Arcade-Style Game Design – Pinball's Connections to Coin-Op Videogames[1]

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One of the three main traditions applied to the study videogames within the humanities is the history and analysis of board games, card games, or games like *Dungeons & Dragons*. While by no means representing the totality of the authors' research and methods, books including this angle include *Rules of Play* (Salen/Zimmerman 2003), *Game Design Workshop* (Fullerton et al. 2004), and *Challenges for Game Designers* (Brathwaite/Schreiber 2009). Tabletop game traditions are unlike the other categories that I'll address in that they are oftentimes games primarily of strategic decision making rather than skillful real-time execution. That is, when I as a player choose to move a knight to a certain position, or play a particular poker hand, that decision is easily performed with complete accuracy, without risk of error from overshooting or undershooting the knight's move, or accidentally playing a different hand in cards. Where chance is involved it generally can be calculated beforehand as a fixed probability as when rolling dice, spinning a spinner, or considering what the other and next cards may be in poker.

Another of the three primary frames often applied for making sense of games is rooted in sports or related physical activities, from professional

[1] For context: the material has been adapted, updated, and abridged from my Master's thesis in Digital Media at Georgia Tech from May 2012, "Arcade-Style Game Design: Postwar Pinball and the Golden Age of Coin-Op Videogames." This is the form presented at the History of Games in Montreal, Canada. The original thesis advisor was Dr. Ian Bogost, and on the committee were Georgia Tech professors Dr. Brian Magerko, Dr. Celia Pearce, and Dr. John Sharp, in addition to Steve Swink of Enemy Airship.

athletics to playground games. Gumbrecht (2006), Eichberg (2010), Suits (1978), and Dekovan (1978) - among others - investigate and comment at length on the history and philosophy of sports. Meanwhile other researchers with more direct videogame involvement, such as Juul (2005, p. 58) and Schell (2008, p. 442), occasionally turn to sports as a reference for analyzing aspects of real-time games. Topics within the domain of sports studies include bodily athleticism, sportsmanship, spectatorship, or symmetrical competition between players. In these types of games strategy alone is often insufficient, instead being balanced with tests of reflexes, timing, and coordination in the execution of physically demanding tasks. In these games the goal is often clear: land the shot in the goal without the opposing team obtaining the ball, or in golf get the ball into the next hole with as few strokes as possible. When Bernard Suits wrote about lusory attitude (Suits 1978, p. 52), referring to the acceptance of inefficient means as a central feature of gaming, he used golf as a prominent example: because there are more reliable ways to move a golf ball to the hole than hitting it with a club, we make a game of golf partly by our voluntary acceptance of the restriction to use the less efficient means of swinging the club.

A third category popular in game studies within the humanities is the track that focuses on narrative and cinematic qualities. *Hamlet on a Holodeck* (Murray 1997) was a hallmark in this space in and out of academia, while other practicing designers including Crawford (2004) and Klug/Lebowitz (2011) have written guides focused on this aspect of games. Videogames prioritizing features studied in this category range from *Zork* to *Myst*, *Heavy Rain* to *Skyrim*. *Dungeons & Dragons* spans both this category and the first mentioned (board/card games), inviting different types of analysis or discussion from either body of researchers and practitioners. These broad groupings for games and their features are by no means mutually exclusive.

The central qualities, interactions, and strengths of coin-op videogames are largely in a blind spot of those three perspectives in game studies. Such games include of course classics such as *Donkey Kong*, *Space Invaders*, *Berzerk*, *Galaga*, *Q*Bert*, *BurgerTime*, *Defender*, *Pac-Man*, and *Joust*, in

addition to hundreds of more examples that were less commercially successful or for various other reasons no longer very widely recognizable now two or three decades later.

When viewed through the lenses of those dominant perspectives, these types of games don't stack up well by their primary criteria. In terms of strategy, arcade games seem to be of a far shallower sort than games with turns for making calculated decisions. In contrast to sports, most arcade games minimize the amount of full body coordination and conditioning by playing through button presses and joystick wiggling (although digital controls often still involve practiced, precisely timed finger dexterity and mildly contribute to fatigue, the role of cardiovascular and strength training are rendered negligible). In terms of story, arcade-style games tend to rely on simple clichés for recognizability (as with spaceship battles against aliens), or the fantastically absurd as in games like *BurgerTime*, *Q*Bert*, *Pac-Man*, and *Joust*.

