

Article

# Reappraising *Braid* after a Quantum Theory of Time

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**Abstract:** *Braid's* (Jonathan Blow, 2008) time-bending gameplay allows players to engage with a virtual world in which a player's perceived 'past' can be endlessly rewritten, duration extended, and the ludic arrow of time can be reversed. One could assume that as mistakes can simply be undone, in-game actions cease to have consequences. However, the climax of the game's narrative arc disrupts our assumption of control over these mechanics and encourages players to reflect on the possible moral implications of actions, both in context of the game world and—through careful invocation of real-world scientific experiments—on everyday life. In this paper, I propose that *Braid* uses gameplay to explore the difficulty of making moral judgements in a world without an objective past. This is, for the most part, achieved through *Braid's* utilization of a specific interpretation of quantum theory—in accordance with the game's lead designer, Jonathan Blow—that “starts to threaten our very existence” by questioning the possibility of a singular, objective, real 'past' and the possibility of a definitive account of past actions. I first argue that the game's mechanics immerse players in a game world inspired by Blow's understanding of quantum mechanics. Placing an emphasis on certain technical aspects, I outline how the functioning of the game's central rewind mechanic—although initially seeming to reinforce visions of our reality consistent with C.D. Broad's 'growing block' theory—questions the notion of an objective past and so resonates strongly with both the work of J.A. Wheeler and an agential realist theory of time. With this understanding in place, I go on to analyze the climax of the game, reading it as an exploration of—and challenge to—the role of a presumed objective 'past' in understanding the morality of a given situation. Finally, through a reading of the game's closing moments, I suggest *Braid* promotes a turn to individual responsibility for agency; *Braid*, I argue, recommends one accept the continuing existence and changeability of the past within the present while embracing one's own role in the shared process of constantly remaking reality and history. As a result, well-intentioned actions in the present are framed as more important than a focus on precedent to predict outcomes, making a cautious suggestion on how one might live without reference to an objective existence. Although I highlight some of the wider ramifications of this at the end of this paper, *Braid* is far from a fully developed ethical system; it stands, however, as an engaging attempt to formulate a comment on time, temporality and morality through interactive media.

**Keywords:** videogames; Karen Barad; intra-activity; time; creative coding; philosophy of science

## 1. Introduction

*Braid* is well established as the focus of critical study.<sup>1</sup> However, I want to highlight an element of the game that, while popularly acknowledged, is rarely singled out. I want to explore how a

<sup>1</sup> Patrick Jagoda sees it as cross-temporal engagement with the cultural impact of World War II and humanity's increasing compulsion towards computer-like processes, algorithms and activities over reflection and comprehension [1]. Liam Mitchell positions *Braid* as a reflection of the inherent violence that drives and arises from technological obsession, whether this is in the form of creating weapons or in attempting to measure, understand and control something as seemingly abstract as time [2]. Dušan Stamenković and Milan Jačević see the game as a tool for exploring the tensions between cognitive spatial/temporal metaphors and how players engage with narratives [3]. Luke Arnott has understood it as an example of spatially organized narrative that imparts meaning as much through level spatial layout as its text [4].

specific understanding of time drawn from quantum theory can shape a reading of the game's central mechanics and narrative—specifically the popular interpretations of delayed choice experiments promoted by J. A. Wheeler [5] and more recent re-interpretations of those writings by Karen Barad in which 'the past never finished' and is thought of as more theoretical than objective [6] (p. ix). Although I will discuss the details in greater detail later in this paper, *Braid*—in short—places the player in a virtual world in which time-bending gameplay allows them to endlessly rewrite the virtual 'past' at their will. This, however, is contrasted by a series of narrative events late in the game that are beyond the player's control and have the potential to cast their previous actions in a new light. This in mind, I aim to ask, if we accept, as certain theorists and physicists do, that if 'the past' is potentially theoretical, should we still place an emphasis on it to decide what's right or wrong? Resonating with Wheeler and Barad, the game can be read as engaging with the moral implications of a quantum theory of time both in the context of the game world and perhaps, by extension, on wider reality.

There's good reason to read *Braid* with reference to quantum physics. The game's central time-altering mechanics are reminiscent of invocations of quantum mechanics in popular science-fiction. In the television work of Dan Harmon or the past decade of superhero cinema, the theories of quantum physics are, at times, comparable to magic. Beyond this similarity, although the game contains no explicit written references to quantum science, there are several references to scientific practices more generally. However, the strongest connections between *Braid* and quantum mechanics are the explicit statements from the game's creator.

In a 2008 interview with AV Club, Jonathan Blow claims that an early idea for the game was "to explore a fundamental law of quantum mechanics that appears to be true, which is that there is no arrow of time at the quantum mechanical level" [7]. In the interview Blow seems chiefly interested in quantum mechanics' impact on understandings of time and temporality. Specifically, he expresses confusion at how a human aware of modern scientific theory could retain a sense that there could be a single, correct account of the flow of time. However, the aim of *Braid* is not solely to educate users by visualizing scientific theory. Rather, the game appears to be Blow's exploration of how the theories of time derived from quantum physics might impact on lived human experience. For example, in contrast to the dynamism Blow sees in quantum theory, in the same interview he reflects on the implications of determinism and the plausibility that one could "remember the future". He states that, "if you think about what that means, it starts to threaten our very existence. Because everything that we think about, everything that we do every day, is predicated on this idea that we can choose things. [The reason *Braid*] is an exploration of time and space is because there are things that seem to be facts about time and space, that threaten our very existence" [7]. For Blow, it seems, quantum mechanics functions as the antithesis to a deterministic universe: unbounded action enables existence whereas predetermination threatens it. *Braid*'s engagement with quantum theories of time are not purely epistemological, therefore, but ontological and existential.

