The Cognition of Gameplay: Cognitive Task Analysis and Portal 2

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Abstract: Cognitive task analysis, though widely used in industry and education to analyze the cognition of task performance as well as parse out learning requirements, has not been applied to analyze the cognitive requirements of expert game performance or create a cognitive map of a game. ADL researchers have developed a novel methodology for applying CTA to gameplay in order to analyze video game design and video gamer cognition within a particular game.

Background

To better understand how video games can be leveraged for learning, the ADL Next Generation Learner Team recently studied the effects of playing a game with certain design characteristics, and of amount of game play experience in general, on cognitive adaptability, a skill that involves responding to uncertainty and to changing circumstances and monitoring one's own thinking processes. The study used Portal 2, a game developed by Valve Software, for its perceived inclusion of the five design characteristics (implicit rule sets; implicit shifting of rules; dynamic, shifting environments; implicit reinforcement of actions to achieve a goal; and relatively open-ended gameplay) proposed to help improve cognitive adaptability. A preliminary literature search revealed a void of research throughout the fields of gaming, education, and cognitive psychology on the specific effects of game design principles on cognitive adaptability, so these five characteristics were extrapolated from research findings in the fields of clinical psychology (specifically cognitive remediation therapy for improving cognitive flexibility; Delahunty, Reeder, Wykes, Newton, & Morice, 1999; Wykes & Reader, 2005; Wykes, Reeder, Landau, Everitt, Knapp, Patel, & Romeo, 2007), feature overlap theory (Halpern, Hansen, & Riefer, 1990), and existing research on cognitive adaptability in order to take existing theoretical and practical efforts to foster cognitive adaptability and translate them into game design features. As a result, the following questions emerged: how does one understand empirically whether Portal 2's design really fits those five characteristics, and is it possible to capture the thought process of an expert gamer as they make their way through a game and map out, scientifically, exactly what it takes to conquer a game like Portal 2?

Cognitive Task Analysis

Cognitive task analysis is a technique that has traditionally been used by researchers and industry professionals to capture both the behavioral and cognitive processes and activities that go into accomplishing a task at an expert-level. This includes decision-making processes, recognizing and responding to critical cues, responding to environmental conditions, utilizing tools, performing smaller sub-tasks, and analyzing and altering one's own performance (Clark, Feldon, van Merrienboer, Yates, & Early, 2006; Cooke, 1994; Militello & Hutton, 1998; Wei & Salvendy, 2004). While CTA has been applied to educational game design in some ways, such as Boyle et al.'s (2012) study which utilized CTA to aid in the design of a digital game to support research and statistics education, very little cognitive task research has been done on the cognitive and behavioral performances of expert gamers or the cognitive requirements of existing games. As precedents for this kind of analysis did not emerge from the literature on industrial/organizational psychology, cognitive psychology, or gaming, the ADL team prototyped a protocol for performing a CTA to analyze video game design and video gamer cognition within a particular game. Drawing on established CTA literature as well as exploration, the team produced a method for cognitively mapping the design and cognitive/behavioral requirements of gameplay.

Cognitive Task Analysis and Video Games: Current Research

The group leading the CTA effort has been observing expert Portal 2 players—those who have played through the entire game multiple times—playing through each chapter and level in the game. Through a combination of real-time narration of the players' actions and thoughts throughout gameplay and after-action interviews after each level where the player and the researchers review a recording of the gameplay made using FRAPS video capture software as well as independent audio recordings, the researchers are mapping out a clear cognitive and functional picture of each level. This includes painting a complete cognitive map and decision matrix of each level of the game by determining what affordances (objects, tools, and environmental features that the player has to interact in order to achieve the final goal) and micro-puzzles (smaller puzzles that need to be solved in order to achieve the larger puzzle of the overarching goal) are present in each level, as well as what manual steps (e.g., walking down a hallway, shooting a portal, pressing a button, moving an object, etc), cognitive steps (e.g., taking note of visual

and audio cues, making decisions, inferring or deducing things from events or information in the game, etc), and prerequisite and requisite knowledge are required in order to complete the level.

Additionally, after each level, a post-play interview is conducted to examine the presence or absence of the five design features posited to foster cognitive adaptability: implicit rule sets, implicit shifting of rules, dynamic and shifting environments, some degree of open-ended gameplay, and implicit reinforcement for individual actions to achieve a final goal. During this interview, the player is asked to describe what rules (constituative or operational) are present and if, how, and where they've changed from previous levels; what new or altered environmental features arise; what feedback or cues informed the player's decisions (whether implicitly or explicitly); and what, if any, constraints to gameplay the player perceived. Player feedback in this regard is then analyzed to pinpoint the presence of the five game design characteristics thought to influence adaptability in thinking, as well as the qualitative decision making required to work through them. The rubric of design characteristics is thus used in conjunction with the cognitive- and task-mapping focused questions to examine further where these five design tenets present themselves within Portal 2 and subsequently influence player cognition during gameplay.

Goals

By performing a CTA on Portal 2, ADL researchers hope they will be able to pinpoint both what expert performance looks like cognitively, establish a baseline of the intersection design features and cognitive adaptability design tenets, and understand how the game's design features influence player cognition during gameplay. This is essential for assessing the cognitive impact of gameplay and game design, a key component of the growing effort to leverage games for educational purposes. The undertaking is also producing a novel framework for and approach to using cognitive task analysis to harness the potential of video games for improving learning and cognition.

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