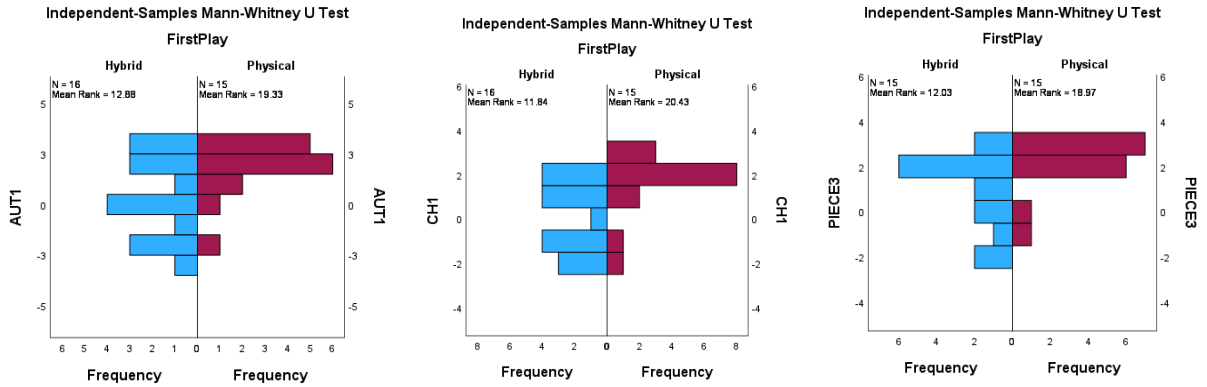
Table 1 summarizes the means for each item, and the results of the Mann-Whitney U tests comparing mean scores between versions. The mean scores are all positive, implying that both groups had overall positive experiences with the games. We find three significant differences between groups in autonomy, challenge, and materiality.

Autonomy (a Psychosocial PXI construct): Physical players reported higher feelings of autonomy in play (AUT1, U = 170.00 p=0.049). Both groups had positive mean scores and large standard deviations ($AUT1_P$ = 1.80, SD 1.37; $AUT1_H$ = 0.38, SD 1.99). Fig. 6a shows the distribution of scores, with a skew in the Physical group towards higher scores and a closer to uniform distribution through the Hybrid group.

Challenge (a Functional PXI construct): Physical players were more likely to consider the game to be appropriately challenging (CH1, U = 186.50, p=0.007), indicated by their higher scores in this item. Both groups' mean scores were positive with a high standard

Table 1: Comparing Likert Items.
Legend: * indicates item is not part of miniPXI, bold indicates significance.

		Means		Mann-Whitney	
Label	Item	Physical	Hybrid	U	p
AA2	I liked the look and feel of the game	2.50 SD 1.03	2.44 SD 0.892	137.00	0.752
AUT1	**I feel free to play the game in my own way**	**1.80 SD 1.37**	**0.38 SD 1.99**	**170.00**	**0.049**
CH1	**The game was not too easy and not too hard to play**	**1.60 SD 1.40**	**0.13 SD 1.54**	**186.50**	**0.007**
CUR1	I wanted to explore how the game evolved	0.85 SD 1.77	1.33 SD 1.45	82.00	0.496
EC1	It was easy to know how to perform actions in the game	2.56 SD 0.81	2.33 SD 0.62	152.00	0.216
ENJ3	I had a good time playing this game	2.67 SD 0.62	2.25 SD 1.13	148.00	0.281
GR2	The goals of the game were clear to me	2.80 SD 0.41	2.62 SD 0.72	129.00	0.740
IMM3	I was fully focused on the game	2.44 SD 0.89	2.75 SD 0.58	103.50	0.361
MAS1	I felt I was good at playing this game	1.56 SD 1.37	0.25 SD 2.11	175.00	0.080
MEA1	Playing the game was meaningful to me	1.63 SD 1.15	1.69 SD 1.25	121.50	0.809
PF3	The game gave clear feedback on my progress towards the goals	2.20 SD 1.42	1.87 SD 1.59	105.00	0.572
*MAT1	Moving the physical pieces helped me to plan what to do in the game	1.47 SD 1.69	1.13 SD 1.78	135.00	0.572
*MAT2	Seeing other people move their pieces helped me to understand their strategy	0.45 SD 2.07	0.18 SD 2.32	156.00	0.305
***MAT3**	**Moving the physical pieces helped me to understand how to play the game**	**2.13 SD 1.19**	**1.00 SD 1.65**	**164.50**	**0.029**
*MAT4	I enjoyed touching the pieces of the game	2.00 SD 1.16	2.13 SD 1.09	124.00	0.897
*SOC1	I enjoyed playing the game with other people	2.81 SD 0.40	2.69 SD 0.60	137.50	0.724
*SOC2	Sitting around a table with other players was meaningful to me	2.62 SD 0.50	2.63 SD 0.62	123.00	0.867
*SOC3	I felt connected to the other players	2.20 SD 0.78	2.19 SD 1.33	105.00	0.572
*SOC4	I would like to play this game with my friends or family	2.06 SD 1.53	1.62 SD 1.46	165.00	0.171
*STE1	I had enough information to understand the state of the game	2.75 SD 0.45	2.44 SD 0.73	156.00	0.305
*STE2	It was easy to understand the state of the game	2.75 SD 0.45	2.38 SD 0.72	164.00	0.184