Given Blow's comments, it's important to adopt a specific understanding of quantum mechanics in this context: 'quantum mechanics' here is not an invocation of the ongoing international study of the rules that govern the behavior of subatomic particles and fields. Instead, Blow's mentioning the 'quantum mechanical' inspiration for *Braid* should be understood as an engagement with the potential everyday implications of specific popular interpretations of theories that have existed for decades. As such, in this paper, I am approaching *Braid* using what can be considered 'quantum theory', as distinct from quantum mechanics; the focus here is squarely on how theories derived from quantum physics can shape a reading of the human questions surrounding *Braid* such as feelings of temporality, existence and experience. Certainly, quantum theory can challenge commonly held ontological and epistemological beliefs. This is summed up beautifully by Wheeler and Zurek in their collection on quantum physics and measurement. They write, reflecting on the epistemological changes that occur when we shift from a classical mode of thought to one focused on the behavior of subatomic matter and energy, "our supposed knowledge of a particle with its definite track through space and time dissolves into a wave, definiteness becomes indeterminism, and predictability of place is

replaced by a predictability of the properties of nuclei, atoms, molecules, solids, liquids, and gases" [8] (p. xv). The principles of superposition and uncertainty, that subatomic matter and energy exists not in definite locations but as "unsharply defined individuals within finite space-time regions" [9] (p. 96) can and should be considered as having important ontological and epistemological dimensions. This is, I believe, the impetus behind Blow's game and the foundation of my reading here.

While the "facts of time and space" as Blow put it, are far from factual and are still actively being explored and debated, it is undeniable that findings from within the field have contributed to philosophical debates on the nature of time and reality. One need only look to the work of Saunders, Zimmerman or even Julian Barbour for evidence of this—philosophies of time must now reconcile themselves with or explicitly diverge from theories of relativity, quantum gravity and Bell inequalities [10]. Alternately, within the field of feminist science studies—such as Barad's work discussed in this paper—quantum theory inspires readings that radically queer scientific practice and its extensions into the every day. The idea that scientific theories of time and space can "threaten our existence", as Blow writes, is understandable in this context: quantum theory challenges world-views contrary to it. If one happens to consider themselves as intrinsically part of an 'objective' reality (a 'real world' of things 'out there', a Kantian noumenal or some other formulation of that which 'really' exists whether or not it's being observed), if they feel that they can only truly be said to exist if their existence can be verified as an objective fact, then a broad understanding of the implications of quantum theory would not reassure them. Such an empirical world-view is, of course, not unsophisticated either as many theorists and scientists still refute interpretations of quantum theory that suggest nature is, at a quantum level, in some way stochastic. Famously, Einstein died unconvinced of elements of the theories put forth by Heisenberg, Bohr and others, infamously rejecting the unknowability of aspects of physical quanta, giving rise to the famous (though apocryphal), 'god does not play dice with the universe'. However, with *Braid*, Blow has embraced the odd interpretations of quantum mechanics to construct a mediation of time and temporality that engages with its 'existence threatening' potential. Wheeler states "what we call reality consists of a few iron posts of observation between which we fill in by an elaborate papier-mache construction of imagination and theory" [5] (p. 194). *Braid* revels in this idea by doing more than presenting players with gameplay mechanics and in-game text that resembles scientific writings. Instead, by giving players abilities to engage with ludic space-time in unconventional ways and a non-linear narrative that resonates with these mechanics, *Braid* presents players with a virtual world governed by the implications of quantum theories where past and future are entangled with actions in the present. As I will go on to show in this paper, this not only has the power to challenge players' ontological assumptions, but also to confront the nature of moral engagement with events.

I first want to explore how the game's mechanics immerse players in a game world inspired by quantum theory. To do this, I'm going to describe the game in some detail, before going on to try to creatively imagine how the central game mechanic might work at the level of code and hardware. Doing so reveals some interesting properties of the game and maybe even destabilizes how one might think of it. I will first construct a basic model of how one could comprehend the rewind mechanic, based solely on a supposed player's experience with the game. I will then complicate this by adding details to this model provided by Blow in a Game Developer's Conference (GDC) talk from 2010. I will show that the complex underpinnings of the game's technical system resonate fruitfully with quantum theory. However, my intention is not just to highlight *Braid*'s similarity to these elements of scientific theory; rather I want to suggest the game is making some cautious suggestions on how we might live our lives should we embrace quantum theory and choose to reject the idea of an objective past, present or reality. With an understanding of the game's system in place, I turn to the game's narrative, analyzing the climax of the game, presenting a novel reading of *Braid* as one deeply engaged with how perception of time shapes morals. While it could be said that the game asks more questions than it answers, I do think it provides players with a rough outline of how we might attempt to live a moral life with a worldview shaped by quantum theory. In the closing section of this paper, I will outline

my reading of the game's closing moments to suggest *Braid* is prompting players to adopt an ethics focused on well-intended action and taking responsibility for those actions rather than a focus on precedent or outcomes. Although this is far from a fully developed ethical system, I think it marks an intriguing first step to formulate a philosophy through interactive media.

## 2. Complicating *Braid's* Rewind Mechanic through Quantum Theory

Although sharing many similarities with other two-dimensional platform games, *Braid* is built on a single, fundamental aberration from the form: in *Braid*, the player character can't 'die': instead, falling on pits of spikes, touching fire or falling victim to any of the several enemies that exist in the game's world, just results in the player character freezing in place as color fades from the screen. As such, progression in the game depends on the player 'rewinding' their actions, getting back to a place of safety and trying again. To do this, in the early stages of the game, players can press shift to start rewinding time, and watch as their actions play back before them in reverse. The player's avatar, most often referred to as 'Tim', will repeat—what seems to be—the exact same sequence of the player's events in precisely reverse order. Once the player releases shift, time begins to play out again in the 'normal' way. This mechanic is further complicated later in the game, as when players are given a magic ring that can be thrown to slow time down within a certain radius, and again in the final levels, where the flow of time appears to become tied to the player's location in the game world.

*Braid* is not the first game to feature time-distortion mechanics: players familiar with *The Prince of Persia: Sands of Time* (Ubisoft, 2003) or even *Max Payne* (Rockstar Studios, 2001) will likely not be too impressed by time rewinding. More recent games like *Super Time Force: Ultra* (Capybara Games, 2014) have used reworkings of these processes to create gameplay of almost absurd complication where a player has to generate and team up with multiple past versions of themselves to overcome environmental challenges and enemies; players even receive bonuses for generating temporal paradoxes in which your future self, generated by your past self's death, rewinds time to prevent that death from happening. However, it's *Braid's* utilization of these techniques that are distinct: here, time-manipulation abilities are not just super powers that allow the player to have an easier or more fun play experience. Blow's clever game design makes these abilities essential for navigating a game world like no other.

