Disrupting the Player's Schematised Knowledge of Game Components

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ABSTRACT

The concept of 'conservatism' in game design has been a subject of debate for a number of years. This 'conservatism' is linked to 'player-centricity' in design. Such player-centricity can be suggested to place a limit on the fulfilment of high level cognitive player needs. A framework is thus proposed for *disruptive game design* that focuses on the player and how they learn about game components. It actively seeks the disruption of knowledge construction as well as the recall process used in applying that knowledge to new situations. Such disruption aims to increase the player's cognitive engagement with the game in a way that does not entirely prevent them from understanding the game, which may cause frustration or confusion. This design approach thus aims to provide greater potential for fulfilment of a player's high level cognitive needs. The framework is applied to a small case study of the game *Amnesia: A Machine for Pigs* (The Chinese Room, 2013) that was designed and developed utilising its principles.

Keywords

Schema, disruptive game design, cognition, memory, development-led research.

'CONSERVATISM' IN GAME DESIGN AND THE NEEDS OF PLAYERS

The dominant trend within contemporary computer game design is suggested to be one of player-centric and monologic design (Wilson and Sicart, 2009, 2010), placing the fulfilment of the player's needs and desires in the position of highest importance and also ensuring a high degree of accessibility for players. This trend is suggested to represent an "intrinsic conservatism" (Wilson and Sicart, 2010, p.41) within the medium.

The notion of 'conservatism' has been identified by academic and industry professionals for a number of years and remains a current debate. In 1998, Costikyan (1998) suggested that risk-averse publishers subsequently "constrained [the] imaginations" of designers, limiting them to the use and reuse of particular game concepts if they were to successfully attain a publishing deal. At this time, Herz (1998) discussed a conservatism

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"rut" and suggested the cause to be too much focus being placed on technological advances, while advances in the field of *design* suffered. Herz's article has recently been republished (Herz, 2013) with emphasis placed on the ongoing relevance of the issues originally raised. Dymek (2010, 2012) echoes Herz's suggestion of design innovation suffering due to a heavy focus on technological advancement in his discussion of what he terms specifically a "creative conservatism" (2010, p.46).

'Conservatism' as identified by Wilson and Sicart (2010) is suggested to be evident at a design theory level, existing across a range of current game design literature and thus codified as 'best practice' in terms of what designers should aim to achieve in their games. It is suggested that design is the process of fulfilling player desires and ensuring usability and accessibility of the game by placing the player at the centre of the game experience (i.e. player-centric design). Adams (2010, p.30) provides a similar supporting definition, suggesting that the designer has both "a duty to entertain" as well as a duty "to build the game to meet the player's desires and preferences for entertainment".

From the perspective of the player, rather than the designer, the notion of 'conservatism' may be considered in terms of how players construct knowledge about a game as they play, how that knowledge enables ongoing in-game learning and thus, how it enables successful continued play. This knowledge construction process can be understood using Crawford's (2003, p.115) definition of an *incremental accretive design* process as a basis. Crawford suggests this process as one of designing by taking existing game designs and making minor adjustments or additions to them. This can be suggested to extend to the process of knowledge construction during gameplay in the form of *incremental accretive learning*. If only minor adjustments or additions have been made to a game as compared to other available games then the amount of new knowledge construction, or learning, required by the player will be similarly minimal (i.e. the game is more readily accessible).

Player-centric, accessible games present players with a simple 'starting state' to which other game mechanics are incrementally added as the player discovers them or the game introduces them. These newly discovered mechanics form a more and more complex 'play state' via incremental accretion. The *Metroid* or *Zelda* games (Nintendo, 1986-2010 and Nintendo, 1986-2013) epitomise this approach, providing players with very limited initial mechanics with which to progress, gradually allowing the discovery of new items, weapons and tools that incrementally build on the previous play state. However, given the significant importance of fulfilling the needs and desires of players that is described in definitions of player-centric design, it is necessary to consider precisely what 'needs' and what 'desires' such games may actually be capable of fulfilling.

