Proceedings Paper:
Kumari, Shringi, Deterding, Christoph Sebastian orcid.org/0000-0003-0033-2104 and Kuhn, Gustav (2018) Why Game Designers Should Study Magic. In: Deterding, Sebastian, Khandaker, Mitu, Risi, Sebastian, Font, Jose, Dahlskog, Steve, Salge, Christoph and Olsson, Carl Magnus, (eds.) Proceedings of the 13th International Conference on the Foundations of Digital Games, FDG 2018. New York, NY: ACM Press .

https://doi.org/10.1145/3235765.3235788

Why Game Designers Should Study Magic

Shringi Kumari
University of York
York, UK
sk1382@york.ac.uk

Sebastian Deterding
University of York
York, UK
sebastian.deterding@york.ac.uk

Gustav Kuhn
Goldsmiths, University of London
London, UK
g.kuhn@gold.ac.uk

ABSTRACT

For millennia, magicians have designed illusions that are perceived as real regardless of their impossibility, inducing a sense of wonder in their audience. This paper argues that video game designers face the same design challenge - crafting believable and engaging illusions - and that the practice of magic provides an untapped wealth of design principles and techniques for game designers. To support this claim, the paper introduces two key principles of magic, affording perceived causal relations and forcing perceived-free choice. It then presents techniques to create and exploit these effects and discusses their parallels and applications in game design, encouraging game designers and researchers to further explore the field of magic for testable theories and applicable techniques.

CCS CONCEPTS

• **Applied computing → Computer games**; • **Human-centered computing** → Interaction design process and methods;

KEYWORDS

Games, Game design, Magic, Forcing, Perceived causality, Autonomy

ACM Reference Format:
Shringi Kumari, Sebastian Deterding, and Gustav Kuhn. 2018. Why Game Designers Should Study Magic. In *Foundations of Digital Games 2018 (FDG18), August 7–10, 2018, Malmö, Sweden.* ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3235765.3235788

1 INTRODUCTION

Science fiction author Arthur C. Clarke famously observed that any sufficiently advanced technology is indistinguishable from magic [11]. This quote captures a key commonality of games and magic: both aim to provide entertainment such that the audience don't see through the 'user illusion' into the 'gears' underneath [37].

Magic is one of the oldest and most enduring forms of entertainment. Through its history, magicians have honed the art of creating and sustaining engaging illusions, tested and refined techniques that allow people to "experience the impossible" [53]. Magicians have not only probed some of the most fundamental psychological questions, like consciousness or agency, but also readily adopted psychological insight into their practice [22, 24, 53, 73].

The same is true of games. According to Eugene Subbotsky, one of the preeminent scholars of magical thinking, any perceived breach of the laws of physical reality constitutes magic [68]. In this respect, games are repeat offenders: cards talk (*Hearthstone* [2]), rules of physical space don't always apply (*Monument Valley* [75]), worms battle and bad-mouth each other (*Worms* [71]), and plants defend their territory against waves of invading zombies (*Plants vs Zombies* [48]). Not only are games often set in fantastical worlds where magic is real, game designers like magicians strive to create an engaging experience for their audience - adapting, testing and refining insights from fields like psychology [77] to find better ways to foster engagement [49], create surprise [61], afford a sense of autonomy and agency [59], etc.

More than two decades ago, Bruce Tognazzini [74] made a case for applying stage magic principles to human-computer interaction (HCI). He observed an "eerie correspondence" between the two fields and encouraged a broad array of researchers and designers to probe and use ideas and techniques from magic in interaction design [4, 28, 50, 51]. Arguably, if principles from magic can be used to improve interaction design and HCI research, game design and research should stand to benefit even more. Both games and HCI try to provide seamless and meaningful user interactions [20], and game design by some accounts is the 'true' embodiment of experience or entertainment-centric interaction design [3, 8, 18]. The underlying concepts are not exclusive to magic, however, magic shares uncanny similarities with games - they both revolve around the same core experiential qualities, like engagement [49], immersion [7], or escapist fantasy [81], making magic a unique lens to study the underlying principles.

Game designers make no secret of the fact that they regularly 'learn' [67] (or rather, 'plunder' [80]) from other media to inform the 'total art work' of games - one of the more frequently recommended design books among game designers is the 'non-game design book' *Understanding Comics* [30]. Among these inspirations, magic has been proposed as a design source [40] and game designers like Will Wright frequently cite magic as inspiration. [14, 36, 67, 80].

Yet unfortunately, very little has been worked out more rigorously about the structural parallels between magic and game design, and how magic might inform game design practice. This paper takes a starting step towards filling this gap. The primary author is an experienced practising game designer who analysed existing work on the art of magic to discuss it's applications in game design. A notable part of this analysis is based on existing work on magic principles and its underlying psychology by one of the co-authors - a practising magician, who is also a cognitive psychologist. The other co-author, an HCI researcher who specialises in gameful

FDG'18, August 7-10, 2018, Malmö, Sweden

ACM ISBN 978-1-4503-6571-0/18/08.
https://doi.org/10.1145/3235765.3235788

design, has cross-verified and helped streamline the analogies presented in the paper. We make no claim of providing a systematic let alone comprehensive survey of the intersections between games and magic. Rather, we want to make the case for applying magic to game design by demonstrating how fundamental concerns of magic mirror those of game design and how related techniques could be transferred today. Specifically, we will unpack two key magic principles, creating perceived causal relations and 'forcing', that is, directing perceived-free choice. For each, we will explain the principle and then work through a number of techniques game designers could import. We close the paper with limitations and pointers to future work.