(a) Autonomy scores. **(b) Challenge scores.** **(c) Materiality 3 scores.**

Figure 6: Score distributions for Autonomy (a), Challenge (b) and Materiality (c). Blue bars are Hybrid group, red bars are Physical.

deviation ($CH1_P$ = 1.60, SD 1.40; $CH1_H$ = 0.13, SD 1.54). However, the Hybrid players are noticeably more bimodal in their view of challenge (Fig. 6b).

Materiality (a non-validated boardgame specific phenomenon): Physical players reported that the material components were more helpful in understanding how to play the game than Hybrid players (MAT3, U = 164.50, p = 0.029). Both groups had positive mean scores with large standard deviations ($MAT3_P$ = 2.13, SD 1.19; $MAT3_H$ = 1.00, SD 1.65). Notably the Hybrid group's mean score is more positive for this item than the other statistically significant items. This is reflected in the score distributions (Fig. 6c) where there is a noticeable peak at 2 (Agree) for the Hybrid group, while the Physical group skews high.

5.1.1 Survey data about the app. The Hybrid group surveys also included seven Likert-items about their experience with the app. The mean scores are found in Table 2, which highlights a seemingly overall positive experience with the app belied by large variations. Notably, APP4 is the only item that has a negative mean score (-0.88 SD 1.93).

Table 2: Hybrid players' Likert scale responses about the app.

Label	Item	Mean
APP1	I enjoyed using the app to play the game	1.73 SD 1.22
APP2	The app worked smoothly as part of the game	2.13 SD 1.09
APP3	The app made me a better player at the game	0.25 SD 1.65
APP4	The app adds interesting variety to my options to play this game	-0.88 SD 1.93
APP5	Using the app helped me to plan what to do in the game	0.50 SD 1.97
APP6	The app made it easier to play the game	1.44 SD 1.41
APP7	The app helped me to understand how to play the game	1.13 SD 1.82

5.2 Group Interview Findings

Following our qualitative process (Sec. 4.4.2) we generated five major themes from the interview data. These speak to the PX of *Spy Guy: Fantasy* in both Physical and Hybrid form, and connect to larger ideas and beliefs about hybrid play.

5.2.1 Understandings of Core Gameplay and Chores Influence Expected PX and Perceptions of Hybridity. For *Spy Guy: Fantasy*, players generally agreed that "the purpose of [the] game is, like, finding the objects" (N08)—positioning finding objects on the board and (to a lesser extent) moving the tokens as *core gameplay*—the actions and tasks that players feel are central to their engagement and enjoyment of the game. In contrast, *chores* are the necessary articulation tasks performed by players to support and enable gameplay [72, 98]. Players intuitively construct their personal understandings of the core gameplay based on their expectations of and interactions with said game. By extension, players perceive the chores to encompass everything not part of that core. Thus, for *Spy Guy: Fantasy* the chores include managing and monitoring the timer, and shuffling and drawing the cards [87]. Understanding the core and chore gameplay in a boardgame provides insight into a player's expected PX in relation to gameplay.

In post-play interviews, players of *Spy Guy: Fantasy* consistently differentiated between what they saw as the *core* and the *chores* across the physical and hybrid variants, implying that these classifications are related to the game design not the game medium. Their feedback also described a clear hierarchy of these activities, which we illustrate in Fig. 7.

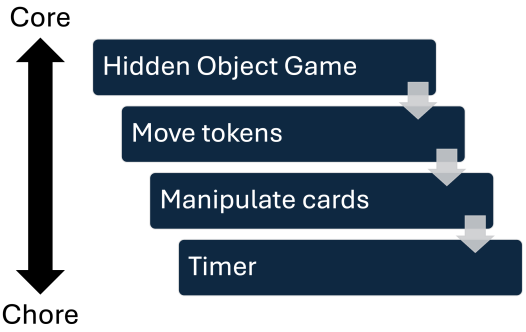


Figure 7: Spy Guy: Fantasy Game activities in players' priority order from Core actions to Chores

Attitudes towards the value of digital tools seem to be influenced by their perceptions of cores and chores. To players, a strength of the app was the freedom to *not* constantly monitor the timer—a requirement that many found frustrating—instead relying on the notification from the app: "I feel like with the app I was able to actually focus on just playing the game," (N01). This contrasts with the sentiment, expressed by several players, that checking the timer might be a role assigned to an ancillary player – "we almost would've needed a third person who was supposed to sit out each round and just be like...in charge of the timer" (N01) – albeit a rather dull and uninteresting role.