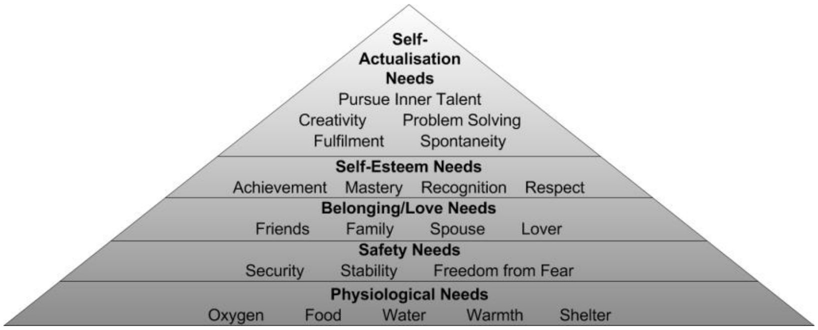

Figure 1: Hierarchy of Needs, following Schell (2008, p.127) and Maslow (1943).

Schell's (2008) collection of conceptual 'lenses' for perceiving the game design process includes "The Lens of Needs" (2008, p.127) which utilises the hierarchy of human needs (Figure 1) originally proposed by Maslow (1943). Schell suggests that many common game activities are focused on the needs of 'achievement' and 'mastery' of skills (e.g. to jump, dodge and shoot enemies in *Metroid* or to use the available tools to navigate the environment in *Zelda*), placing them at level four of the hierarchy, 'self-esteem'. However, in order to ensure the fulfilment of these needs, the player is only ever challenged, as Wilson and Sicart (2010, p.2) state, "within the limits of what an implied player model suggests". The challenge likely requires incremental accretive learning as opposed to more significant cognitive engagement in the form of substantive 'new', non-incremental learning. Higher level needs (i.e. those at level five, 'self-actualisation') that are predominantly cognitive in nature are therefore potentially less likely to be fulfilled through such 'limit-bounded' challenges in games.

This paper considers how it may be possible to retain the underlying principle of player-centric design (i.e. player need fulfilment) but to place more focus on fulfilment of high level cognitive needs alongside fulfilment of the achievement and task-mastery needs. The aim is thus to encourage a greater degree of cognitive engagement through challenging players to engage more frequently in 'new', non-incremental learning during gameplay and importantly, to *sustain* this challenge throughout a game without needing to construct elaborate new game components. This position is presented via *disruptive game design* (Howell, 2011). This is a design approach that emphasises ways in which previously learned game information, including how such information is stored and recalled from memory, can be co-opted to create situations in which players are challenged to cognitively engage with the process of *understanding* and *choosing* an action, rather than simply challenged to demonstrate their skilful *performance* of actions. This approach encourages frequent 'new' learning as well as active re-learning and reconstruction of understanding of game components throughout a game.

A SIMPLE MODEL OF KNOWLEDGE CONSTRUCTION AND RECALL

In order to design in a way that influences how players construct knowledge during gameplay (i.e. 'ludic knowledge') and how they acquire an understanding of game components, a cognitive basis for knowledge processing and use is necessary. Being such a widely researched area, there are a range of available models that could be used as such a basis. In the context of ludic knowledge construction, Mayer's (2001) model of multimedia learning provides a particularly relevant example of such a basis (Figure 2). A key component in this model is the active integration of prior learned multimodal knowledge (both visual and auditory) into *working memory* (Baddeley, 1992, 2007) alongside incoming information from the game. The combination of each of these types of knowledge allows the player to understand what they perceive during gameplay.