2 PERCEPTUAL CAUSALITY: PRESENTING A BELIEVABLE WORLD

Immersion and presence are widely valued and studied experiential qualities of gameplay [7, 64]. Both require the maintenance of a fundamental illusion present researchers have called "non-mediation" [64]. As any other work of fiction, games present a diegetic world that is entirely unreal: every interaction via the graphic interface of a game is an illusion. Players endorse the belief that they are directly manipulating objects on screen through some external control unit while in reality they are interacting with the game code which in turn interacts with the computer's processor to carry out the action. Unless by intention, this is not the experience game designers want the players to have. They devalue moments when this illusion of non-mediation is disrupted through glitches, lag, or unresponsive controls etc. and instead want players to stay in the magical reality of the game world [39].

One of the main aims of a magician's deception, is just that: to make the spectator's illusion more and more 'real'. For example, the magician Derren Brown recently designed a *Ghost Train* [27] in one of UK's leading amusement parks which tries to scare people with unreal objects and events, both represented via virtual reality (VR) and holograms. In many VR gaming experiences, players remain aware of the VR headset, diminishing the sense of presence. *Ghost Train* overcomes this issue by asking players to wear a gas mask (a disguised VR headset) to protect them from poison gas released into the train. This narrative frame accounts for the existence of the headset and makes the representational device a logical part of the presented illusion. Such narrative framing is a common principle used in magic and offers a nice demonstration of how magic techniques can be implemented in a game environment to help enhance the user illusion.

2.1 Learning the Laws of a Magical World

More principally, a successful magic illusion generates the experience in the audience that an impossible cause was behind an observed effect. For instance, in one of his more famous illusions, the magician Robert-Houdin seemingly grew oranges on a barren tree by raising his hand [55]. Houdin tried to convince the audience that he possessed gestures of magical power that *caused* the oranges to appear within seconds. The underlying psychological principle leading the audience to 'buy into' the illusory cause to an observed effect is called perceptual causality [63]: for certain kinds of sensory experience, we have the tendency to directly and automatically perceive or experience a causal relation. Experimental data supports that people during magic tricks experience the perceived cause-effect relation as real *although they are aware* that it defies their knowledge of the world [43]. Sceptics like Hume [19] caution against assuming a causal relation between B and A simply because we observe a pattern of B following A. Courses in logic or research methods repeat the mantra that correlation does not imply causation. Yet, the human mind organises the world in terms of cause and effect, deriving it from the sequence of occurring events: if B closely follows A, we perceive A to cause B [34, 62]. In everyday life, this is why, people often perceive and endorse illusory casual relationships - and magic exploits this fundamental perceptual tendency.

Evidence suggests that, the more perceived causality is *coherent*, the more it contributes to the experience of presence in virtual environments [9]. In other words, to uphold a coherent illusion, all of the elements of the game world must make sense with relation to each other. In a game, this coherence is determined by the behaviours of game objects: how they react on interaction with one another and the player's input. For example, in the game *Katamari Damacy* [38], the player plays as the Prince of Cosmos who is sent to Earth with orders to roll its contents into several oddly-shaped balls. Players roll a katamari ball around, and objects smaller than the ball get stuck to it, increasing its size, while objects bigger than the ball present as obstacles. The whole conceit of the game is outlandish, and yet the game quickly makes sense to the player. It achieves this by audio-visually presenting coherent causal relations between game objects: on 'collision' of the on-screen katamari ball with an on-screen item, the item is 'stuck' to the ball if it is of appropriate size. A magical physical reality is created: the player is repeatedly exposed to a correlation between collision, ball and item size, and sticking/non-sticking, learning to see and accept the causal interaction between them as the magical reality of the game world.

As can be seen, the mechanism of perceived causality is already at work in any interactive interface and can be used as a lens to evaluate and improve how the game world is presented to the player. At the most basic level, any perceived causal incoherence is likely to confuse the player. Furthermore, if there are several potential causes preceding one effect, this makes it harder for the player to perceive and learn the actual intended causal relation. Take *Badland* [16], an action adventure game where the player flies around as a little creature navigating a number of traps, puzzles and obstacles in the woods. The player has to avoid environmental obstacles to survive. Now, if the player's avatar simultaneously collides with a gear (obstacle) and a spike (obstacle) and dies, the player doesn't know which item caused the death and is to be avoided: the spike, the gear, or both. It would therefore be advisable to introduce these causal relationships separately as part of the on-boarding process to facilitate the player's learning. The more the game's causal laws deviate from our lived reality, the more important it becomes to explicitly introduce them. The interaction of objects in the game world itself can 'teach' them instead of artificial tutorials. Where game designers talk about tutorials, on-boarding, or learning the game, they often exclusively focus on learning how to master the controls, how to win, or how to play strategically well [79], when indeed players in most games have to learn a more fundamental dimension of the game as well: the causal laws of its magical reality. Evidence from psychologists studying magic suggests that causal relationships that are in line with our prior beliefs are endorsed more readily than others. In one study, participants were asked to place their driving license into a box and suggested that a magic spell will be cast that removes the stamp on the license. Very few participants entertained the possibility that the stamp could be removed by magic. However, when the suggested cause was changed from magic to a physical device, many more participants accepted it's possibility [69]. This suggests that even within illusory causal relations, one must understand the boundaries of what the audience is ready to endorse.

One concrete design take-away of perceived causality is to expand the means and ends of on-boarding to include guided demonstration and trial and error opportunities that convey the cause-and-effect-relations of the game world.