Unlike seemingly similar games, *Braid's* time manipulation is not presented as a limited superpower, only to be used when required. Instead, time manipulation is presented as something to be played with and used to explore. To encourage players to use the special powers, pleasing audio and visual effects occur: rewinding and slowing down time results in blurred visuals and interesting changes to the game's soundtrack as it appears to play in reverse. Using the mechanics can also result in the player's character achieving fantastic feats. For instance, rewinding time after a long fall, can change our perspective on events: Tim appears to take flight, ascending to great heights, ignoring gravity in the process. Likewise, many of the game's non-player-controlled objects, such as enemies and walkways, are also affected by the time manipulation, resulting in the feeling that, by using these mechanics, the player can take control of almost the entirety of the game world. This encouragement to use the mechanics is important as, arguably, unlike in *Max Payne*, *Prince of Persia*, or *Super Time Force* there is no way of progressing through the without them.

In practice, although the time manipulation mechanics may seem like superpowers, within the context of *Braid's* levels and puzzles, they're an essential requirement for progression. In the world of *Braid* time manipulation is necessary as the levels are designed around puzzles with both spatial and temporal dimensions. For example, in the level 'The Pit' there is a key that cannot be reached through normal means, held by an enemy at the bottom of a pit (Figure 1). If the player leaps down, they can defeat the enemy and take the key, but they cannot jump back to the higher level. Using a normal formulation of the rewind mechanic, rewinding would also mean that the key object is returned to the enemy. However, as part of Blow's design for exploration and play, there's something special about this key: it's glowing green, and when the player rewinds time, the key moves with the player, back to the top of the level. Blow has designed a puzzle that requires an avatar capable of moving throughout



both space (in order to jump down and grab the key in the first place) and time (to enable us to travel back to 'the past' in order to get back to our starting point). No matter how much the player might try, it's simply impossible to navigate this game world without the ability to move through both time and space.



**Figure 1.** The beginning of 'The Pit'. Retrieving the key is impossible with rewinding. As such, the rewind mechanic becomes akin to walking in a world where navigating time is as important as navigating space.

Although the game encourages players into manipulating the flow of events to achieve new ends, I want to contend that there's also another point to the central gameplay. Problem solving in *Braid* is also distinct from challenges in similar 2D platform games. Players do not have to rely on twitch reflexes, split-second timing or pixel-perfect precision for their progression. Instead, they are encouraged to generate, test and modify hypotheses through constant repetition and evaluation of results. For example, in the level 'Leap of Faith' there is a moment where players can jump down a deep chasm (Figure 2).



**Figure 2.** Using the rewind mechanic is a process of trial and error.

In the center of the chasm is a pit of spikes. Below and to the left of this pit is a small platform with an important jigsaw piece collectable on it, and directly beneath that, another spike-pit. To the right of that is an opening that allows players to progress. If a player jumps exactly to the right or to the left of the chasm, they will generate one of two outcomes: they'll either halt the gameplay due to a collision with spikes or land on the ground, ready to proceed to the end of the level. In either outcome, the player will not collect the jigsaw piece. Instead the player must rewind, repeat and adjust the arc of their fall, mid-way, in order to gather the collectible. The player can test an endless number of outcomes to this experiment, seeing what happens when they fall in a variety of different angles without penalty. While it might seem pertinent to avoid colliding with the spike pits, there's really no reason not to; in fact, colliding with the spikes generates a natural feeling pause to game action, allowing a player to reconsider their trajectory. While it might seem like a stretch to say this is invoking the scientific method all on its own, this process of generating a hypothesis, repeating and altering it based on results is repeated throughout the game. What's more, scientific practices are mentioned in some of the in-game text snippets you can collect throughout the game: "he worked his ruler and his compass. He inferred. He deduced. He scrutinized the fall of an apple, the twisting of metal orbs hanging from a thread." On balance, gameplay in *Braid* is more about considering a problem and putting solutions into practice, rather than the speed or accuracy of a player's input.

With *Braid's* central mechanics being evocative of the scientific method, and Jonathan Blow's comments about quantum theory, it's tempting to start reading *Braid* as a reflection on scientific practice. This isn't lost on critics such as Mitchell who have stated, "This juxtaposition suggests that Tim's actions concern the general exercise of science, of experimental research science, rather than of any particular scientific experiment" [2] (p. 94). However, there's an issue here: while it's fine to say that *Braid's* mechanics can be read as a very vague reflection of some of the abstract principles behind the scientific method, going any further than that requires specificity. If *Braid's* central gameplay is evocative of scientific measurement and experimentation, what exactly are we measuring and what might that mean?

I suggest there are two distinct different ways to read *Braid's* central game mechanics in a scientific light: the first is how we experience the game as a player, the second is obtained by adding technical knowledge to this experiential understanding. These distinct modes reflect two epistemologies of scientific practice within quantum theory. The distinction comes down to an aspect of the so-called 'measurement problem': whether we see scientific measurement—or *Braid's* rewind mechanic as metaphor for it—as capable of 'objective' measurements of an 'objective' world, or, if scientific measurement is an engagement and alteration within the world that enacts change through process. Going back to the Wheeler and Zurek quotation from earlier, this can be envisaged as the difference between thinking of the world, on the one hand, in terms of particles in absolute positions or, on the other, as Bohr put it, "unsharply" defined individuals within regions. We can, I suggest, think of *Braid* as a game shaped around the recording and recalling specific positions of (game) objects within the (game) world at specific moments of (game) time. Alternatively, we can see *Braid's* central mechanisms as an imperfect measurement-like processes that (re)generates variable values of data that are subject to change and alteration out of sync from the player's temporal experience suggesting the ability to rewrite and alter the past within the present. In this sense, it does not attempt to measure definite objects objectively, but instead playing the game is to take part in producing semi-arbitrary, apparent objects through co-constitutive processes.