Player's understanding of core gameplay influences how they feel about the game overall. Since players thought 'finding the objects' was the core gameplay in *Spy Guy: Fantasy*, they logically assumed that the game's overall difficulty, using the dragon's movement speed as a proxy, would be tied to the item design. During play, however, participants realised that the dragon's movement "was always connected to the amount of objects on the board, not necessarily how easy it was to find" (K13). As well, the dragon starts to move at full speed as soon as the players reach the treasure; poorly performing players could get caught almost immediately after getting the treasure. This creates frustrations in players because they perceive it to undermine the core gameplay:

> "It feels like we're being penalised for finding that many, because if we only found eight, it would've been a much better, like, position to win going forward. So it's like we got penalised for, like, doing the goal of the game." (K19).

Taken together this made the time limit and chase mechanisms seem extra punitive and against the expected PX, leading one participant to say of Balasar, "why is he moving so fast? He's a cheater" (K20). This was further frustrating due to the perceived difficulty of successfully completing (winning) the game. Participants routinely asked us whether it was possible to win the game *at all*, and questioned winning groups about it during the interview sessions. This led to players critiquing the game design and fairness and suggesting ways for us to "improve" the game:

> "it also just felt like there were very little win conditions and there's like a lot of ways that you can lose the game. It's like, oh the, the dragon can move one and then he can move more and then he can also fly. It's like, I want a power up too. <laugh>. It's like, where's my power up?" (K20).

5.2.2 The Hybrid variant does not conform to players' expectations of this type of game. Participants expressed that "hidden object games are supposed to be calming" (K23) and should make players "feel very relaxed" (K25). The game's mechanical simplicity meant that participants "assumed it was more a family style board game <laugh> like play this with your kids" (K16). Together this implies an expectation that as adults, succeeding at this game should be somewhat easy. However, our participants found the game was difficult and stressful due to "both the time pressure and, like, the fact that the dragon just moved so ridiculously quickly" (K23). The majority of groups lost the game regardless of variant, leading to feelings of frustration about the game's unexpected difficulty, and a desire to focus solely on the Search phase: "can we just at our leisure find the items?" (K28).

In the hybrid variant, the digital timer added to this sense of time pressure, providing a non-negotiable countdown for players, effectively policing the game's timeframe. Additionally, the final 10 second countdown added a sense of imminent doom. While players generally felt this was an appropriate behaviour for the timer, its accompanying stress was not conducive to their play. This increased pressure in the hybrid variant ties into notions of control and rules flexibility that are specifically relevant to the boardgame setting, where rules negotiation can occur, unlike in a videogame where fixed rules are applied and enforced by code. By building rules into the underlying code of the game, hybrid tools—much like videogames—constrain what is allowed during play, creating a tension between a player's expectations and their play reality.

5.2.3 "Minor Cheats" and the flexible affordances of physical vs. digital components. Players seemingly ease this tension between their expectations and reality through negotiating the boundaries of fair play. These negotiations were sometimes explicit, like changing the rules to fit their expectations: "I thought if you found all the items [Balasar] wouldn't move," (K18). Other times they were implicit, like accidentally missing when the physical sand timer ran out: "You'd find one, look up, see the timer ran out ... I guess we probably cheated." (K13). Players were more likely to engage in implicit negotiations in the physical variant, but were conflicted about the acceptability of a decision when questioned about it. We see this in how players often ask if it was "cheating", with one participant labelling these small modifications as "minor cheats" (K29).

In effect, players used these implicit negotiations in the physical variant to determine what was acceptable play that could then bring their game experience into alignment with their expectations. The most frequent "minor cheats" revolved, in the physical game, around policing the sand timer — both when it started and when it ends. The game rules specified that the timer should start as soon as the card is drawn, however, players in the physical variant "would take a good look at the card before this timer starts....It wasn't a conscious thing...I just assumed that, you know, the time would start when we actually started looking," (K29). Players in the physical variant also lacked a constant view of the sand timer's status, meaning that they were unaware of when precisely their timed search phase had ended. One player even gave up entirely on monitoring the sand timer, telling her partner that "I was full on relying on the fact that you kept on noticing that it would run out," (N01).

