A Cognitivist Theory of Affordances for Games

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ABSTRACT
Affordances, broadly construed as opportunities for action, have been used to explain game-related phenomena in a variety of different contexts. This paper presents a cognitivist theory of affordances, which is general enough that it subsumes several related theories, yet precise enough that it provides a useful lens through which to view games. The framework is a re-contextualization of older work that unifies approaches taken in the fields of ecological psychology, interaction design, and human-computer interaction. The Cognitivist Theory of Affordances in Games is thus a theoretical contribution, which synthesizes several views by presenting three independent manipulable entities that are relevant to the study of games: 1) *real* affordances, what actions are possible in a game, 2) *perceived* affordances, what actions players perceive possible in a game, and 3) *feedback*, perceptual information introduced in the game by its designers to advertise real affordances in the hopes of eliciting accurate perceived affordances.

Keywords
theory, affordance, games, cognition

INTRODUCTION
The term *affordance* is broadly linked to an opportunity for action; to afford an action is to facilitate or enable it. Affordances as a concept have been employed in the analysis of game-related phenomena in a variety of different contexts, such as games for education (Linderoth 2010, Spires, et al. 2011, Meluso 2012), theories of game design (Mateas 2001, Deterding, et al. 2011), and gamification (Deterding, et al. 2011). However, the broad use of the term in the research literature is not grounded on a generally accepted formal definition (Horton 2011). Several researchers from different disciplines have operationalized the term into pragmatic definitions, with no clear agreement on its usage. In the sections that follow, we will study affordance from different perspectives that are relevant to games, and subsequently will present our Cognitivist Theory of Affordances, which is general enough that it subsumes several related theories, yet precise enough that it provides a useful lens through which to view games. Our theory unifies approaches taken in the fields of ecological psychology, interaction design, and human-computer interaction. The contribution of this work is primarily theoretical; it presents a framework by way of a set of concepts and definitions, which we contend is useful in the design and analysis of games. We present our arguments for this position as well as one example of this theory applied to the analysis of a game, subsequently discussing our theory's relevance in the design of games.

Proceedings of DiGRA 2013: DeFragging Game Studies.

A BRIEF OVERVIEW OF AFFORDANCES

As noted earlier, affordances have broadly used conceptually to analyze the operation of designed systems. As a result, a systematic review of the concept is not possible here. We do however review what we feel is the most relevant work in the area, as a way to provide a conceptual grounding to our theory.

Initial Formulations

Gibson coined the term *affordance* as an element of his Theory of Direct Perception (J. J. Gibson 1979) within ecological psychology. Unfortunately, Gibson's work on affordances is contradictory. In the same work, Gibson described an object's affordances as the set of ways an actor can relate to an object (which varies from actor to actor), and as an objective property of the object: "the affordance of something does not change as the need of the observer changes. …the affordance, being invariant, is always there to be perceived" (J. J. Gibson 1979). For Gibson, affordances relate to perception in that, when we perceive an object, we do so by perceiving its affordances. However, his theory posits that mental symbols and representations do not play a significant role in the process of perception. In his framework, perception is abstracted beyond the mental recognition and classification of objects. Subsequent work within ecological psychology focused on defining the mental structures created when affordances are perceived, but mostly deferred the justification of how the structures are created in the first place to the Theory of Direct Perception (Chemero 2003, Stoffregen 2003, 2004). Vera and Simon (1993) analyzed the theory put forth by several sectors of the ecological psychology community and conclused that the collective body of work was not anithetical to mental symbol representation and manipulation. Disregarding the Theory of Direct Perception as the justification behind mental structures are created, Vera and Simon put forth a theory based on physical symbol systems (Newell 1976): affordances revolve around mappings we make between a declarative representation of the world to actions. Affordances, they proposed, "are in the head, not in the external environment, and are the result of complex perceptual transduction processes" (Vera and Simon 1993).

Modern Perspectives

Gaver's (1991) work on "Technology Affordances" preceeded Vera and Simon's cognitivist treatise on affordances, but has influenced much of the modern work within the Human-Computer Interaction community, leading us to begin with his work for an analysis of modern perspectives. Gaver borrowed Gibsonian affordances when he studied complex user actions during computer use; his emphasis on the environment's effect on the user is palpable. Gaver's approach was fundamentally rooted in Gibson's psychological approach, and focused on the importance of affordances in exploratory behavior. Norman considered affordances in a model he describes to answer the question: "When you first see something you've never seen before, how do you know what to do?" (Norman 1999). Whereas Gibson discussed an object's affordance independent of whether or not the actor perceives it, Norman proposed that what is really important is what is perceived to be possible, rather than what really is possible (Norman 1999). Norman argued that the designers of computing systems should constrain the design based on what actions are perceivable by users rather than what actions are possible.