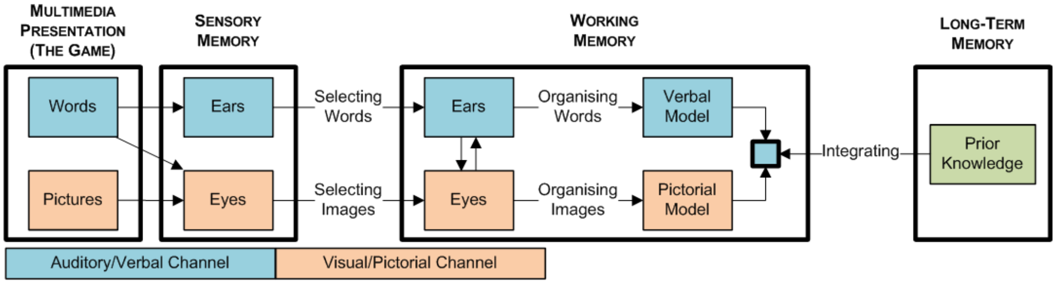

Figure 2: Model of multimedia learning, following Mayer (2001).

However, the contents and structure of long-term memory and the method of information recall through which prior knowledge is integrated are less clearly defined. It is not suggested for example how information is encoded into long-term memory, nor how it is stored and organised. Nor is it defined how working memory selects and integrates appropriate information for the current situation from the large amount of knowledge potentially available. This is vital information that is required if the content of long-term memory and the process of selection will be affected via disruptive design.

MULTIMODAL STRUCTURE OF LONG-TERM MEMORY

Tulving (1985) proposed the idea of the existence of multiple different memory types within long-term memory. These types are defined as *procedural memory*, *semantic memory* and *episodic memory* and these definitions remain in current usage within a range of psychological work (Crittenden, 2013, Pitel et al., 2007, Weiner, Healy and Proctor, 2012). At a high level, procedural memory stores information regarding actions and processes; semantic memory stores concepts related to objects or phenomena and the properties of those objects/phenomena; episodic memory stores memories of personally experienced events, which may include elements of both other types of memory combined. Episodic memory is organised in relation to spatiotemporal information (it contains information relating to when and where, as well as what), while procedural and semantic memory store information independently of contextual information (Table 1).

	Type of Information	**Gameplay Information Example**
Procedural Memory	Actions, Processes	The pattern of attacks required to defeat an enemy. The sequence of button inputs required to perform attacks.
Semantic Memory	Facts, Concepts	The concept of a generic game ‘enemy’. The properties of a particular game enemy instance.
Episodic Memory	Personal Events, Personal Experiences	Personal memory of fighting a particular enemy in a particular game.

Table 1: Memory types and example stored information.

Integration of prior knowledge from long-term memory may draw upon all of these memory types to differing extents. If one is learning to perform a task, such as using a new input device to control a character on a screen, then recall and integration may come primarily from procedural memory. Alternatively, if one is learning factual or conceptual information, such as character attributes, weapon and armour statistics or particular weaknesses of enemies in a role-playing game, recall and integration may come primarily from semantic knowledge. Each of these types of knowledge construction are informed and contextualised further by any relevant prior knowledge of similar personal experiences (episodic memory), such as the last time the person learned how to use a new device, or the last role-playing game that they played. However, recall and integration of prior knowledge must be driven by a process that prioritises the most relevant information and ignores less relevant information. Such a process must be facilitated by an organisational structure within each of these memory types.

SCHEMA-BASED ORGANISATION OF LONG-TERM MEMORY

While organisation of long-term memory remains a debated topic, schema theory provides a particularly useful structure with which to consider learning during gameplay and in turn, disruptive game design.

Schema theory was introduced by Bartlett (1932) into ‘mainstream’ psychology and further built upon by a range of other theorists (Minsky, 1974, Neisser, 1976, Piaget, 1970, Rumelhart and Norman, 1976, Schank and Abelson, 1977). The idea of a mental *schema* itself is now most often perceived as a cognitive structure that contains patterns or behaviours in an organised fashion that can be used to help understand interactions with the world (Plant and Stanton, 2013). Neath (1998, p.328) and Arbib (1998, p.43) also note the key role that mental schemas play in forming expectations about aspects of the world, which may influence decisions and behaviours. That is, expecting a particular response from the world (or game) following an action may predispose an individual to deciding to perform that action. Such predisposition provides one possible focus for disruptive game design via the disruption of cause (input) and expected effect.