In contrast, the hybrid variant did not afford these implicit negotiations because the app rigidly implemented the timing rules as written. This difference led players to reflect on the acceptability of their choices: "Maybe that was us cheating <laugh>. So we would like [look at the card and then start the timer], whereas [the app] starts like as soon as you draw the card," (K29). Some players expressed feeling conflicted about how to re-establish fairness after 'minor cheating': "you kind of want to stick to the rules. So it feels more rewarding when you do sort of win. Whereas if you feel like you've got an extra 30 seconds, you are not sure how to, like, negatively compensate for that," (K17). While hybridity enforced rule correctness for Timing in a way that added value for some players, other players felt this was not sufficient to justify using the app: "I'd be tempted to play the regular version...but use an iPhone timer or something," (K16).

When considering Randomising, players did not exhibit any 'minor cheating' in the physical variant that hybridity could address through rule enforcement. In fact, the digital cards (i.e. hybrid variant) did not afford turn tracking in the same way physical cards did through the discard pile. This unintentional reduction in feedback opened up space for confusion about "cheating" and the game state in regards to Balasar's movement. A small number of groups questioned whether they had moved Balasar the correct number of spaces, particularly during the early stages of the game when he only moves one space per turn. In the physical variant, groups were able to use the game materials to confirm his location – "if we have the physical card, we can count the number, how many cards we have got" (N05).

This trade-off between flexibility and correctness in play is a core tension between the physical and hybrid variants. Digital components ensure correctness, but also enforce a specific play experience that may not be aligned with player expectations. Physical components afford more flexibility in their use and allow for players to negotiate the play experience through minor cheating.

5.2.4 Technology implies Complexity. Despite the app's value, there was a sense from players, particularly knowledgeable ones, that apps should only exist for *complex* games like *Terraforming Mars* "because there's multiple things you have to do at the same time.

And then the [unofficial Helper] app allows you to not use that physical part of the calculation and then it calculates it automatically for you," (K12). This highlighted a latent connection players have between technology and complexity — both in terms of gameplay and number of features.

This strong implicit association between technology — particularly apps — and complexity influenced players' perceptions of gameplay complexity in the hybrid variant. **H**ybrid participants wondered whether the app incorporated adaptive difficulty. They imagined that, after Spy Guy reached the treasure, the app might deliberately be dealing them more difficult cards: "not sure if the game actually adapted and thought, oh, you can see the big ones. Let's give you some small ones," (K27). As noted above, they wondered whether the game itself was cheating, asking "did it get less time as we moved on or do we just get like harder or do we just get like low skill?" (K19) or "does the game lie? Are there really 6, 7 [items]?" (K27). This perception of what an app *could* do characterised how participants understood what *was* happening in the game and what they would expect a hybrid version to do.

We further explored this idea that technology implies complexity by asking participants about the features they would want to see in the hybrid version. The most common category of suggestions were quality-of-life improvements for the Search phase, like adding "an option where at the end somehow you actually found out where they all were hidden" (N01), changing the noise made by the timer so it was "like steady and then had a ring at the end" (K17), being able to end the timer early, and making "the [card] image itself a little bigger" (N07). The next common set of suggestions focused on rule enforcement and correct play: "ideally [the app] would also recognise if you make a mistake" (K27). This included knowing whether a player had found the right item, or moved Balasar correctly. Bordering between functional and quality-of-life improvements are suggestions to add to "the storytelling part, it would be cool if some of the characters in the cards had stories as well and animations" (K29). One participant noted that adding sound effects would both add engagement and be a cue so "we don't have [to look at the card], we have like, okay, bird, bird, bird. Yeah. That's the thing we are looking for" (N31). Beyond this participants suggested changes to the underlying game mechanisms that could be supported by the app, like power ups, "have like different times for different things" (K23), the ability to take further actions, or Remembering functions "like a leaderboard and you compare to other people who are using the app or playing it" (K24). Two groups suggested that we build an electronic card holder that would automatically trigger the start of a timer when a physical card was placed on it. In short, potentially because they already assume technology affords more complex interactions, participants felt "if you're already going to be having the app, you might as well go all out," (K23).

5.2.5 The importance of sociality and the labour of teamwork transcends game medium. Despite the ups and downs participants had with the game and technologies, a through line in conversations across both the physical and hybrid variants was the importance of sociality and teamwork. Even participant pairs who did not know each other well generally felt that "the fun of the game was failing together" (K28) and exhibited a strong sense of camaraderie by "trying to say, oh, that was easy. Or things like that to try and pump us up" (N26). Participants intuitively developed search strategies:

> "Like I search [this] side, you search [that] side, and we also divided these [magnifying glass tokens] together. You got five? I got five. To make it easier to collaborate, to save time and to make it easier for us to focus on the area" (N06).