Game-Specific Accounts of Affordance

To our knowledge there are two primary bodies of work that have dealt with affordances as the object of study in a game context.

The first is the work by Mateas (2001), which referenced Norman's vision of affordances as a way to approach the task of designing an interactive narrative that allows players to experience agency – the feeling of empowerment that comes from being able to take actions in the world whose effects relate to the player's intention.[1] Mateas posited that interactive narratives and games have two types of affordances. *Material affordances* are opportunities for action that are presented by the game to the player. These affordances can be presented either directly by prompting the player for action, or indirectly by simply allowing the action to take place. *Formal affordances* provide the motivation to perform one particular action out of all actions that could potentially be available.

The second is the work by Linderoth (2010, 2011). His work is rooted in Gibson's ecological approach, and uses an analysis of a game's affordances to argue that games are not naturally good learning environments (Linderoth 2010), because they can encode and facilitate *exploratory* and *performatory* actions, which in turn can make game progress effectively built-in. Exploratory actions yield more knowledge about affordances, whereas performatory actions realize them. Using similar ideas, Linderoth also leveraged affordances to override the distinction of games being digital versus non-digital, which he considers a sort of false dichotomy in the study of games (Linderoth 2011). In Linderoth's work, however, he avoids discussing the storied debates between the basis for his theory (i.e. ecological psychology) and cognitive psychology directly, and our aim here is to clarify said academic precedent. While we agree with several of Linderoth's positions, we feel that a theory of affordances applied to games must involve cognition, a position that Gibson famously rejected (J. J. Gibson 1979, Vera and Simon 1993, Norman 1999, McGrenere and Ho 2000).

The Need for Cognition

An anti-cognitivist approach to the study of games, which the ecological approach exemplifies, is burdensome to defend as it would leave how players perceive, understand, and learn in a virtual environment unexplained. Game players must come to understand the rules, mechanics, and (if applicable) the story context of the game in order to traverse it, regardless of how well said game environment supports learning (Linderoth 2010). Whether or not such learning transfers out of the game is also not in question; some degree of learning must take place, which taps into cognitive processes related to comprehension, understanding, the activation of prior knowledge (i.e. memory), and more (Shuell 1986). Attempting to take actions that are unsupported by the game would also become difficult to explain without cognition: if a player perceives an affordance that is not a part of the environment, it is unclear what that would be due to. In a cognitivist approach, such a phenomenon is termed *breakdown* (Vera and Simon 1993), the cognitive process through which people diagnose mistakes by understanding ever-finer levels of problem details until they are able to rationalize and repair their mistakes. As noted by Gaver (1991), including cognition in the analysis of design has the potential to make the analyses "seem baroque and overly complicated." We argue, however, that a principled approach to cognition has the potential to provide great explanatory power that would be otherwise impossible to achieve. In this paper, we provide an example of such an analysis, anchored on our Cognitivist Theory of Affordances.

A COGNITIVIST THEORY OF AFFORDANCES

The primary thesis that our cognitivist theory contends is that, in the context of game design, designers should primarily focus on what players *perceive* they can do, as opposed to what players can actually do in an interactive virtual environment. While this might seem trivially true, it has a subtle implication: if a virtual environment does not

support an actual affordance, but never presents feedback to elicit that course of action, player agency may remain unaffected (Wardrip-Fruin, et al. 2009). Our theory follows from the work by Norman (1999, 2002), who identified the three manipulable entities, which make up the bulk of our theory. All the forthcoming concepts are taken in the context of games:

1. *Real* Affordances – what is actually possible in an interactive virtual environment; these affordances are actionable by the player. Borrowing the terminology presented by Wardrip-Fruin et al. (2009), these affordances lead to actions that are "supported by an underlying computational model." This is the first of two entities that are actually manipulable by the game's designers and developers.
2. *Perceived* Affordances – what players perceive to be possible. Perceived affordances do not necessarily correspond to real affordances. The perceived course of action must conform to what a player believes is possible (a reasonable action) and must be consistent for the player within the game's context. A player's beliefs can be informed by what a player has experienced in the game (her perception and attention), as well as be guided by what similar games have typically expected from her in analogous situations (her memory and analogical thinking skills). Similarly, a player's sense of consistency of actions within a specific game context can be informed by what actions have been available in similar games; by similar, we mean games that can be considered to be within the same genre (Miller 1984).
3. *Feedback* – this is perceptual information used in the game to advertise the *real* affordance in the hopes of eliciting an accurate *perceived* affordance. This is the second of two entities that are actually manipulable by the game's designers and developers.