2.2 Creating Suspense and Surprise

Magicians use the principle of perceptual causality not just to create illusory causation, but also to surprise the audience by violating existing causal expectations or establishing then breaking new ones. Take for instance a standard routine where a magician visibly puts a coin in his right hand, then waves his left hand over his right hand, followed by slowly opening his right hand to reveal that the coin has disappeared. This chain of events produces surprise, as it violates several causal relationships the audience have learned through past experience [43]. This constantly suspenseful and surprising play with setting up and violating (causal) expectations sits at the heart of magic performances and their appeal [21]. Surprise is also elementary to game enjoyment - as Jesse Schell puts it, "fun is pleasure with surprises" [61]. More systematically, Greg Costikyan argues that games hold players' interest through various forms of uncertainty that generate suspense (how will they be resolved in the future?) and surprise upon unexpected resolutions [12].

So how do magicians design their performances to create timely surprises? The basic technique is to first establish and reinforce a cause and effect pattern through demonstration and then break it. For instance, in one routine by the magician duo Penn and Teller [45], Teller hands a fish bowl to an invited volunteer on stage. On Teller's left-hand side stands a fish tank filled with water. On his right side, the volunteer is seated with an empty fishbowl in their hands. Teller washes his hands in the water-filled fish tank on the left. Rubbing his hands in the water, he seemingly produces a coin from nowhere in his hands, throwing it into the empty fishbowl held by the volunteer. Teller continues to produce coins from his hands, establishing the pattern that his hands are producing coins. Teller doesn't stop there though. Once people start becoming familiar with this pattern, he twists the variables by shaking the participant's necklace and glasses and his own tie to produce more coins from each. Doing so, he extends the domain space of what objects can produce coins, both building upon and gently violating the previously set expectation. He ends the show by collecting all coins and blowing on them, thereby converting them into fishes in the fish tank. Once the audience have come to expect the magical reality of coin production, this expectation is again built upon and broken - coins can now both be produced out of nothing and transformed into other objects. The overall experiential sequence is captivating and surprising at every turn.

If we take a step back, we can here see a more general pattern of gradual reveal of the causal laws of an illusion that is at once educational, suspenseful, and surprising: establish, then break and extend. We can again see immediate parallels with how games introduce mechanics. Take *Bejeweled* [47], a tile matching game where players swap one gem with another adjacent gem to form a horizontal or vertical line of three or more matching gems of the same color. The player is first taught that creating matches makes the gems disappear. Once the player has learned to expect that relation, they are presented with matches that change the board, creating a subtle surprise while expanding the player's knowledge of the game's rules. Next, the player finds that the board can also affect the gems by locking them, etc. As this example shows, it is not as if this kind of scaffolding is absent in games. But within frameworks like rational level design, game designers discuss and design it chiefly in terms of difficulty balancing or challenge [31, 79], but not with a view of using the causality of the game world for introducing it or creating enjoyable surprises in its discovery. 'Open world' or 'sandbox games offer an obvious case in point where this delight in exploring and discovering weird, new, unexpected, surprising possibilities of a magical reality is front and center [82]. Here and in other game genres, magic can give us a template for orchestrating or sequencing the reveal of the game world to interleave suspenseful uncertainty and delightful surprise, much like Teller does in his act.

2.3 Designing Puzzles

For a certain part of their audience, magic tricks don't just unfold a magical and surprising reality, they also present puzzles to solve: How did the magician manage to create this illusion? As the magician is performing their routine, some audience members are mentally trying out 'solutions' that would provide a possible causal explanation for the seemingly impossible cause of events they witness. To maintain the illusion (and keep puzzle-solving audience members intrigued), magicians need to constantly think one step ahead of the audience. They have to anticipate what possible explanations the audience will come up with, to then either break the resulting expectations or work with them as a way to misdirect the audience's attention. The misdirection applied would lead the audience to mentally track a plausible but false 'solution' that will result in even greater surprise if followed by events that cannot any longer be explained by it. For example, if the audience is convinced that the magician has just hidden a card up their sleeve (because the magician went through motions hinting that), the audience is likely to continue to think so and try to 'read' the remainder of the performed trick from that light, allowing the magician to do the actual relevant parts of their trick relatively unattended, e.g., keeping the card hidden in their other hand all the time, generating all the more surprise when the card 'suddenly' appears in that hand while the audience assumed it hidden in the other hand's sleeve.

Solving the puzzle of how a card disappears and reappears or how Teller manages to produce coins from nowhere is fundamentally similar to finding the combination of inputs that opens a lock in the puzzle game *The Room* [15]. The same choreographic pattern that serves to introduce a world or allow suspense and surprise (establishing, then building on and stepping beyond causal expectations) also provides a good heuristic for designing enjoyable problem sequences, be it magic tricks or level sequences for puzzle games [33]. Puzzle designers need to gauge what solution strategies the player currently knows and is likely to use to create a new problem that is one step ahead but not too far, depending on the designer's intent. Again, the principle is to introduce a pattern and then break and extend it the very instant the player both begins to expect the pattern and can 'see' and digest a deviation. Popular puzzle games like *Monument Valley* [75], *Angry Birds* [56], *Portal* [76], *The Room* [15], or *Limbo* [46] demonstrate this in different ways. In the puzzle platformer *Limbo*, for instance, the player controls a boy who can move, jump, climb, and push or pull objects to pass through each level. Levels are designed so that the player would see a situation that makes them think of one learned solution - say, jumping over an opening trap door. However, the game also 'thinks one step ahead' and sets up a puzzle whose solution requires the player to realise how to deviate from and extend the prior solution, for instance, a timed jump over the trap door that would lure a chasing creature to be trapped by it. Solving the puzzle by breaking and extending a learned pattern or solution generates enjoyable surprise and a sense of increased mastery or competence [33]. Unlike magic, where actually knowing the solution of how a magic routine is done may make it less enjoyable, games do want the player to find the solution with varying degree of ease as per the game's requirements. Thus, only the principles behind anticipating the audience's plausible thoughts to lay out the problem is something designers can learn from magicians, however, balancing in a way that the problem is not impossible to solve.