This strategic sharing of labour extended to helping each other more clearly understand the task, through activities like callouts, where participants "counted aloud for ourselves together" (N01) and sharing information whereby " if somebody found the first object, we'd both look at it to sort of determine the size" (K13). While the broader practice of dividing the board was discussed as an explicit strategy, the implicit elements were not thought of as a strategic choice but rather just good cooperation. The most commonly discussed marker of this was feeling equally competent at finding items:

> "In some [rounds] like I've got nine and the other one he's getting nine. So I'm not feeling like I'm the only one finding it or he's the only one finding. I feel like it is balance. Both of us are doing the exact good job" (N32)

While the explicit pressure of being a good teammate centred around finding a sufficient number of objects, a few participants brought up taking on invisible roles that helped facilitate play. As K29 said to their partner, "I was kind of in the back of my head thinking about what you were doing". K18 similarly remarked about being "kind of worried the whole time of like, if K17 had found a few [objects], like maybe he'd run out of [tokens]. So it was kind of like sort of checking sometimes," (K18). This creates an interesting sense of somewhat parallel play between the team roles which could foster a greater sense of cooperation and sociality.

6 Discussions, Limitations, and Future Works

These themes provide holistic insight into PX of hybrid Timing and Randomising functions, thus we can now attempt to answer our research questions. We address RQ1 through discussing the relationships both within our set of themes and survey data, and between our themes, survey data, and existing work. We then address RQ2 through reflecting on our methodology and insights. We also discuss broader insights into HDB design and PX that may be interesting to the general games research audience. We wrap-up this section by outlining limitations of this work and potential future extensions.

6.1 RQ1: Specific Insights from Hybridising Timing and Randomising Functions

We discuss here the potential impact of our implementation of Timing and Randomising functions on PX, and then extrapolate from those some considerations and specific insights for hybridising published games. While our interviews indicated marked differences in the overall PX between hybrid and physical variants, the quantitative results showed only marginal differences. This seems to imply that although the games felt different, both were generally enjoyable for the players.

6.1.1 Timing: Although players did not necessarily perceive the digitised timer as a negative (see Table 2), the increased awareness of time pressure that it engenders via the audio-visual feedback seems to influence the game's perceived challenge, regardless of the fact that the time limits were the same between versions. By keeping players more aware of the time constraints, our "juicy" Timing implementation may have increased their anxiety which potentially manifested in the significant difference in perceived challenge between the physical and hybrid versions (see Table 1). This is surprising given the evidence that "juiciness" should not affect PX constructs beyond audio-visual appeal [35, 42], but it aligns with Adams understanding that a game's perceived difficulty (i.e. challenge) is the combination of the intrinsic gameplay difficulty and stress induced by time pressure [3, pp. 259-261]. It is also supported by Rogers et al. who suggest that players in higher arousal states, like anxiety, report increased (not significant) perceived challenge [69], and could lend weight to Juul and Begy's suggestion that "juicy" feedback might increase cognitive load [42], which may then result in greater feelings of perceived challenge.

Our interview discussions highlighted that the anxiety had some positive effects, given the discussion of cheating (Sec. 5.2.3), desire for rule enforcement features (Sec. 5.2.4), and social bonding of failing as a team (Sec. 5.2.5). From our thematic analysis, the most anxiety-inducing element seems to actually be the discrepancy between players' expectations that the game should be relaxing and the hybrid variant's time pressure tension. Existing work in videogames has shown that threats to the desired play experience may cause players to exhibit *autonomy frustration* [94]. In our study, this increased timer awareness made it seem like the hybrid Timer was policing the *"core" gameplay* in a way that contradicted players' expectations of a relaxing and easy game (Sec. 5.2.2). Players were then unable to safely enact "*minor cheating*" through neglecting the timer because they were hyper aware of when it ended (Sec. 5.2.3). This mismatch between expectations and reality, along with the inability to "fix" it through negotiated fair play could be the reason why players reported lower feelings of autonomy and increased perceived challenge in the hybrid version.

6.1.2 Randomising: Our Randomising implementation of the digital deck of cards did not have particularly juicy feedback; when a card was drawn it just appeared on screen and started the timer, with no additional visual or unique auditory embellishments. Accordingly, the actual act of Randomising was not as apparent to the players as Timing was. Multiple works have discussed the overall importance of articulation work [70, 87, 98] and materiality [71] in boardgames, particularly as it supports player cognition [60] and helps players understand a game's strategy [70]. Removing the materiality of Randomising through hybridised automation, despite maintaining the boardgame metaphor of a deck of cards, may cause players to receive less implicit feedback about its fairness from their interactions with the game system. This, along with players' preconceptions about what technology could be used for, may have created space for players to speculate that the app had some form of dynamic difficulty adjustment (DDA) built into the randomising function (Sec. 5.2.4). Existing work in videogames has shown that DDA impacts a player's sense of immersion and challenge [22], and that this effect is based on the player's perception that DDA exists rather than its actual presence [23]. This lack of transparency could be why we see higher ratings for MAT3 (Moving the physical pieces helped me to understand how to play the game) in the physical version and why the hybrid version seemed to feel more challenging to players. In contrast to our app-based implementation, a physical deck of cards affords transparency of the randomisation process.