Schematic Organisation of Procedural Memory

Schematic organisation within the three memory types differs slightly due to the different information being stored. Procedural schemas (Turner, 1994) are hierarchical or linearly arranged plans of action that are carried out in response to a type of situation (loosely referred to as a ‘stimulus’ in this context).

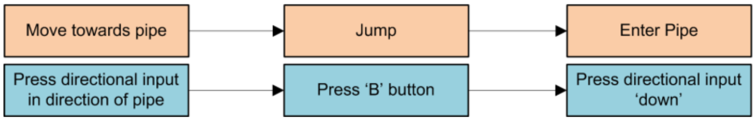

Figure 3: A procedural schema for making Mario move towards, jump onto and then enter a pipe in *Super Mario World* (Nintendo EAD, 1990).

Procedural schemas contain only directly relevant information and are not contextualised with spatiotemporal information. The process is stored as generic ‘process’ and ‘action’ information in a linear structure, with two hierarchical levels that describe high level processes supported by lower level actions (Figure 3). Recall and integration of this prior knowledge alone would be meaningless however (outside of a gameplay session, for example) and thus it must be integrated alongside other semantic and episodic information that can provide context for the process and actions.

Schematic Organisation of Semantic Memory

Within semantic memory, a similar hierarchical organisation of information is proposed although at a more complex level. A schema in semantic memory is simultaneously both a store for abstract concepts and facts (properties) related to them, as well as specific information regarding *concept instances* of that abstract concept (Cohen and Murphy, 1984, Komatsu, 1992). Figure 4 provides an example of this using the ‘Firearm’ concept. A 'Firearm' schema, may contain abstract properties such as 'has a trigger', 'requires ammunition' and 'requires aiming skill', along with specific concept instances that fit the abstract schematic definition, such as 'Walther P99', '.44 Magnum' or 'Laser Rifle'. These, in turn would have instance-specific knowledge attached to them, such as the 'Laser Rifle' being 'fictional' (a property which itself may be stored elsewhere in memory as a high-level schema) and also 'requires recharging'. These specific properties may operate in addition to the *inherited* abstract properties within the schema by providing instance specific detailed information on a property, such as the specific type of ammunition that is required. They may also temporarily *overwrite* them such as the 'requires recharging' property overwriting the 'requires ammunition' property for the particular concept instance of the 'Laser Rifle'.