Skill in arcade games has more to do with reaction and timing than it does physical performance or pure strategy. These games tend to be made for high replay value - designed for repeat enjoyment, even though presenting the same content each time. The game often takes place on either one board (*Pac-Man*) or a repeating rotation among a relatively small set of boards (*Donkey Kong*, *Ms. Pac-Man*). These games were designed to be extremely hard, resulting in very short sessions for typical players. Early coin-op games were played until the player lost, with no hope of every achieving a positive resolution (kill screen errors for world class players aside). Losing was never intended as permanent since the player was meant to play again; since the primary goal for many of these games was to achieve a high score rather than losing every play the player could be considered as winning to varying degrees based upon the score at the time of game over. The games rewarded successful play with prolonged play from the same payment, through a combination of extending the lifetime of a single credit or also by free play and extra lives. Spectacle in the form of flashing lights, loud sounds, sometimes even short animated sequences provided a more visceral form of feedback to acknowledge player achievement.

To the point of spectacle, as pinball designer George Gomez explains it, “Everything in the game is designed to reward [the player] the further he gets into the game, make him feel like a hero. We should be going crazy with the lights, the music should come up... all those things should be giving the feedback to the player that WOW, look what I just did” (*Tilt* 2010). In much the same way as fans might cheer to excite an athlete following a particularly skillful move, that type of acknowledgement gets designed into these games.

In *Pinball Wizardry*, Polin and Michael Rain describe that due to the high speed of a steel ball on waxed wood, with bursts as fast as 4 meters per second during normal play (Polin, Rain 1979, p. 22), relative to the dimensions of the playfield reaction time is insufficient to wait for an event to happen in order to react to it. Polin and Rain refer this in saying that pinball is a "game of prediction, not reaction" - not in a strategic sense as one would expect to play chess successfully, but rather at a tacit level of starting reactions based on where the ball will be. Likewise in *Asteroids* a player cannot wait until collision is about to happen with an asteroid or UFO shot to begin dodging. The delay required by the simulation of acceleration in the game means the player frequently needs to be in proper motion prior to the anticipated event.

There is surprisingly little academic research on the gameplay of pinball. There are at least a few notable exceptions. Decades ago, Sherry Turkle referred to pinball as the "godfather" of videogames (Turkle 1984, p. 502). Turkle goes rather quickly over the similarities between pinball and computerized games, implying it almost as obvious or given, to focus instead on the differences in how videogames are not constrained by physical consistency and limitations or material realities in the same way that a hardware-reliant game like pinball is. She points out that this gives videogames a far less constrained design space, and the potential to create a much wider variety of game types. In 2008 professors Stephen Jacobs and Christopher A. Egert used *Future Pinball*, a digital pinball game where you can design your own tables, as a level design exercise in a game history course (Jacobs, Egert 2012). While pinball does on occasion find its way into game studies, and this research does not reflect the first or only work done on the subject, for the most

part the other material available about pinball isn't really coming from academic scholarship but instead from collectors, enthusiasts, repair people, documentaries interviewing people that know the industry from the inside (including the developers), and a select couple of pinball historians.

In some older machines from the 50's or 60's a rack of balls lost during play served as a visual indicator of the player's errors toward game over. This vaguely parallels the way in which player avatars in many early coin-op videogames served as a visual indicator in the other direction - rather than how many avatars were lost, showing how many more the player could have on the field after losing the current one. *Defender*, *Dig Dug*, *Pac-Man*, and *Donkey Kong* all put multiple avatars in a corner to show lives remaining. It's easy to forget how weird and unnatural an expression this is for how many Jumpmen or Dig Dugs are left, though the stacking pinballs hints as some possible evidence for prior, if inverted, convention.

This separation of identity from the piece currently in play implies a type of strangeness in virtual identity. In another interview for *Tilt* (2010), George Gomez explained a new marketing employee at Williams pitching pinball designer Steve Ritchie the question, "So, Steve: I'm trying to understand... Am I the ball?" In pinball many things are happening on the table, but it's not really clear that the player should think of himself or herself the ball, the flippers, or even the whole table - especially perhaps during multiball. Similar oddness is visible but often overlooked in the early coin-op videogame *Galaga*, in which a player can obtain a double ship then seamlessly become whichever vessel remains after either half of the pair gets destroyed by aliens.