6.1.3 Considerations When Hybridising Existing Games: Our intent was to compare two minimally different variants of the same game, such that we could isolate the PX effects of hybridising specific functions from the impact of larger game design decisions. Our results and specific insights into hybridising Timing and Randomising demonstrate that **one-to-one functional recreations are not necessarily one-to-one experiential recreations**. This phenomenon has previously been discussed in both tabletop (e.g. [14]) and digital boardgame play (e.g. [67]), but has not been specifically reported for HDBs and hybridisation. While seemingly intuitive, this growing body of evidence is particularly important because we do not have a detailed understanding of *why* these differences exist and *how much* they impact PX. In relation to this, our results raise that contrary to work in videogames where "juicy" design seems to only affect audiovisual appeal and not other PX constructs [35, 42], **"juicy" designs for Timing functions in HDBs can change the perceived PX of the game.** In this study, the "juicy" Timing functions impacted autonomy and challenge by providing more information through feedback than the physical timer. As well, our results imply that **automating Randomising functions in HDBs may change player perceptions of the game's difficulty and fairness**. Our study proposes this is because digitising a deck of cards makes randomising less discernible to players compared to physical cards, and so they may misattribute random elements, like an unlucky card draw, to game intent. Instead of focusing on *functional* recreations, future work may want to instead explore various *experiential* recreations to see the variety of ways hybridity may preserve or alter a game's PX without change the "core" gameplay. Future studies may also want to explore the potential for PX differences in boardgames based on function visibility.

6.2 RQ2: Specific insights about studying hybrid play experiences

Our secondary aim for this study was to develop a robust and repeatable method to study PX in HDBs. With this goal, we reflect on the procedures and design decisions of our study and offer future researchers a set of considerations for their own work as a response to RQ2.

6.2.1 Measuring PX in Boardgames: Part of our decision to take a mixed-methods approach was to have the ability to quantify PX for easy comparison between game variants. By using a standardised measure (ie. the miniPXI) to have players report their PX for each variant, we thought we could be more confident to identify any differences in the data as resulting from the function hybridisation. Recognising that boardgame and videogame PX may not be exactly the same [28, 54], using existing videogame-based PX measures is a fairly standard practice in boardgame PX literature (e.g. [4, 8, 26, 41]). However, reflecting on the discrepancy between our qualitative and quantitative results, we are unsure whether the

standardised PX measures are sufficiently able to capture experiential differences between minimally different boardgame variants, or even are suited to boardgames more generally. The absence of a reliable and validated set of PX constructs for boardgames—let alone HDBs—is a limitation for anyone attempting to quantify PX. This is a core concern that echoes the arguments set out by Soraine and Carette [86]. We stress that this is not intended as a criticism of the PXI (or miniPXI) itself, but rather as recognition that it was not designed for this setting and that therefore its applicability to boardgame PX is dubious.

6.2.2 Choosing a study design: Our research began with a within-subjects study because a controlled A/B-style experimental setup is theoretically the best way to understand the impact of subtle differences between artefacts. While this approach generated robust and interesting qualitative data, the quantitative results were biased by the first variant played. We responded to this by recruiting additional participants who each only played a single game, analysing the new data and reanalysing the first plays from the first half of the study as a between-subjects study. While this decision likely improved the quantitative data, removing the context of playing both variants of *Spy Guy* reduced participants' ability to reliably comment on the two variants, impacting the qualitative data as players speculated about their potential experience after seeing the other variant. Given this apparent choice between generating high value qualitative or quantitative PX data, we would in future opt for robust qualitative PX data over out-of-context quantitative PX data. This is particularly important given that boardgame PX is an under-explored field that currently lacks reliable or validated measures. However, in this study the collection of data using these two methods provides robust data about the strengths and limitations of these two approaches.

6.2.3 Studying Boardgame and HDB PX:. The lack of existing knowledge around boardgame PX and trade-offs between study designs leads us to think that **when comparing boardgame variants researchers ought to take a qualitative, within-groups approach**. This would allow for deeper insights into the boardgame PX that could capture nuances of the PX between variants. This recommendation is tempered by obvious practical considerations. A within-subjects study of *Spy Guy: Fantasy*, which is approximately 15 minutes per game, is readily achievable, but studies of longer games may necessarily be limited.

Our experience with this study also suggests that given we do not have strong theoretical understandings of whether videogame-based PX constructs are relevant to boardgames, **studies investigating boardgame PX, even for HDBs, should be cautious when using common quantitative PX measures**. To the best of our knowledge there is a lack of research into the theoretical underpinnings of boardgame PX, with efforts in creating validated measures instead focusing on boardgame player motivations and attitudes (e.g. [51]). This study leads us to believe **there is a greater need for examining the constructs underlying boardgame PX** more seriously. Future work should both explore the elements of boardgame PX and the design of reliable measures.