If game designers want to predict and steer players' thinking the way a magician sets up 'solutions' in their audience's heads, the question arises how to ensure a player or audience member is thinking of one particular 'starting' solution rather than any other. If players start from a 'wrong' solution (e.g. mistaking a jump-and-time puzzle for a run-and-jump puzzle), they will simply fail repeatedly without getting closer to the new, extended solution. To ensure audience think of and expect the 'right' causal pattern at the right time, magicians rely on several principles of misdirection to manipulate what people perceive and remember providing valuable insights into how best to guide the player's thinking processes towards the goal. For instance, when a magician throws a ball in the air several times and then the ball 'vanishes', the majority of the audience perceive and remember the ball to leave the magician's hand, move upwards, and disappear, even though the ball did not leave the magician's hand [22]. The magician first establishes a familiar causal pattern (throwing things high in the air) and then provides visual cues (a rapid upward hand movement) that recall that pattern, making the audience think of and assume it to be the actual causal pattern [23].

Magicians also rely on the *Einstellung effect* (from the German word "Einstellung", literally "setting" or "installation") [26]. This describes the well-validated effect that when people have learned a solution to a given problem, they are likely to think of and stick to this solution when presented with a new situation that shares familiar features of the first problem, even if the solution doesn't work or better solutions exist. For example, studies by Thomas and colleagues [73] have shown that when participants were primed with a false solution to a magic trick (e.g. that the magician palmed a card in his hand), this false solution prevented them from discovering the true solution to the trick even though they knew that this solution was impossible. This effect is just as relevant to designers of puzzle and other games, as it can get players stuck or be used to 'signpost' solution routes. In the guessing game *Codenames* [78], for instance, two competing teams need to guess the right set of 25 'code' words laid out in front of them. Each team has a "Spymaster" who gives one-word clues pointing to multiple words at once. Once a guesser is convinced of one interpretation of the Spymaster's hint, it is hard for them think of other interpretations. This plays out delightfully in the game's social setup as vibrant discussions among guessing team members. However, if *Codenames* were a single player game, the guesser could easily get stuck on their idea and thus frustrated by repeatedly making wrong guesses. Similarly, if a puzzle game like *Limbo* wants to avoid players getting stuck on wrong solution paths, it would do well to time it and use audio-visual cues that recall the earlier situation in which the first part of the correct solution path was established and learned.

3 FORCING: OFFERING PERCEIVED AUTONOMY WHERE NONE EXISTS

Choice is fundamental to gameplay and gameplay enjoyment. Sid Meier famously says that, "Games are a series of interesting decisions" [32]. According to self-determination theory (SDT), autonomy, the experience of acting self-determinedly, with volition, willingness, and in congruence with one's own goals, values, and identity, is a basic psychological need whose satisfaction makes an activity intrinsically motivating and enjoyable [58]. And while 'having choice' as such does not equate autonomy, an open environment or situation that affords many different options contributes to the experience of autonomy [58]. In the last decade, numerous researchers have tested self-determination theory to explain gameplay enjoyment, e.g. through the measurement of Player Experience of Need Satisfaction (PENS) [44, 52, 59, 70]. Numerous empirical studies support that SDT in general and autonomy experiences in specific can explain significant portions of gaming motivation and enjoyment (see [58] for a general review and [13] for a review regarding autonomy). Games support autonomy by giving players a high degree of choice in who they want to embody, how they want to appear, and what goals, strategies, and activities they want to pursue [54]. A good example is *Minecraft* [35], where the player can freely choose what to do or build in an open world [77].

Providing players 'total' freedom of choice is practically impossible in digital games. Increasing player choice quickly explodes production costs, as any possible choice needs to be met with rendered game content, from the earliest text adventures to today's open world games. In addition, the more control over the flow of events is handed to the player, the less ability the designer has to prepare and ensure a desired experience. Thus, game designers are usually faced with a trade-off between fidelity, polish, production values and authorial control on the one hand and player choice on the other: The more well-crafted the content, the less choice developers can afford to offer.

At the same time, most designers want to give their players the impression of choice. Essentially, they want players to believe that the game world is expansive and will support their free choices within the limitation of its laws, such that players experience limits as a 'natural' outcome of the world's internal logic rather than an 'artificial' limitation of technology and production budgets. For example, while playing a platform game, a player should experience that if only they could jump higher, there would be an effectively infinite sky above them, and not think or experience that they will literally bump into an 'invisible wall' where the staged scene ends.

Magicians have been faced with the essentially same dilemma: how to give their audience the impression of free choice when in fact they stay neatly within the course of action the magician planned e.g., steering an audience member to 'freely' draw just the *Queen of Hearts* the magician predicted they will draw. *Forcing* is the name for the set of techniques magicians use to influence a person's choice without them being aware of it, and it is one of the most powerful and versatile magical tools [1, 66]. And just like perceptual causality can help understand and improve how games introduce their magical reality, surprise players, or provide satisfying puzzles, we suggest that forcing provides inspiration for how game designers can afford a sense of autonomy and choice in games without needing unlimited content. In addition, forcing provides a useful lens to assess whether a game unintentionally influences player choice in a way that harms the player experience. In this section, we discuss four particular forcing techniques we consider particularly valuable in this regard: identical choice, stereotypical choice patterns, saliency, and equivocation.