What initially primed me to begin hunting for these kinds of connections between pinball and videogames was *The First Quarter* (Kent 2000, p. 1). Kent devotes the whole first chapter of his book on videogame history to the business overlap and cultural momentum from pinball and other eletromechanical games toward creating a niche soon thereafter filled and expanded greatly by videogame culture. As Kent explained it, pinball helped people grasp videogames much like calling a car a "horseless carriage" helped people

understand what role the car was build to fill in civilization (Ibid.). The connection, however, seems more substantial than conceptual.

Eugene Jarvis and Larry DeMar, who worked on pinball both before and after their work on videogames, created *Defender* and *RoboTron 2084*, two highly successful early coin-op videogames. Gottlieb, a company otherwise known before and after that time primarily for making pinball machines - it played a key role in establishing the pinball industry as a major business beginning in the early 1930's - is responsible for the famous coin-op videogame *Q*Bert*, which used a speech chip from a pinball machine and a pinball machine's free play "knocker" (a solenoid device that uses electromechanical force to cause a jarringly loud sound via a contained mechanical collision) when *Q*Bert* fell off the screen (Davis 2012). Stern, a family brand long associated with pinball manufacture and later acquiring a different company as one of the last remaining pinball manufacturers, created the arcade classic *Berzerk*. Steven Kent even pointed out that Toru Iwatani, who created *Pac-Man*, was a pinball enthusiast who really wanted to make pinball machines (Kent 2000, p. 144). Namco Japan, where Toru Iwatani worked, did not make pinball machines, and he made *Pac-Man* instead. Even without specific intent to mimic pinball design elements in coin-op videogames, when a pinball enthusiast like Iwatani designs a videogame emphasizing parallel core mechanics like lane coverage (the basic pills) and changing scoring relationships mid-play (power pills), there's at least a hint of possible bleeding over from pinball's rollover lanes and the special when lit mechanic. Atari, Data East (creators of *BurgerTime*), Sega, Capcom, and Taito - all companies mostly known for their videogames - also created pinball machines (Stafford, Wolf, Laughlin 2012).

Gameplay design concepts that pinball designers talk about can help improve our thinking about the types of gameplay patterns found in successful early coin-op videogames. For example, pinball designer Pat Lawlor refers to the importance of designing games with "near miss" in mind (*Tilt* 2010). Near miss refers to an effect Lawlor describes as creating an opportunity for the beginning player to still think or feel "I meant to do that" when something

different but still cool happens after a player's failed attempt to perform some action during play. A well designed playfield is set up in such a way that if the player misses a ramp, it can smoothly take the orbit instead, or missing one near bank of playfield targets might have another bank of targets further downfield to receive and score the momentum of the missed shot. In many early coin-op videogames - including for example *Space Invaders*, *Asteroids*, *RoboTron*, and *Centipede* - at the start of play players fire into a dense pile or row of targets such that it's hard to miss at least hitting *something*. Shooting for something but missing still hits something else, which the player can feel good about. Remember that these arcade games were designed to be played in public where strangers or friends might be watching, so creating a game such that the player could attempt it while still looking decently competent (even if only at first) was important to not making a player walk away in shame after the first coin. As the videogame progresses and enemies thin out or as pinball drop targets fall and most of the rollover lanes get lit by random chance, it becomes increasingly difficult and requiring of mastery to hit the remaining targets or lanes, preserving (though building up smoothly to) the level of intense difficult required for a game which depends on failure sooner rather than later to earn its next payment or open up for another player.

While there were other kinds of electromechanical novelties before and alongside pinball - shockers, grip/"love" testers, mechanical dioramas, fortune teller automatons, Kent noted that by the 1950's all of those game types except pinball were drying up and being resold overseas at budget prices (Kent 2000, p. 265). More importantly however to my line of investigation, the mechanics of such electromachanical novelties as a whole didn't fit as fully into the pattern of mechanics and properties shared between pinball and early coin-op videogames: playing well to prolong play, high score as the primary objective, and skill based primarily on timed button press input (rather than full physical movement as found for example in EM lightgun shooting galleries) to respond in real-time to trajectories in continuous space and game time.