6.3 Broader Insights into HDB Design and Boardgame PX

Beyond answering our two research questions, this study offers valuable insight into measures of hybridity and the value of autonomy in HDB-PX.

6.3.1 "Goldilocks"—or Just Right—Hybridity: Despite feeling like the audible timer improved their immersion and focus on the game (or would have for physical-only players), players shared an overwhelming sentiment that the game is too simple to justify having an app (Sec. 5.2.4). When asked what features they would expect in an app for *Spy Guy: Fantasy*, players emphasized the potential of technology to improve the "core" gameplay, but were of mixed-opinion on what would actually enhance their experience. Suggestions from players varied from allowing for customization of existing game mechanisms (e.g. adjusting the time limit, or selecting a subset of item cards for play), to Storytelling functions like animations of the items on the cards and sound effects that related to the item or item category (e.g. clanking metal for weapons), Housekeeping functions like tracking in-game resources (e.g. managing game tokens), and Informing functions that could reveal the location of objects at the end of the search phase. These player suggestions generally reflect ways to improve autonomy in the game through customization and automation of social labour and enhancing the perceived core gameplay by providing feedback on how to improve at the inherent challenge (e.g. informing functions and some storytelling).

This finding seems to imply that there is some **nebulous "Goldilocks"[3] hybridity where the use of in-game technology becomes "just right" and therefore meaningful to players**. Our work suggests that the "Goldilocks zone" is not defined by an *amount* of hybrid functions that would be seen as optimal but, rather, is driven by a sense of the *value* that those functions add to gameplay and — importantly — how they extend what the game offers, "expanding the possibilities of [boardgame] play" [95, p.198] rather than simply replacing physical components. This supports the design guidance [45] that hybrid tools "are only meaningful ... if they offer added value that cannot be achieved in other ways" [95, p.158]. Of particular note for HDB design, players' suggested hybridisations focus more on enhancing the "core" gameplay, rather than inherently changing or automating the "chores". For example, players did not suggest getting rid of the timer—a chore seen at best as detracting from core gameplay and at worst undermining it—but rather, having its limit adjust with the item difficulty, changing its sound qualities, or having it provide "power ups" when you beat it. All of these suggestions allow for the player to engage more deeply with the "core" Search phase, and align the actual gameplay with their expectations of it. This suggests that the added value of the "Goldilocks Zone" overlaps with the boundaries of core gameplay. Therefore, when creating an HDB or hybridising an existing game,

[3] In the fairy tale "Goldilocks and the Three Bears", the human child Goldilocks finds an empty house in a forest. She samples three bowls of porridge that she finds there, finding one too hot, another too cold, and the third bowl just right, before repeating this with chairs and beds (too hard, too soft, just right). The name Goldilocks has been used in multiple settings as a metaphor that denotes that a 'preferred' solution sits somewhere between two opposite and unacceptable options. Among the best-known examples of this is the "Goldilocks Zone" in astronomy, used as a synonym for the habitable zone around a star, denoting the region that can contain planets that are not too hot and not too cold – and therefore may be just right to potentially support Earth-like life [52].

designers should not default to automating existing chores or fiddly elements of the game, but should rather **consider what is the core gameplay and how digital components could deepen engagement with that core**.

6.3.2 Autonomy in Boardgame PX. As seen in Sec. 5.2.2, players contextualise their gaming experience through their gaming histories and literacies. In the context of *Spy Guy: Fantasy*, players' experience with hidden object games led them to perceive the Search phase as the "core" gameplay, thus implicitly positioning the race and chase mechanics (ie. the timer, and Balasar) as being in opposition to the "core" fun (ie. "chores"). In the physical game, players exercised their autonomy through making choices that enhanced their enjoyment of the "core", regardless of its effect on intended challenge — "If I were playing this with like a group of friends, I'd be like – I don't really care about what rules say. Like dragon's gonna move after" (K20). However, this was less possible in the hybrid version as the automation enforced certain rules as written. These findings lead us to question the nuances of *autonomy* in boardgames compared to videogames, and the relationship between autonomy and cheating.