3.1 Identical Choice

One of the most basic forms of forcing relies on restricting choice by making it physically impossible to choose another item - for example, choosing a card from a pack of cards that has only identical cards [1]. We can see a ready equivalent in interactive fictions that present players with a perceived branching tree of choices that still converge on the same main story beats. This straightforward technique is however also easily uncovered the moment the audience member would draw a second card from the same deck or the player replays the game and chooses a different path. Still, for a single time play experience, this technique can be effective. A slightly modified version would maintain the same fundamental gameplay function while offering low-cost 'cosmetic' differences on top. Many game tutorials for instance use a very forced linear path to teach the game's mechanics, which leads a portion of players to abandon the game. But if the player could early on choose between a number of incidents with slightly different theming that would still each teach the same mechanic, this would likely increase player autonomy, enjoyment, and thus retention with little extra production effort.

3.2 Stereotypical Choice Patterns

A second forcing technique is to exploit people's stereotypical choice patterns. For example, if one places four cards on the table and asks an audience member to touch one card, they are unlikely to touch the cards on the outside, and most likely to go for the one just right of center [41]. Similarly, simply moving food to a less convenient location reduces the chance of it being chosen and consumed [57]. A recent psychological experiment on the probability of people naming different playing cards found that some cards, such as the *Ace of Hearts* and *Queen of Hearts*, are named with a significantly higher frequency than all others [42]. Some of these and other choice patterns well-known in mental magic could be directly tested in games. As of yet, we know little empirically about players' in-game choice patterns and what features affect them, e.g. if players choosing quests or avatars make decisions based on sequence or other inclinations beyond their capabilities and value in the game world. Stereotypical behaviour has the obvious limitation that it is probabilistic and cannot guarantee that a particular option will always be chosen. Thus, stereotypical choice patterns alone cannot be relied on to decrease production load. Nonetheless, it can inform designers how player choice may be biased in different ways.

3.3 Visual Saliency

In his popular TV show *Mind Control* [5], the mentalist Derren Brown once invited a volunteer to freely browse a toy store and in their mind choose one of nearly quarter of a million toys without telling him. It was seemingly impossible for Brown to know what toy they would pick - and yet, he correctly predicted their choice of a giraffe [6]. In the program, Brown states that he used a range of subconscious priming techniques to subtly direct their mind towards the giraffe toy, e.g. making a giraffe symbol with his hands while giving directions. Yet, the volunteer had no clue that they have been primed and considered their decision a free choice. It is important to note that Brown's claim of being able to manipulate choice using scientific principles is unsupported. Magicians often frame their performances as a demonstration of psychological mind control, when in reality other forms of deception are used to create psychological mind control [25]. However, this should not distract from the fact that subtle psychological principles can be used to force a person's choice.

Visual saliency is a well-validated principle, in which a particular option is made more perceptually prominent [41, 66]. Take the popular trick where a magician asks a volunteer to mentally choose a card while the magician flips through the deck. As the magician flips through, each card can only be seen for a split second - except for the card the magician wants the participant to choose, which is shown just a little longer. A recent study found that this technique effectively directed people's card choice 98% of the time, and most participants failed to notice that their choice had been forced [41].

In many instances in games, designers want to direct players' choice and attention for a smooth experience without compromising on displaying the full extent of the content. Level designers want players to pick the right path through a jungle while feeling they made a competent, non-trivial choice in the course. In navigating game inventories and menus, interface designers want players to quickly direct attention to the option that is relevant to their current task. In scanning a game world map in an open world game, game designers want players to quickly notice relevant new points of interest without feeling 'railroaded' into choosing them. While in HCI and interface design, visual saliency is already understood to guide visual attention [29], what magic adds here as a consideration is the impact of unconscious visual saliency on perceived free choice. Be it choosing paths, points of interests, interface options, or other choices, visual saliency can be used to highlight certain choices for the player without impeding their perceived free choice and competence.

3.4 Equivocation

Another interesting forcing principle is equivocation [17], where magicians give apparent free choice to the audience but devise the next steps of the trick in a way that any choice leads to the same result. For instance, they might place two cards on the table and ask an audience member to choose one. If they choose the intended card, the magician asks them to keep the card. If they choose the other card, the magician asks them to discard it and keep the intended card. This ensures that the used card is always the one the magician intended while the audience member had actual free choice because how this choice is then interpreted and used is determined on the fly to align it with the magician's intention. A simple example application for this in a game could be playful choices between mystery boxes (or any choice based system where the outcomes are fairly balanced). If due to content limitation or story continuation, the game has only one outcome to offer between the two boxes. The player's choice could be opened or destroyed, making the intended box the outcome.

Magic performances appear to involve lots of spontaneous social interactions when in reality they follow a fixed structure underneath. For example, in classic *cups and balls* [10] routines, where the magician makes balls magically appear, disappear, transform and penetrate solid cups, magicians appear to genuinely interact with and respond to the audience in what they do with cups and balls, yet every move and word follows a careful script thanks to equivocation (and other techniques).