I first want to engage with the first potential: to examine *Braid's* rewind mechanic as if it is recording objective values. This is important as I think, intuitively speaking, this concept might make sense as a player. What's more, it reveals certain ramifications the game could have and helps establish a clear sense of what the alternative understanding of the game challenges (discussed in detail subsequently). When playing the game, players move Tim through the game world. We feel like we know Tim has been in specific places at specific moments in time; we 'know' this partly because we played some part in taking him to those places, at those specific times. As such we can think of

game time as spaced out into distinct frames and consider Tim's location within these frames. At the beginning of a level, frame 1, Tim's location could be expressed as 'X = 0, Y = 0', given that the game is two dimensional. It's relatively easy to imagine what this would look like in pseudo code.<sup>2</sup> It would be something along the lines of:

```
public ArrayList playerPositions;  
  
void Start()  
  
    playerPositions = new ArrayList();
```

A little piece of code like this is an easy way to imagine how the rewind process works in *Braid*. At the beginning of our game we could set up a simple program to run that generates an array, an empty collection of values, called 'player positions'. This array could then function as a perfect record of Tim's location at every moment of the game. This is relatively easy to imagine too as we could just write something like:

```
void UpdateEveryFrame()  
  
{  
  
    playerPositions.Add (gameController.frameCount);  
  
    playerPositions.Add (player.position);  
  
}
```

It's not difficult to imagine a subroutine that uses this logic, one where, every time a new frame of the game is being constructed, after the player has pressed the buttons on their controller and after inputs are calculated, added to object-variables alongside the values of the computer-controlled-characters, a chronological number of the current frame could be generated and both this number and the player's exact current position could be added to a new entry within a 'player positions' array. This logic could be extended to all objects in the game and, in the end, a chronologically ordered array of values would be produced providing a perfect account of each item in the game at each frame. After all, this is indicative of common computer work in videogames, generating specific 'states' as the product of the ongoing game loop. Each new state is simply the outcome of algorithms in which the current values of game objects are subject to transformations determined by the value of player or non-human inputs. If this was the case, the rewind mechanic would simply be recalling frames, restoring objects to previous locations; depending on how long a player holds shift, the computer would move through a perfect history of in-game actions, restoring whichever state the player chooses. From Jonathan Blow's GDC talk in 2010, we also know that this, to some extent, is how the game's central mechanics are programmed [11]. Blow even provides a screenshot (Figure 3) of a digital object's properties so it's possible to picture how each variable would be stored.

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<sup>2</sup> Jonathan Blow is a community focused developer and provides sections of code for developers to look at and take inspiration from on his blog 'number-none.com'; however, the source code for *Braid* itself is not widely publicly available. Even if it was, it would still arguably be more efficient to discuss this aspect of the game using pseudo-code rather than attempting to analyse the source code due to the entangled nature of game coding.

entity_flags	4
group	0
position	(vector)
velocity	(vector)
width_in_pixels	48
height_in_pixels	48
texture_name	(null)
label	(null)
depth_value	10
theta	0
facing_left	<input type="checkbox"/>
support_height_fraction	1

Figure 3. Object Properties from Jonathan Blow's 2010 GDC Talk.

A system like this would effectively create a complete record of the fictional, ludic past and store it until such time as we needed to recall it back into existence. In the context of the game, the past has become an objective 'thing' expressed in bits and bytes. This thing can be recalled, brought back into existence, through an algorithm.

If we take Blow at his word, appreciate his expression that *Braid* was designed to explore a specific element of quantum mechanics, it's difficult to extend this formulation of the game's mechanics to any one interpretation within quantum theory. However, it is possible to read this understanding of the game's design as reminiscent of an aspect of older and outdated interpretations; one that does away with much the characteristic oddness of quantum science. As part of an answer to the 'measurement problem' of quantum physics, several scholars suggested the 'collapsing wave function' or associated process of 'wave packet collapse'. Although now somewhat dismissed due to the popularity of new theories (particularly that of quantum decoherence, though—importantly, these new theories are not complete solutions), early proponents of this theory—the so called 'Princeton school'—proposed that the 'wave function', the several possible states of materiality at a quantum level in several possible positions in space (the superposition of a quantum eigenstate) eventually collapses into a single reality, regardless of the act of observation or measurement [12]. Implicit in this process, subatomic matter shifts from a seemingly stochastic, indeterminate state to a knowable, stable, objective reality. The many suggestions to why this could be have included human consciousness, some property of gravity, the product of what are actually 'hidden variables', the signature of many multiple realities all existing simultaneously, or the interaction of quantum matter with classical scale matter (decoherence). Within the scope of the humanities, I think the important knowledge to gain from the 'collapse' theory and measurement problem more generally, is that there is an underlying tension between scientific practice's lust for definite answers and the feeling that we live in a world that exists to some extent beyond either our apprehension or comprehension.

Applying the notion of the collapsing wave function to *Braid*, the game would need to have a state of indeterminacy and then a collapse into knowability. It is tempting to read the game's functional, real-world 'present', as a mid-way point in the process of generating the subsequent frame by the



central game loop. Prior to its final calculation—like an eigenstate in superposition, or a wave function prior to collapse—while the frame is still being generated, the exact location of each object within the game world is still being calculated and remains, briefly, indeterminate. Though depending on the computer, the calculations are happening extremely quickly, likely in the order of 100ths of a second. But until this outcome has been completed, literally through the interaction of electrons within CPU and RAM, this exact material process is difficult to determine, even if we attempted to use an electron microscope. The moment the co-ordinates of game objects are recorded in the rewind array, therefore, is like the collapse of this wave function into knowable ‘reality’, in the form of a solidly stored electronic charge in magnetic storage media.