The formalisms presented here admit the possibility that a real affordance might have poor feedback advertising it so that no adequate perceived affordance is possible. Gaver treated an object's affordance and the presence of adequate feedback (perceptual information) as binary in his work. He plotted the space of interactions between adequate/inadequate feedback versus real/non-existent affordance in a graph comparable to that presented in Figure 1 (Gaver 1991). As Norman (2002) concluded, a designer should try to live up to her end of an unspoken design contract by providing adequate feedback to an actor so as to maximize that actor's probability of perceiving a real affordance.

Subsuming Related Theories

Mateas (2001) argues that agency arises as a result of the balancing of material and formal affordance. Material affordances (opportunities for action presented by the game to the player) are delivered as feedback to communicate a game's real affordance. Formal affordances (motivation to pursue particular material affordances) are also delivered as feedback to communicate a game's real affordance. Note that, while both material and formal affordances take the form of feedback in our framework, their purpose is different. Material affordance feedback targets perception and attention (e.g. through the use of lighting (El-Nasr, et al. 2009)), whereas formal affordance feedback targets problem-solving and decision-making (e.g. through the use of influence (Roberts, et al. 2009)).

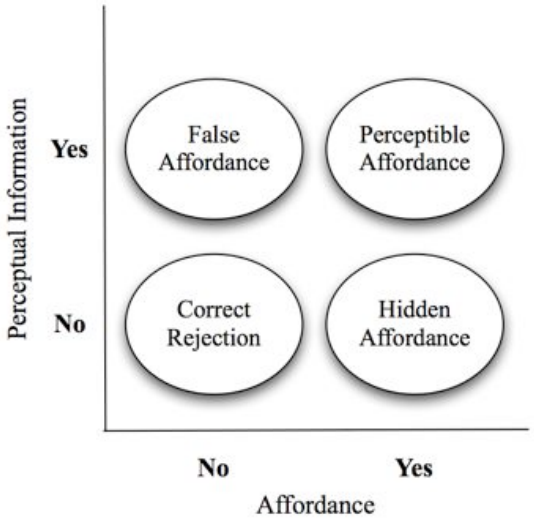

Figure 1: A recreation of a graphic presented in Gaver's (1991) work on affordances. Gaver distinguished between perceptual information and affordances to explain the space of possible interactions between actors and objects in a computer environment.

Linderoth (2010, 2011) argues that gameplay can be analyzed as requiring players to perceive suitable actions and/or perform suitable actions, and borrows from a similar distinction presented by E. J. Gibson and Pick (2000), where exploratory actions yield knowledge about affordances and performatory actions realize them. Like Vera and Simon (1993) before us, we recognize the contributions from the ecological psychology perspective, and consider them to not be antithetical to a cognitivist approach to games,[2] but, as justified earlier, we reject the notion that an analysis of player behavior in games is complete when looking at the game environment (digital or not) in isolation. In the context of our theory, exploratory actions seek to clarify perceived affordances, and performatory actions capitalize on a successful mapping between a real and a perceived affordance.

A CASE ANALYSIS OF GAMES: THE ELDER SCROLLS V: SKYRIM

To add concreteness to our preceding discussion, we present an example game scenario that can benefit from an analysis of player behavior using our cognitivist framework. In *The Elder Scrolls V: Skyrim* (Bethesda Game Studios 2011), players can complete a short sequence, close to the landmark called *Bard's Leap Summit*. This sequence is not designated as an explicit quest, which makes it particularly interesting for analysis. A player, while exploring the surrounding area, has the chance to find her way to the top of the waterfall shown in Figure 2. A player likely knows – due to either from memory of this game, or other platform/adventure games, or even real life scenarios – that falling down a chasm typically results in them getting hurt and/or dying. Beyond jumping to certain death, a player perceives no other affordance. In reality, however, acting upon the cliff's affordance leads to the discovery of another affordance: that of the lake below which breaks the player's fall. Note that the cliff always provides the real affordance of jumping off the cliff. The player, however, perceives no affordance beyond jumping off with the consequence of dying.