This situation maps neatly to e.g. the game design challenge of making non-player characters with pre-programmed and thus limited behaviours appear to engage in rich, varied, responsive interaction with the player. One immediate translation of equivocation here would be to script sequences of non-player character responses in such a way that they 'make sense' against any prior player action. At a higher level, the episodic game series *The Walking Dead* [72] presents the players with a series of choices in trying to survive a zombie apocalypse that seem consequential while the major outcomes of each episode remain the same. For example, no matter whether the player chose to spare the character Ben's life in episode 4 or not, the game's script finds a way to have both outcomes lead to Ben's final death at the midpoint of episode 5. Still, players feel that their decisions 'count' as they are not aware of later pre-scripted events at the time of choosing. More subtly, while player choices do not necessarily change the outcome, they see how their decisions shape and express their own in-game character, Lee. More indirect translations would touch the actual underlying structure and game mechanics. For example, in the game *Her Story* [60], the player views video clips in the order they choose from a set of fictional police interviews to solve the case of a missing man. The player searches for a word and chooses one of the videos in which it was spoken to learn more about the case. 'Browsing an archive' is a game mechanic that makes immediate sense of content items appearing in a disjointed order.

4 DISCUSSION AND CONCLUSION

The art of magic has developed and fine-tuned centuries worth of tried patterns, principles and techniques in affording and steering audience experiences that are increasingly underwritten by contemporary cognitive psychology. Like practitioners of any other art, game designers have long poached other fields for techniques and inspiration [80]. Some game designers have pointed to magic as one such important source of inspiration [14, 36, 67, 80], yet there has been little if any substantial demonstration of what kinds of techniques, principles and patterns could be used where. In this paper, we demonstrate in some detail how magic can offer a useful lens on crafting and steering player experiences in games. We have explained the principle of perceptual causality and how it can be used to better introduce the laws of a game world to players as part of on-boarding, craft enjoyable trajectories of suspense and surprise, and design surprising and non-frustrating puzzle sequences. We have also introduced the concept of forcing, steering a perceived-free choice, and illustrated how several forcing techniques from magic can be used to enhance players perceived autonomy despite limited content and guide player attention without impinging on autonomy.

Notably, we do not claim that the discussed psychological mechanisms like perceived causality or visual saliency are in any way unique to magic or games: they are, to the extent psychologists have studied them, universal. We do believe, however, that in highlighting their fit with current concerns and practices in game design, we have contributed to the discovery of basic constructs and theories for game research to model, explain, and predict the impact of game design on player behavior and experience - and potentially, to instances where games and game design could serve as experimental petri dishes to further our understanding of said basic constructs and theories themselves. We also do not claim that the connected design techniques and principles discussed here are only found in magic. The choreographic pattern of setting up then breaking and building on expectations is also found in music [65], for instance. However, any creative dialogue needs to start *somewhere*; magic's striking overlap with games in terms of whats presented in the paper and other parallels like showmanship, consistency, visual deception make it a compelling candidate with which we hope to have highlighted some valuable starting points for practitioners and comparative researchers. Furthermore, we wish to emphasise that any of the discussed parallels and suggested potential applications in games are at present untested hypotheses. Each of them require empirical work to probe their generalisability and boundaries of application from magic to games. Finally, we have not presented all potential cross-fertilisations between magic and game design. We only hope to have made the principled case that they exist and are worthy of further exploration by designers and researchers alike. We will consider ourselves successful if this paper serves as a directed itch if not a fulfilling appetizer for its readers.

ACKNOWLEDGMENTS

This work is funded by EPSRC grant [EP/L015846/1] (IGGI).