Reading *Braid* as a metaphor for the collapsing wave function, we can understand the game’s central mechanic as generating certain outputs from the processual pseudo-uncertainty of calculation through the activity of electrons. Taking this to be true, one could read the game as generating a concrete record of past gameplay events by storing output in a digital record. If this was the case, *Braid* would not only be an effective metaphor for the Princeton school of quantum theory, but also of certain philosophies of time. If *Braid* functioned the way I have suggested up to this point, it would be an excellent tool for understanding J.M.E. McTaggart’s A-series philosophy of time, “that series of positions which runs from the far past through the near past to the present, and then from the present through the near future to the far future, or conversely” [13] (p. 458). Perhaps, a more exact parallel could be drawn between *Braid*’s functional mediation of time and C. D. Broad’s ‘growing block’ theory of time in which the present, the cutting-edge of events that are occurring, are then added to the physical history of reality, without any change. According to Broad, “nothing has happened to the present by becoming past except that fresh slices of existence have been added to the total history of the world” [14] (p. 66). If *Braid* functioned in this way, the game would appear to rest on the idea that the past, at least, can be said to objectively exist, separately from humanity, with or without perception, measurement or observation. As the game system would be functioning as both part of and a metaphor for Broad’s growing block as new entries are added to the functional algorithm that can be recalled at any moment, their existence—as specific configurations of electrons stored in magnetic memory—is an inarguable fact.

Taking both the scientific and philosophical theories on balance, if *Braid* worked exactly as I have been describing up until now, the game could be read as a monument to objective scientific practice. If a virtual world worked the way I have suggested, we would have a time-stamped, undeniable record of each moment of time that could be relived at will. Thinking of *Braid* in this way, it’s possible to see the game as following in the wake of Hegel or Thomas Kuhn where applying the best possible scientific models to our practices of observation brings us ever closer to apprehending a world beyond our senses; through better and better practices of measurement we grow closer to not only apprehending what we see but perhaps also the ‘true’ Platonic ideal, Kantian noumenal or ‘thing-in-itself’, of the infinite, absolute or ‘real’. For a videogame, this would be quite an achievement.

Perhaps it is fortunate then, given the philosophical ramifications, that what I have outlined above is only the beginning of how *Braid*’s rewind system works. Although this was one of his initial ideas for the game Blow quickly found that this option resulted in quickly inefficient memory use and problems when memory was full. As such, he was forced to make some important changes that completely change how *Braid* relates to scientific practices and appropriate theories of time. Perhaps the most important detail Blow highlights in his talk is that although the rewind mechanic does not theoretically have to be limited within *Braid*, it does have to be limited in practice due to the mechanical limitations of the amount of memory a system has [8]. Depending on what version of *Braid* a user plays, this limit can change, although originally it was set to work within the 512mb RAM limit of the Xbox 360, the console *Braid* was originally released on. Due to this physical limitation, Blow was faced with a few options for the rewind mechanic. One option, reminiscent of ‘eternalism’ or a B-theory of time, would have been to make *Braid* a deterministic system, where each action’s consequences would have been mapped out mathematically. Through elegant algorithm design, Blow could have made a game where

player input always resulted in predictable output. In this way, *Braid* would have been a functional representation of a theory of time in which every moment exists simultaneously, and past, present and future are arbitrary perceptual distinctions, such as that put forward by Julian Barbour [15]. This seems to inspire some of the later stages of the game where object movements are linked to the player's position. However, Blow chose not to follow this model as possible programming errors would have resulted in large mistakes.

In the end, Blow settled on a system in *Braid* where the assignment of player data to memory was semi-arbitrary, allowing for easy overwriting, and limited to about an hour before self-overwriting. Beyond this, Blow outlines that his mechanism utilized a form of numeric compression to ensure maximum efficiency. Perhaps even more importantly, the recording process was also staggered so that the properties of *every* game object were recorded only at fixed intervals. The properties of active game objects, on the other hand, were recorded more frequently. These asynchronous recording mechanisms allowed Blow to optimize his system, but they also radically alter the epistemological impact of the work.

Following the details Blow provides in his GDC talk, the system does not generate a one-to-one record of events as they occur. Instead, still using a process like the array system discussed above, it generates a rough record of events based on frequently gathered data from the most active game objects. However, the array entries aren't ordered in an absolute manner. Rather, entries are generated flexibly with reference to the current frame to allow for easy overwriting of data. Then, a more staggered operation that takes a complete snapshot of every game object, occurs at fixed intervals. This data is then compressed into a more compact data form. The recall mechanic then decompresses the stored data and interpolates between the current player position and the positions recorded  $x + n$  distance from the current frame. As such, the rewind mechanic does not really rewind at all but generates new states from data that is distinct from the previously experience game-states. It's possible to think about this more complex account of the storage process of the rewind mechanic in the following way:

```
void UpdateEveryFrame()
{
    masterPositions.Add(player.position);
    masterPositions.Add(enemy1.position);
}

void UpdateEverySixtyFrames()
{
    masterPositions.Add(allPositions);
    Compress(masterPositions);
}
```

As the actual system functions more like to this new example, we can begin to develop a new understanding of it. When using the recall mechanic, although it may seem like rewinding through saved frames that are accurate representations of our previous gameplay, instead, entirely new frames are being generated through complex compression, decompression and interpolation of values. Although it might seem like jumping back into the past—at least within the virtual world—Tim is still moving forward, in the game's temporality, just using a different method.

*Braid's* mechanics work similarly to the 'no-boundary principle' that informed Hawking's thinking on the three arrows of time that account for the feeling temporal progression in a cosmologically

expanding but thermodynamically entropic universe [16] (p. 125). While in the world of *Braid*, although there is no natural flow of entropy to speak of, so no thermodynamic arrow of time, and no natural contraction or expansion of the universe, so no cosmological arrow, we still have a psychological arrow of time: our perception of temporality, the feeling of past and present. On top of this, we have a new arrow, that of an arrow of game-time, that seems to either flow alongside our perception or against it. We may assume that if one arrow of time is reversed, so must the others; however, as Hawking observes, this is not the case. Hawking rationalizes that, due to what he and his peers called the 'no-boundary principle', entropy and perception will continue even if beings can live long enough to experience the potential contraction of our universe. As entropy continues, the contraction of the universe will look entirely different from its expansion. We can use this to understand what occurs in *Braid*. Rather than the 'law of thermodynamics' we are instead left to contend with the algorithmic processes of addition and compression that subtly change the way events play out when we rewind time in the game. Although we may change our psychological arrow of time multiple times, the game-time arrow continues in one direction regardless.