Autonomy—sometimes discussed as agency—is one of the core tenets in player-centric game design and seen as necessary for creating meaningful play [79, p.34]. The PXI positions *autonomy* as "a sense of freedom and autonomy to play the game as desired" [1], mirroring other game contexts (e.g. PENS [78]). It manifests in videogames through providing players with choices during play [94], such as narrative options, character customization, and choices between playstyles. *Autonomy* in games has also been discussed in relation to metagaming [12, pp.10-22; 17] and transgressive play [83], both of which highlight creating new forms of play through exploiting the dynamics of the game system. Effectively, autonomy in videogames becomes the act of choosing options within, and exploiting the bounds of, a rigid game system—mirroring Salen and Zimmerman's view of play [79, p.304]—and so existing measures have only considered it as a relationship between the individual player and the game. However, boardgames require that the rule system is implemented by the players at the table, meaning autonomy can be more broadly enacted through negotiating the rules and concepts of fair play between players. In this way **autonomy in boardgames may be more closely related to the concept of the *magic circle of play***—"the social contract that is created through implicit or explicit social negotiation and metacommunication in the act of playing" [90]. This would explain why our players found "minor cheating" to be both an important and normal part of playing a boardgame; it is a means of exercising autonomy to allow for a gaming experience that meets the expectations and needs of the group which may be prevented when technology is introduced. This mirrors Passmore et al.'s findings about "cheating" in single-player videogames, predominantly that it serves as a way to meet needs around player's moods, stress, and larger relief [64]. Overall this concurs with findings [28, 54] that while the same or similar PX constructs may exist in both videogames and tabletop games, they are experienced slightly differently due to the mediums.

6.4 Limitations and Future Work

In answering our research questions we identified some limitations. A limitation in the design of our custom hybrid variant was the unintentional issues with "juicy" design. A limitation in our approach to studying HDB-PX was the lack of reliable boardgame PX measures. We similarly described potential future works in our discussions, such as exploring how to design experiential recreations when hybridising a game, exploring the relationship between function visibility and PX, researching more into the theoretical constructs of boardgame PX and designing more reliable PX measures.

This study generated a great deal of information about players' perceptions of the potential for a more satisfying app to support play of *Spy Guy: Fantasy*. Participants suggested that they would like the app to offer animated storytelling, board-sized (and maybe larger) images, and a musical soundtrack. After the end of the round, they would like information about where the required objects can be found on the map. Furthermore, they would like to modify the duration of search time, to end the timer once they have found all the required objects, and to change the timer sounds. Although we remain committed to the A/B testing-inspired minimally different model for game evaluation as a means for understanding the PX of distinct functions and elements of hybrid digital boardgames [75], we nevertheless have been convinced by these participants that a further study investigating a souped-up, Maxi-hybrid *ad extremum* variant of *Spy Guy: Fantasy* would add new insight to this experience.

7 Conclusion

This paper explores player experiences of hybrid digital boardgames using a mixed-methods A/B-inspired testing protocol to compare minimally different variants of the game *Spy Guy: Fantasy* [55]. In doing so we found that while the quantitative measures of player experience showed minimal difference between versions, the qualitative data highlighted significant underlying differences in expectations, desires, and play styles.

Our hybrid Timing mechanism, the digital timer, while helpful with rule enforcement during play, clashed with player expectations in a way that could not be addressed through "minor cheating" and so created a more stressful and challenging PX. Our hybrid Randomising mechanism, the digital card deck, obscured how randomising worked from players in a way that led them to speculate that the game was more adaptive and complex than it actually was. Thus, **the impact of hybrid Timing and Randomising mechanisms on the PX of a boardgame was experientially large but measurably negligible (RQ1)**.

As part of this work, we critically considered how the choice of study design (within-subjects vs. between-subjects) affected the quality and type of data we collected. In particular, we found that while the between-subjects design may have improved the quality of our miniPXI data, it significantly decreased the depth and robustness of our interview data since participants could no longer meaningfully compare the variants. We realised that videogame-based PX measures— even when augmented for this setting —do not always apply to the boardgame/HDB context, and so **work on boardgame player experiences should be more aware of their**

study design and measurement tools in order to effectively capture experiential differences (RQ2).

This study makes an important contribution to HDB design by recognising and articulating the existence of a Goldilocks Factor of "just right" hybridity, which is measured not by the quantity of hybrid functions but by the autonomy they offer to players and by the way they extend what is possible in a purely physical boardgame. Supporting this design insight are specific considerations for hybrid implementations of Timing and Randomising functions in hybrid digital boardgames, and boardgames more broadly. This work also contributes to a broader understanding of PX in boardgames by examining the differences between autonomy in videogames and boardgames. This contribution is supported by insights about the connections between the design of hybrid Timing and Randomising functions and their impact on player experience constructs. Finally this work contributes to discussions about methodologies for studying PX in different contexts, as supported by our reflections on our study design.

Acknowledgments

This work is supported through an Australian Research Council DECRA fellowship (DE240100730) to MJR. We are enormously grateful to the study participants and pilot testers, and to the hybrid game Critical Play Reference Group. We also thank the designer and publisher of *Spy Guy: Fantasy*, Mariusz Majchrowski and Trefl Games.

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