REFERENCES

[1] Theodore Annemann. 2011. *202 Methods of Forcing.*
[2] Blizzard Entertainment. 2014. *Hearthstone.* (April 2014).
[3] M A Blythe, K Overbeeke, A F Monk, and P C Wright. 2006. *Funology: From Usability to Enjoyment.* Springer Science & Business Media.
[4] Susanne Boll, Albrecht Schmidt, Dagmar Kern, Sara Streng, and Paul Holleis. 2008. Magic Beyond the Screen. *IEEE Multimedia* 15, 4 (2008), 8–13.
[5] Derren Brown. 2007. *Tricks of the Mind.* Random House.
[6] Derren Brown. 2014. A Toy's Story - How To Control The Nation. (Jan. 2014).
[7] Paul Cairns, Anna Cox, and A Imran Nordin. 2014. Immersion in Digital Games: Review of Gaming Experience Research. In *Handbook of Digital Games.* 337–361.
[8] J M Carroll and J C Thomas. 1988. Fun. *ACM SIGCHI Bulletin* (1988).
[9] Marc Cavazza, Jean-Luc Lugrin, and Marc Buehner. 2007. Causal Perception in Virtual Reality and its Implications for Presence Factors. *Presence: Teleoperators and Virtual Environments* 16, 6 (Nov. 2007), 623–642.
[10] Milbourne Christopher. 1996. *The illustrated history of magic.* Heinemann Educational Publishers.
[11] Arthur C Clarke. 1973. *Profiles of the Future: An Inquiry into the Limits of the Possible.* Popular Library.
[12] Greg Costikyan. 2013. *Uncertainty in Games.* MIT Press.
[13] Sebastian Deterding. 2016. Contextual Autonomy Support in Video Game Play: A Grounded Theory. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16).* ACM, New York, NY, USA, 3931–3943.
[14] Christian Donlan. 2015. "A compelling, impossible thing": Where magic and video games converge. http://www.eurogamer.net/articles/2015-05-10-a-compelling-impossible-thing-where-magic-and-video-games-converge. (Oct. 2015).
[15] Fireproof Games. 2012. *The Room.* (Sept. 2012).
[16] Frogmind Games. 2013. *Badland.* (April 2013).
[17] Phil Goldstein. 1996. *Verbal Control: A Treatise on the Under-exposed Art of Equivoque.*
[18] Marc Hassenzahl. 2010. Experience Design: Technology for All the Right Reasons. *Synthesis Lectures on Human-Centered Informatics* 3, 1 (Jan. 2010), 1–95.
[19] David Hume. 2003. *A Treatise of Human Nature.* Courier Corporation.
[20] Anker Helms Jorgensen. 2004. Marrying HCI/Usability and computer games. In *Proceedings of the third Nordic conference on Human-computer interaction - NordiCHI '04.*
[21] Gustav Kuhn, Alym A Amlani, and Ronald A Rensink. 2008. Towards a science of magic. *Trends Cogn. Sci.* 12, 9 (Sept. 2008), 349–354.
[22] Gustav Kuhn and Michael F Land. 2006. There's more to magic than meets the eye. *Curr. Biol.* 16, 22 (2006), R950–R951.
[23] Gustav Kuhn and Ronald A Rensink. 2016. The Vanishing Ball Illusion: a new perspective on the perception of dynamic events. *Cognition* 148 (2016), 64–70.
[24] Gustav Kuhn and Robert Teszka. 2017. Don't Get Misdirected! Differences in Overt and Covert Attentional Inhibition between Children and Adults. *Q. J. Exp. Psychol.* (2017), 17470218.2016.1.
[25] et al. Lan, Y. Fake science: The impact of pseudo-psychological demonstrations on peopleâĂŹs beliefs in implausible psychological principles. (????).
[26] Abraham S Luchins. 1942. Mechanization in problem solving: The effect of Einstellung. *Psychol. Monogr.* 54, 6 (1942), i–95.
[27] Rowland Manthrope. 2017. Derren brown's vr ghost train is back – and this time it's actually scary. http://www.wired.co.uk/article/derren-brown-vr-ghost-train-thorpe-park. (March 2017). Accessed: 2018-1-25.
[28] Joe Marshall, Steve Benford, and Tony Pridmore. 2010. Deception and magic in collaborative interaction. In *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10.*
[29] Christopher M Masciocchi and Jeremiah D Still. 2013. Alternatives to Eye Tracking for Predicting Stimulus-Driven Attentional Selection Within Interfaces. *Human–Computer Interaction* 28, 5 (Sept. 2013), 417–441.
[30] Scott McCloud. 1993. Understanding comics: The invisible art. *Northampton, Mass* (1993).
[31] C McEntee. 2012. Rational design: the core of rayman origins, gamasutra. (2012).
[32] Sid Meier. 2012. Interesting Decisions. https://www.gdcvault.com/play/1015756/Interesting. (2012).
[33] Jolie Menzel. 2016. Level Design Workshop: Solving Puzzle Design. https://www.gdcvault.com/play/1023139/Level-Design-Workshop-Solving-Puzzle. (2016).
[34] Albert Michotte. 2017. *The Perception of Causality.* Routledge.
[35] Mojang. 2011. *Minecraft.* (Nov. 2011).
[36] David Mullich. 2016. How Stage Magic Influenced My Career. https://davidmullich.com/2016/01/18/how-magic-influenced-my-career/. (Jan. 2016).
[37] P N Murthy. 2002. The user illusion: cutting consciousness down to size. By Tor Nørrentranders (translated by Jonathan Sydenham). Published by Penguin Books, New York, 1999, 480 pp., ISBN 0 140 23012 2, £10.99. *Syst. Res. Behav. Sci.* 19, 5 (2002), 509–512.
[38] Namco. 2004. *Katamari Damacy.* (March 2004).
[39] Michael Nitsche. 2008. *Video Game Spaces: Image, Play, and Structure in 3D Worlds.* MIT Press.
[40] Stuart Nolan. 2016. Stuart Nolan: Games and Magic. https://youtu.be/oJ-V4UA-R40. (2016).
[41] Jay A Olson, Alym A Amlani, Amir Raz, and Ronald A Rensink. 2015. Influencing choice without awareness. *Conscious. Cogn.* 37 (2015), 225–236.
[42] Jay A Olson, Alym A Amlani, and Ronald A Rensink. 2012. Perceptual and cognitive characteristics of common playing cards. *Perception* 41, 3 (2012), 268–286.
[43] Ben A Parris, Gustav Kuhn, Guy A Mizon, Abdelmalek Benattayallah, and Tim L Hodgson. 2009. Imaging the impossible: an fMRI study of impossible causal relationships in magic tricks. *Neuroimage* 45, 3 (April 2009), 1033–1039.
[44] Wei Peng, Jih-Hsuan Lin, Karin A Pfeiffer, and Brian Winn. 2012. Need Satisfaction Supportive Game Features as Motivational Determinants: An Experimental Study of a Self-Determination Theory Guided Exergame. *Media Psychol.* 15, 2 (2012), 175–196.
[45] Teller Penn Jillette. 2015. Penn & Teller Fool Us - Coins & Fish Trick. (July 2015).
[46] Playdead. 2010. *Limbo.* (July 2010).
[47] PopCap Games. 2001. *Bejeweled.* (May 2001).
[48] PopCap Games. 2009. *Plants vs. Zombies.* (May 2009).
[49] Andrew K Przybylski, C Scott Rigby, and Richard M Ryan. 2010. A motivational model of video game engagement. *Rev. Gen. Psychol.* 14, 2 (2010), 154–166.
[50] Majken Kirkegaard Rasmussen. 2013. Magical realities in interaction design. In *Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction - TEI '13.*
[51] Stuart Reeves, Steve Benford, Claire O'Malley, and Mike Fraser. 2005. Designing the spectator experience. In *Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '05.*
[52] Leonard Reinecke, Ron Tamborini, Matthew Grizzard, Robert Lewis, Allison Eden, and Nicholas David Bowman. 2012. Characterizing Mood Management as Need Satisfaction: The Effects of Intrinsic Needs on Selective Exposure and Mood Repair. *J. Commun.* 62, 3 (2012), 437–453.
[53] Ronald A Rensink and Gustav Kuhn. 2015. A framework for using magic to study the mind. *Front. Psychol.* 5 (2015).
[54] Scott Rigby and Richard M Ryan. 2011. *Glued to Games: How Video Games Draw Us In and Hold Us Spellbound: How Video Games Draw Us In and Hold Us Spellbound.* ABC-CLIO.
[55] Jean-Eugène Robert-Houdin. 1859. *Memoirs of Robert-Houdin: Ambassador, Author, and Conjurer.*
[56] Rovio Entertainment. 2009. *Angry Birds.* (Dec. 2009).
[57] Paul Rozin, Sydney Scott, Megan Dingley, Joanna K Urbanek, Hong Jiang, and Mark Kaltenbach. 2011. Nudge to nobesity I: Minor changes in accessibility decrease food intake. *Judgm. Decis. Mak.* 6, 4 (2011), 323.
[58] Richard M Ryan and Edward L Deci. 2017. *Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness.* Guilford Publications.
[59] Richard M Ryan, C Scott Rigby, and Andrew Przybylski. 2006. The Motivational Pull of Video Games: A Self-Determination Theory Approach. *Motiv. Emot.* 30, 4 (2006), 344–360.
[60] Sam Barlow. 2015. *Her Story.* (June 2015).
[61] Jesse Schell. 2015. *The Art of Game Design: A Book of Lenses, Second Edition.* CRC Press.
[62] A Schlottmann and D R Shanks. 1992. Evidence for a distinction between judged and perceived causality. *Q. J. Exp. Psychol. A* 44, 2 (Feb. 1992), 321–342.
[63] B J Scholl and P D Tremoulet. 2000. Perceptual causality and animacy. *Trends Cogn. Sci.* 4, 8 (Aug. 2000), 299–309.
[64] Martijn J Schumie, Peter Van Der Straaten, Merel Krijn, and Capg Van der Mast. 2001. Research on presence in VR: a survey. *J Cyberpsychol Behavior Delft* 4, 2 (2001), 183–202.
[65] Christopher Scoates. 2013. *Brian Eno: Visual Music.* Chronicle Books.
[66] Diego E Shalom, Maximiliano G de Sousa Serro, Maximiliano Giaconia, Luis M Martinez, Andres Rieznik, and Mariano Sigman. 2013. Choosing in Freedom or Forced to Choose? Introspective Blindness to Psychological Forcing in Stage-Magic. *PLoS One* 8, 3 (2013), e58254.
[67] Mike Stout. 2015. Learning from other Media. http://www.chaoticstupid.com/learning-from-other-media/. (Sept. 2015). Accessed: 2018-3-20.
[68] Eugene Subbotsky. 2010. *Magic and the Mind: Mechanisms, Functions, and Development of Magical Thinking and Behavior.* Oxford University Press.
[69] Eugene Subbotsky. 2011. The Ghost in the Machine: Why and How the Belief in Magic Survives in the Rational Mind. *Hum. Dev.* 54, 3 (2011), 126–143.
[70] Ron Tamborini, Nicholas David Bowman, Allison Eden, Matthew Grizzard, and Ashley Organ. 2010. Defining media enjoyment as the satisfaction of intrinsic needs. *J. Commun.* 60, 4 (2010), 758–777.
[71] Team17. 1995. *Worms.* (June 1995).
[72] Telltale Games. 2012. *The Walking Dead.* (April 2012).
[73] Cyril Thomas, André Didierjean, and Gustav Kuhn. 2018. It is magic! How impossible solutions prevent the discovery of obvious ones? *Q. J. Exp. Psychol.* (2018), 174702181774343.