The ramifications of *Braid's* virtual timeline being the product of non-determinist creations of new states through the rewind mechanic, complicates the idea that the rewind mechanic can express the objective existence of the game's 'past states.' When a player plays the game, they generate new game states and add new data into the positions array. The newly generated states are distinct from the—once present now past—game states. However, the player is also readying a mechanism that can enable an enactment of what would, functionally, appear almost equal to what we perceive as the initial game state. We can think of it in the same way I considered in the deterministic thought-experiment above, where an imagined character began an imagined level in position  $X = 0, Y = 0$  at frame 0. The imaginary character can travel through the game world ( $X = 10, y = 10, \text{frame} = 10$ ). However, now we know that when the character travels 'back in time', the frame count will continue, even though the character's co-ordinates may change. A new game 'present', let's say ( $X = 0, y = 0, \text{frame} = 20$ ) is created out of what we have come to consider the game's past. However, the data associated with past frame is not absolute. It will be overwritten and altered, constantly changed by our actions in the present. When we begin a new time-recording, after travelling through game time, we begin the array again. Frame 0, or just position 0 within our array, can take on a new value. We now know that the process of developing this state was more complex and that, on a lower level, there are some fundamental differences between the initial game state the state we arrive at.

Understanding *Braid* in this more complex formulation, we begin to get to the heart of Blow's 'existence threatening' understandings of quantum theory. For instance, looking at Wheeler's interpretation of the delayed choice experiment, can open our eyes to some of the implications of the system Blow has designed. Wheeler laid out his interpretation of a familiar, imaginary beam splitter experiment in which, using the logic of a which-path experiment, experiments can be generated that appear to allow events to play out of order from what we might expect. Wheeler describes an experiment in which an electromagnetic wave is split using a one-sided mirror, reflected off two mirrors, back towards a central point and then detected by two detectors [5]. Imagining perfect testing conditions, mirrors and equipment it would be possible to see which path photons were choosing as the 100 photons going in, would be the same 100 photons recorded going out. However, Wheeler imagines a version of this experiment in which a final one-sided mirror could be placed that would cause further interference, "in the new 'delayed-choice' version of the experiment one decides whether to put in the half-silvered mirror or take it out at the very last minute. Thus one decides whether the photon shall have come by one route, or by both routes after it has already done its travel" [5] (p. 183). Wheeler imagines an interstellar version of this experiment where the scale would be so enormous that removing or inserting the final mirror could take enough time for it to be humanly possible. He concludes, "the 'past' is theory. The past has no existence except as it is recorded in the present. By deciding what questions our quantum registering equipment shall put in the present we have an undeniable choice in what we have the right to say about the past" [5] (p 194).

Former theoretical physicist turned philosopher Karen Barad has expanded on this experiment, reflecting on some actually carried out versions of Wheeler's imagined experiment. Referring to what has become known as the 'quantum eraser experiment' as mentioned above, Barad asks, "what if we were to "erase" the which-path information so that the paths were once again made to be indistinguishable; might not the interference pattern return" [6] (p. 311)? In other words, what would happen if the information collected about the light through the which-path experiment was collated and then 'removed' from the data collected by the final detector screen? Much to Barad's jubilation this thought experiment is not only possible, but when enacted in laboratory conditions produced remarkable results. It was entirely possible to reconstruct interference patterns through the erasure of the measurement process. This observation, although it may seem trivial, has enormous significance. Barad reframes this series of observations on an experiment as a comment on the passage of time. They remark, "the point is that the past was never simply there to begin with and the future is not simply what will unfold; the 'past' and the 'future' are iteratively reworked and enfolded through the iterative practices of spacetime-mattering—including the which-slit detection and the subsequent erasure of which-slit information—all are one phenomenon. There is no spooky-action-at-a-distance coordination between individual particles separated in space or individual events separated in time. Space and time are phenomenal, that is, they are intra-actively produced in the making of phenomena; neither space nor time exist as determinate givens outside of phenomena" [6] (p. 315).

For Barad, the ongoing construction of matter and time (spacetime-mattering) takes place in the process of measurement, while for Wheeler, measurement is an elementary act of creation. In their view of reality, there is no single objective past, but instead material configurations continue to exist and can be furthered by activity in the present. Looking back at *Braid's* gameplay in this context, it's not that difficult to really take Blow's words seriously—that the game was inspired by some of the fundamental assertions of quantum mechanics. From the perspective of the game world, if we put ourselves in Tim's position, there really is no objective, stable 'past' of which to speak. Instead, just as Barad suggests in their reading of the quantum eraser experiment, there is matter that can continue to be drawn upon to affect different states of the world, and that can continue to be affected by our actions. Although any game actions, moving or jumping etc., adds data to the positions array, that data is altered when we use the rewind function as well as altering the current game state. *Braid* then functions as an excellent model of these theories as we are presented with a working system always rapidly generating new 'presents' through a manipulation of the apparent pasts.<sup>3</sup>

### 3. Complication *Braid's* Narrative through Critical Quantum Theory

*Braid*, in practice, is an interactive exploration of a world without an objective past. But, beyond this being a, perhaps, interesting observation to some, what's the point of highlighting this? What might this mean beyond the game having certain similarities to quantum theory? Well, this is where it becomes important to look at some of the game's sparse moments of fixed narrative. Towards the end of the game, players happen upon a level entitled '1-1 Braid', implying that this can be read just as easily as the game's beginning as its end. After descending a small ladder, a large knight carrying a woman descends from the top of the screen. The woman is wearing a long dress and a tiara on top of long, flowing—perhaps loosely 'braided', but it's hard to be sure—hair, and is presumably the Princess from the in-game text snippets: we can't know for sure but, similarly, have little reason to think she could be anyone else. The knight declares, "I've got you", only for the Princess to escape, cry for help, and begin running to the right of the screen, much to the knight's fury. We are separated from the knight and the princess by a stone platform and have no choice but to run after the Princess: a wall of