Figure 2: *Bard's Leap Summit*, a landmark within *The Elder Scrolls V: Skyrim*, which provides the context for an interesting case of player behavior, which can be analyzed using our cognitivist framework.

Unfortunately, there is narrative game content[3] that requires that a player to act upon what Gaver (1991) would consider a "Hidden Affordance," (see Figure 1) which is problematic if the game's designers intended for the player to pursue the content; we assume so, otherwise, why insert it in the game? To counter the possibility of the player relying on her perception and problem solving skills, and consequently ignoring the content, the game's designers insert feedback to elicit a perceived affordance; Figure 3 illustrates what is presented. The discovery of the landmark is not triggered by the game until the player is precariously perched at the edge of the rock formation. When triggered, the words "Bard's Leap Summit Discovered" appear on screen. If we frame the interaction between a player and a game as a dialog between them (Young 2002), we can take the perspective of the player and ask: "why would the game have presented that landmark discovery at the precise moment that we approach the cliff?" Assuming that the game's designers are being cooperative (Young 2002) vis-à-vis Grice's *Maxim of Relevance* (Grice 1975), both the textual overlay's content and timing signify more than just a landmark discovery; this reasoning is borrowed from the cognitive faculties we use during every day discourse processing. Of course, while the textual overlay is feedback to elicit a perceived affordance in the player, it is up to the player herself to construct the correct mental representation that will enable action.

Figure 3: In-game discovery of the *Bard's Leap Summit* landmark. In *The Elder Scrolls V: Skyrim*, discovering a landmark is noted by the game through a textual overlay on the player's screen, which in this case provides feedback to pursue the game's affordance of jumping off.

If the player is successful, and realizes the perceived affordance, she will be rewarded in the game: upon falling down the cliff, the player encounters a ghastly image, as seen in Figure 4.

Figure 4: The ghost of the bard, Azzadal. If the player correctly perceived the affordance of the pool that breaks the player's fall after receiving feedback from *The Elder Scrolls V: Skyrim*, she is rewarded with a narrative sequence of the ghostly bard and a skill boost.

After hearing the tale of the bard who unsuccessfully attempted the same dive, she will be granted an in-game skill boost of +1 to Speechcraft.

CONCLUSION

In this short analysis, we can appreciate the mindset that our cognitivist theory allows us to adopt. Despite the relatively short sequence of game content, there is considerable complexity that practitioners and scholars can dissect. As practitioners, we care about including and showcasing in-game content that adds to the overall player experience. Concordantly, we should consistently monitor the user's expected perceived affordances, and take care to include sufficient feedback to satisfy our aesthetic goals vis-à-vis the game's real affordances. As scholars, we care about the dynamics between players and games. Concordantly, we should respect what players bring to bear while playing games (i.e. their cognitive skillset), and understand how interactive game environments elucidate or obscure perception, problem-solving, sense-making, and transitively, player action.

ACKNOWLEDGMENTS

The authors would like to thank the anonymous reviewers for dedicating their time and for their in-depth and helpful comments. The material presented here is based upon work supported by the U. S. Department of Energy Computational Science Graduate Fellowship, Grant No. DE-FG02-97ER25308. The opinions, findings, and conclusions expressed here are those of the authors and do not necessarily reflect the views of the sponsoring agencies.

ENDNOTES

[1] Defining agency is itself a challenge, and beyond the scope of this paper. The main purpose of defining agency here is to provide some general intuition of the concept as a way of concretizing our ideas. For a more comprehensive review of the subject, we recommend the work by Wardrip-Fruin et al. (2009).

[2] In fact, there are additional distinctions that follow from Gaver's (1991) work that are relevant in the analysis of games. *Hierarichical affordances* are encapsulations of smaller affordances grouped in space. An example put forth by McGrenere and Ho (2000) is a word processor application, which affords document editing, but editing is done through affordances for text modification, font selection, and others. *Sequential* affordances reveal information about other affordances, intended to be grouped in time. Another example put forth by McGrenere and Ho (2000) is a drop-down menu, which at first affords clicking, and upon clicking, subsequently affords selection.

[3] When narrative content plays a part in a player's future course of action, it can be considered a *narrative affordance*, as defined by Young and Cardona-Rivera (2011).

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