[74] Bruce Tognazzini. 1993. Principles, techniques, and ethics of stage magic and their application to human interface design. In *Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '93*.
[75] Ustwo Games. 2014. *Monument Valley*. (April 2014).
[76] Valve Corporation. 2007. *Portal*. (Oct. 2007).
[77] Jason VandenBerghe. 2016. Engines of Play: How Player Motivation Changes Over Time. https://www.gdcvault.com/play/1023329/Engines-of-Play-How-Player. (2016).
[78] Vlaada Chvátil. 2015. *Codenames*. (2015).
[79] Matthew M White. 2014. *Learn to Play: Designing Tutorials for Video Games*. CRC Press.
[80] Will Wright. 2001. 'Will Wright's Design Plunder": Will Wright's classic 2001 keynote on game design inspirations. https://www.gamasutra.com/view/news/304470/Video_Will_Wrights_classic_2001_keynote_on_game_design_inspirations.php. (2001). Accessed: 2018-3-20.
[81] Nick Yee. 2006. Motivations for Play in Online Games. *Cyberpsychol. Behav.* 9, 6 (2006), 772–775.
[82] Nick Yee. 2016. The Gamer Motivation Profile: What We Learned From 250,000 Gamers. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '16)*. ACM, New York, NY, USA, 2–2.