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<sup>3</sup> It could be argued that the process taking place while playing this game, the shared bio-chemical-electrical exchange between human and machine transcends the need to discuss this intra-active and entangled process in terms of real-world and game-world, but that is beyond the scope of this paper and requires a much deeper dive into Barad's philosophy and the physics that supports it.



flame emerges from the left of the screen and pursues us through the game world. The Princess appears to help us, closing traps, lowering draw bridges and harmful plants that help us proceed through the stage. However, as we get to the end of the stage, the Princess runs into an anachronistically modern looking house and gets into bed. We can finally enter the top level of the game world but are blocked from touching the Princess by a locked door. As we then rewind our progress, a different story appears to unfold: rather than helping Tim get through the maze, it appears that the Princess may have been setting traps and blocking his progress in an attempt to get away from him. This is reinforced by the Princess now jumping into the knight's arms by choice. The dialogue repeats in reverse with the Princess' cries for help now seeming to be redirected at the Knight and his declaration, "I've got you" to be more reassuring than threatening.

If we side with the readings presented by Jagoda and Mitchell, the climax of the game appears to be one that is about violence, control, manipulation, desire; about how we lie to ourselves and construct narratives to forgive our actions. The end of the game appears to reveal our avatar's true nature, bringing clarity to the obtuse writings scattered throughout the world. Although it's tempting to read the events from an affectively and socially charged perspective—these readings fulfil our human desire for narrative closure—I want to, instead, follow through on the science-influenced frame Blow suggests is useful for reading the game. At the simplest, what we see is one chain of events play out, only for a similar chain of events to occur, that seems similar, but played in reverse and with subtle differences. Contrary to the theorists that see this moment as a revelation of some truer account of past events, I would contend that as *Braid's* virtual world is one consistent with the quantum theoretical notions of a changeable past, seeing this new chain of events occur should not be read as a memory or reflection of 'true' previous events. There is very little reason to see the inversion of the knight and the princess sequence as revealing a truer account of past events. After all, for a player to reach this stage of the game, they will have had to take part in the construction and manipulation of the game's flow of time, of a reconstruction and manipulation of the game's 'past'. Players will have rewritten time so often that, by this stage, any player should be extremely doubtful of any possible record of the past having greater legitimacy than any other. If a player chooses to accept that *Braid's* world is designed around the logic of quantum physics, as Blow suggests it is and as I have argued, this should undermine the temptation to read and make sense of the cutscene in an emotional or moral sense. After all, the game's central mechanics are unchanged after this sequence. Players suffer no penalties, no alterations to their mode of play. They are just as free to continue exploring as they were before. It's possible to read this as simply a fault of Blow's writing, not supporting the narrative themes well enough in the game's design (a possible case of ludonarrative dissonance). However, I think we gain something in taking Blow's word on the game and reading it as a success rather than an interesting failure.

Embracing the game's consistent ambiguity and possible lack of objectivity as a statement within itself, it's possible to sideline the game's text as a primary tool for understanding the game's narrative. Indeed, there are some snippets early on that place a clear emphasis on ambiguity through statements such as "memories of their relationship have become muddled, replaced wholesale" while another, one of the final pieces the player can find, reads: "he cannot say he has understood all of this. Possibly he's more confused now than ever." Given that this snippet comes at the end of the game, it's possible to imagine a player, playing through the whole of *Braid*, perhaps even reading all of the highly ambiguous segments, pondering what their connection might be to their actions, only to read about being 'more confused now than ever' at the game's climax; it does seem to be a knowing nod to the player, perhaps even one that lets a player know, it's ok if they're confused. To be clear, I'm not suggesting that what's contained in the game's climactic cut-scene (or text snippets) isn't important; rather I'm suggesting that by analyzing the game placing a priority on the game mechanics, while still acknowledging the general themes suggested by the snippets, it's possible to add something new to the critical discourse surrounding the game.

Following my quantum theory influenced understanding of the game, seeing *Braid* as using intentional ambiguity to make a statement cohesive with the logic of the quantum theory of Wheeler

and others, it is possible to see the game as disavowing a cohesive meaning entirely. After all, we are given no explicit answers as to what our adventure may have meant or what it was about. However, I do not think this is the case. *Braid* may well be suggesting a cohesive, if somewhat tentative comment on ontology after quantum theory and its possible ramifications on morality.

After the sequence with the Princess and the Knight, players can progress to another area of the game. They can read a selection of more cryptic text-snippets, along with the previously mentioned one that mentions being “more confused now than ever”. However, the player also reads several snippets that are focused on building a Castle: “all these moments he’s contemplated—something has occurred. The moments feel substantial in his mind, like stones. Kneeling, reaching down toward the closest one, running his hand across it, he finds it smooth, and slightly cold. He tests the stone’s weight; he finds he can lift it, and the others too. He can fit them together to create a foundation, an embankment, a castle. To build a castle of appropriate size, he will need a great many stones. But what he’s got, now, feels like an acceptable start.” Throughout the game, snippets have referenced the castle alongside the princess as almost an equal point of obsession. We can read the castle as something equally worthy of focus on Tim’s part. However, I think these last snippets of the game are distinct in a few ways. First, there is a humility to them—the narrator of these snippets has no illusions of grandeur; the scale of the task is clear. Building this castle is something that will take considerable effort; in writing “what he’s got, now, feels like an acceptable start” seems distinct from the desire of other snippets. The narrator appears content to focus on the task at hand, rather than the end goal.