Pinball's origins are from the same family of games as pool and billiards (Bueschel 1988 p. 17). Bagatelle, a pocket target-shooting game from around

the 1700s, involved shooting through gates to knock over pins or land balls in shallow cups. "Parlor bagatelle" came about as a more casual, somewhat less controllable version of the game that couldn't be as easily dominated by skilled players. In parlor bagatelle the player used a wide-head pool stick (a "mace") to shove the ball up a righthand lane on the side of a smooth but slanted wooden table, at the top of which the rolling ball traced along an arc at the back before falling back toward the player, bouncing between a grid of pins on the table toward scoring pockets on the playfield or along the bottom.

Parlor bagatelle didn't become a coin-op industry until the Great Depression, at which time in the early 1930's Americans needed a cheaper form of entertainment (Bueschel 1988 p. 13). In *Pinball!*, Roger Sharpe suggests that a realization made which led to the pinball industry was that for a typical carnival game someone had to be paid to administer the game (coaxing passersby to play, handing over darts or balls in exchange for payment, keeping players from cheating or playing wrong...) - yet if the game's administration could be internalized into the machine then no one would need to be paid to sit there (Sharpe 1977, p. 24). Thus the game owner could charge less per play - even just a penny - yet still pay off the initial investment in the machine and make a profit.

One reason why parlor bagatelle was an especially ideal choice for adoption as a coin operated game is that (a) it mixes player skill with uncontrollable chance, giving players a real sense that they're responsible for the outcome and practice can pay off, while preventing a highly skill player from simply winning every time (b) it's so simple to play that it doesn't require reading instructions or receiving coaching from peers, as most board games and sports do. Such instructions are critical for board games and sports because there are so many things a player is capable of doing but not allowed to do: moving pieces or the body in an unapproved way. In such games only by knowing what is not allowed yet is technically possible can players avoid accidentally doing it.

When the player's only means of control is pulling and releasing a spring plunger, an invention from the patent *Improvements to Bagatelle* (Redgrave 1871), or later beginning in 1947 with the introduction of flippers that actuated at the press of a button, the player doesn't have many ways to do anything disallowed. This helps remove the Bernard Suits lusory attitude mentioned earlier, in which players have to accept the inefficient means of play as part of playing, since short of smashing the playfield glass to get direct access to the ball and targets (or for an arcade game soldering modifications onto the circuit board), simply playing the game with the provided though narrowly limited controls was in many ways the most efficient and convenient way to accomplish gameplay goals.

Digitization and automation of rules makes it possible for players to learn a game's rules and scoring by playing it in a probing fashion, rather than needing to learn all the rules upfront (Liebe 2008). All the player needs is some sense of the goal sought and the failure condition to be avoided, after which experimenting with the input device can be used to play even if the player doesn't know how since only legitimate moves are allowed. In the same way a player with only a minimal notion of what to do with a pinball machine or early coin-op videogame is equipped to play it and learn the details in the process.

Theme is another aspect of arcade-style games that has a peculiar relationship to play. Fiction on first glance for pinball or early coin-op videogames might seem a bit like a superficial skin, like decorative chess pieces, but there's a bit more to it on account of the role of the playfield and backglass art for the machine as a business object, and the use of theme as scoring metaphor or hint of special features.

With some of the first coin-op pinball games, including the historically significant and commercially successful *Ballyhoo*, playfields were covered with purely decorative, eye-catching though abstract patterns. At this point the playfield art served the function of automating the carnival barker to coax interest in nearby people, to give them a reason to come closer. Around that same time one of David Gottlieb's similarly successful tables, *Baffle Ball*, was

painted on the playfield to resemble a baseball diamond, with scoring pockets located where bases should be and a green playfield to look like grass. However scoring and rules had no connection to baseball - no outs, no fouls, and third base was actually worth fewer points than first base since the first base position was on the plunger's side and therefore more difficult to hit. The scoring pockets for such games were marked to indicate pure numerical addition, or sometimes multipliers, but nothing more complicated or involved than that.