Unlike most of the objects mentioned in the other snippets in the game, however, the castle we are to build is present in the game and our way to build it is clear. By completing each level of the game, a block with a corresponding pictograph for that level is added to the castle. Completing this castle does not appear to have any great purpose, although it does give a player the ability to reach a small cloud next to it. Standing on this cloud, one may feel a sense of achievement. Here, the game encourages, but does not force, a player to act. Blow writes of this element of the game, “the reason why this cloud is here is not very verbalisable to me. It’s something about victory, it’s something about having a beautiful vantage point that I can just stand on, and feel successful about. It just felt right that my castle not only encompasses some blocks that were made, but also some elements that were previously antagonistic to me. I just wanted to be in a position where I could look down on the text. I wanted to be high up looking down. Just when I build a castle like this, or added a rampart, it just didn’t feel the same. So again, it’s a pattern break, it’s like everything in the game means something except for this” [17] This element of the game, the cloud, stands out as distinct and removed from the game text. A vantage point that can be realized, but not recorded objectively. A player can reach the cloud and stand on it, but it is ultimately up to them to find achievement in this. There is no achievement triggered by standing on it, no fanfare or graphical flourish. Put another way, there is no record within the game itself that the player ever stood on the cloud.

Through the castle and the cloud, *Braid* suggests something about how we cannot base our readings of what is good or bad, true or false, through a call to objectivity. After all, the certainty and clarity of objectivity we seek, may not be obtainable. To me, this works well with some of the suggestions for living in an ethical paradigm defined by quantum theory suggested by Barad. They write, “can we assume the position of the perfect modest witness and merely observe the universe without disturbing it? When faced with an ethical choice about working on a new technological or scientific project, can we get that kind of distance? Enough to detach ourselves from responsibility? Can we simply follow our passion to know without getting our hands dirty” [6] (p. 396)? Barad’s words can be read in the context of *Braid* as giving a player encouragement to continue striving to ‘build a castle’, when in actuality, the final achievement is up to them. They can choose to stand on the cloud, but this is not written; not set in stone. There will never be an in-game record of those actions. In a world where it is not possible to find a truly objective stance, a place from which we can truly know if our actions are right or wrong, what choice are we left with? Barad, like Wheeler, Bohr and many philosophers before them, have suggested that it is simply not possible to remove ourselves from

the world as we are so intrinsically part of it. Our only choice left then is to act and take responsibility for these actions.

The notion that the only freedom comes from taking actions and responsibility for these actions is, I think, supported by the game. As noted by scholars including Jagoda and Mitchell, if you finish the game in a specific manner, picking up a number of hidden stars throughout the game, it becomes possible to unlock a secret ending for the game. Instead of the Princess simply evading your grasp, it becomes possible to finally touch them. Upon doing so, however, the screen goes white, there is a sound like an explosion and the princess disappears. This has been read by Jagoda and Mitchell as an explosion, supporting the bomb hypothesis reading of the game, or at least a reading of the game where Tim's motivations are scientific obsession and the inherent violence of this ambition. Mitchell goes as far as to say, "her explosion could be read as a suicide" (a particularly pointed reading given that the Princess also 'explodes' in the other ending, just less spectacularly) [2]. Revisiting the starting location of the game, however, the player is given a mark to reward their endeavor: the constellation Andromeda appears clearly in the sky outside Tim's house (Figure 4). Mitchell has presented an interesting reading of this moment, suggesting that this effigy of a "woman in chains" is representative Tim's inability to capture the Princess—understood variously as a human woman driven to suicide, the desire to control the flow of time with technology and an obsessive desire for technological development. However, looking at the depiction of Andromeda, we can see clearly that this mythical princess is now free. It is undeniable that she is falling, she doesn't appear to be celebrating this freedom; but the chains are now broken. In the end of the game then, players, like the princess are free—whether we like it or not—to act and take responsibility for our actions. There is no singular, objective goal to base our future on and no objective past with which to judge Tim. We must make our own choices and see how they unfold.



**Figure 4.** Andromeda's image after the game is completed.

The premise that time is the result of actions, that past and future are entangled with activity, decisions, material fluctuations of the present, and that this process will continue, eradicating a sense of any world 'out there' is a departure from moral philosophies that place an emphasis on subjective engagements with reality beyond ourselves. *Braid's* game world history changes continuously in accordance with our actions, being constantly overwritten to the extent that there is no singular objective account of it. Put simply, *Braid* suggests that there is no noumenal world beyond our senses but that our reality—down to time itself—is irresolvably linked to our actions (and vice versa). Applied to situations that invite our morality, this introduces a sense of ambiguity that is difficult to overcome.

We are left free, frighteningly free, to not simply engage in or look at this world, but to always already be making the world we live in.

#### 4. Conclusions

Braid, read from the perspective of quantum theory suggests that when we stop endlessly pursuing truth, a definitive reality or an objective record of the past, what we are left with is not a paradise, but work. Jagoda has commented negatively on this work-oriented aspect of Braid, “regardless, we act. Videogames, after all, are not the passive activities they are often assumed to be. They demand activity. They absorb and obsess players. To be sure, playing Braid is a blast. But it is also active work that demands motivation and deep focus.” [1] (p. 736). While Jagoda relates this constant need for work to a post-war algorithmicizing of culture and humanity, something perhaps to be lamented, or even resisted, I don’t see it this way. While *Braid* may force players to act, following the quantum theoretical perspectives I have invoked in this paper, it must be understood that it is impossible not to act. We are constantly engaged in the process of creating the world in which we live—of building the castle. The lack of definitive ending, the destruction of our singular goal and the act of setting players free functions as an encouragement to take up arms in an embrace of the present. What we see in *Braid* is a brave attempt for games to ‘do philosophy’ by suggesting a novel departure from ideas of morality and ethics predicated on recourse to a noumenal reality. According to it, there is no world beyond our senses, only the reality we create. Past, present and future are interlinked and nothing is safe from our intervention. Rather than actions allowing the mutability of the past removing consequences, it instead extends consequences in multiple temporal directions. It is a tremendous responsibility.

As I wrote at the beginning of this paper, this is far from a cohesive ethics after quantum time, but *Braid* does provide players with a means to explore this notion in a limited way within a virtual world. *Braid* stands as an early step towards a possible invocation of scientific theories in virtual worlds to explore how players engage with narrative and morality. As I write this, I know there are more fans of the game that desire a definitive ending than there are fans willing to embrace the freedom of personal responsibility and choice in a chaotic world without an objective past, in the sense suggested by Wheeler and Barad. However, I think this is indicative of just how forward thinking *Braid* was in its time and I look forward to interactive fiction taking similar daring steps in the future.

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