Gottlieb's 1932 *Play-Boy* painted playing cards on the field, to make play a bit more interesting - now instead of simply trying to maximize numerical points, the player shot balls in an effort to form a winning card hand. By assuming prior knowledge by the player about card hands, a different type of gameplay could be offered without needing to explain any new information. Although scoring was not automated for *Play-Boy*, with the introduction of electronic "passive" (non-kicking) bumpers for the 1936 bowling-themed game *Bolo* score events could be registered electronically (Stafford, Wolf, Laughlin 2012). Much as *Play-Boy* relied on prior knowledge about card hands, *Bolo* appealed to player knowledge about the basics of bowling: 10 pin-shaped bumpers were on the field, arranged in a triangle as at the end of a bowling lane, and the player had two plunger shots to bump as many pins as possible. Bumping pins caused their corresponding pin number to light up on the backglass display.

Early videogames - and videogames ever since - have likewise long relied on metaphorical representation of other games or recognizable scenes from popular shows to make use of a player's prior knowledge, suggesting a different type of gameplay interaction without the player needing to put much effort into learning the new game. A videogame themed as battling spaceships, street brawlers, or a sport (including racing) can feature or emphasize radically different mechanics than what a simulation of the actual activity might favor, yet still succeed in tapping into the player's prior knowledge and expectation about the basic relations between elements in certain contexts. As in the use of card game, bowling, pool, and other game metaphors borrowed for themes on pinball machines, these art connections help the player immediately understand

- or put simply recognize - complex and varied scoring relationships between otherwise abstract events in fundamentally abstract games.

Pinball manufacturers made money from selling new machines, not from the old machines out on locations. After exhausting other types of games to theme games after, pinball manufacturers tried moving to fictional themes like space travel, days in the park, or days at the beach. This change to characters and fiction expanded the number of unique games that a pinball manufacturer could release without looking like last year's models. However since that use of theme didn't imply previous player associations with special scoring dynamics, this led to decades of scores going back to pure points, with possible variation in gameplay, again making it harder to differentiate new machines from the old. By the mid-1980's with games like *High Speed*, as pinball designer Pat Lawlor explained in *Tilt* (2010), the games took on a narrative concept as the basis for their core playfield feature: in that case advancing a traffic light to red, "running it" by going up the ramp under it, then "escaping" the police. This kind of middle ground allowed both the novelty of fiction as well as innovative scoring mechanisms, and in a way that players could easily understood.

Flippers were introduced in 1947 for *Humpty Dumpty*. This addition of flipper buttons dramatically affected play. This was the addition that made it possible for a skilled player to prolong gameplay by performing well. Buttons are also what allow the game's action to focus on real-time reactions to the fast motions on the playfield, rather than the turn-oriented action of pulling back a plunger for each shot set up. Because powered flippers supply impulse discretely - on when the circuit is closed and off when open - but respond immediately to button press and release, a type of time-based power control could be achieved by tapping the button very quickly to flick or juggle the ball, with a more firm press delivering instead a full impulse. A similar type of analog interaction is central to achieving a sensation of control over jump power in early platforming videogames (Swink 2009, p. 213).

While the dominance of coin-op arcade videogames is now largely in the past, some of these same patterns have been reappearing in the casual and smartphone game markets. In these budget game spaces the lower cost of development (accomplished by replay with heavy reuse of limited content), immediate accessibility (for players not interested in a long or particularly complex experience), and themes establishing distinctive character (without attempting a coherent story) have led to games like *Peggle* by PopCap, which resembles a modernized variation on parlor bagatelle, or *Canabalt* by Adam Saltsman, a high score one-button game frozen endlessly in a single narrative event wherein the player plays well simply to prolong play. This reemergence of arcade-style game designs isn't necessarily an act of deliberately copying history or researching and applying principles; it may simply be a result of convergent evolution, in which similar constraints and priorities (small budget, immediate accessibility, and cheap recognizability through a largely surface-level theme) have led to games in some domains with certain properties succeeding financially, after which other game teams may resort to exploring similar patterns in search of success with similar audiences.

Videogames, of course, did not emerge from any one particular gaming tradition. In an effort to discover what would succeed early game developers had a rich history of many different kinds of games and media to draw from - board games, sports, and narrative forms of all kinds among them. It's worth recognizing in game history, though too often ignored, that some of the key designers and companies involved early on in digital games were in especially close proximity to, had direct involvement with, or at the very minimum shared a market context and paying customers with pinball, yielding design parallels. Investigating the mechanics and player experience in pinball can help draw attention to different aspects of gameplay than the study of other game traditions, increasing the tools and topics available to designers and researchers alike.

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