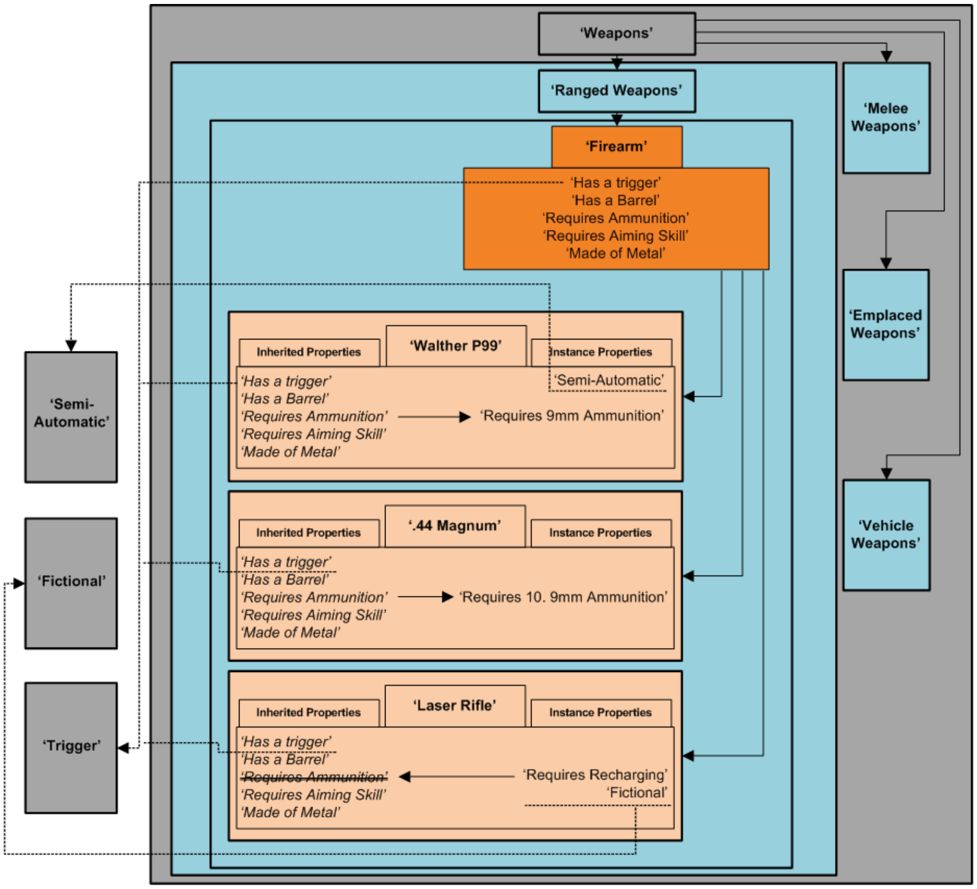

Figure 4: Schematic organisation of concepts in semantic memory.

This structure handles abstract concepts as well as physical object-based concepts such as 'Firearms'. An abstract 'game' schema for example contains factual knowledge that an individual has stored about all types of games. This may have embedded within it less abstracted (but still high-level) schema relating to 'digital games', 'board games', 'live-action role-playing games' and so forth. Then, specific concept instances of these types of game will be contained within these sub-schemas. The embedding of schemas in this manner may potentially be many more 'layers' deep but will contain specific concept instances at the lowest (least abstracted) level. Figure 4 for example represents only a small portion of the larger schema and concept network. A ‘Firearm’ is a sub-schema of ‘Ranged Weapons’ which in turn is a sub-schema of ‘Weapons’, each of which would also contain abstract properties. As noted with procedural information, recall of semantic information alone is unlikely to be particularly useful, unless the game requires simplistic recall and statement of factual information (e.g. the penultimate stage of *Banjo Kazooie* (Rare, 1998) in which players must complete a game-based quiz). It is more likely to be recalled and integrated along with other memory types.

Schematic Organisation in Episodic Memory

Episodic memories (sometimes referred to as ‘episodes’) are ‘snapshots’ of lived, spatiotemporally organised and contextualised events and experiences. Schemas drawn from other memory types during the formation of episodic memories contribute to the formation of the memory by being ‘baked in’ to the episodic memory. This suggestion is supported by the work of Brewer and Treyens (1981). This work also supports the idea that an individual’s existing prior knowledge at the time of an episodic memory’s formation has an impact on what information is selected for storage in that episodic memory and thus, what information is available for later recall.

For example, recalling seeing a computer in a particular office because offices tend to contain computers, despite that office not containing one. This example of recalling a particular episodic memory has been influenced by the abstract ‘office schema’. During the recall and internal reconstruction of that memory, the general contents of the ‘office schema’ are incorrectly incorporated alongside specific episodic memory contents. The reconstructive nature of episodic memory is supported by a range of literature, for example in studies of eyewitness testimony and memory in legal proceedings (Howe, 2013, Loftus, 1981). Episodic memories therefore may be accurate internal representations of the original event, but may also be prone to recall errors introduced through the recall of information that is schema-relevant but not memory instance relevant (i.e. that has been ‘baked-in’ to the encoded memory).

Each episodic memory instance can be perceived as itself being a high level schema, as the information contained within each can be recalled and used to inform understanding of future similar (or apparently similar) events. This functionality is identical to schema-based recall informing understanding of concepts stored in semantic memory when they are encountered in future. If an episodic memory contains inaccurate information however, then not only is recall of that memory affected but so too is the interpretation of any future experiences encountered that rely on the recall of that information. Expectations based on inaccurate information may lead to incorrect selection of appropriate actions or misunderstanding of meaning in future experiences, requiring those expectations to be updated through new learning.

Episodic memory as separate from semantic memory is in some ways problematic. The apparent interdependence of episodic and semantic memory storage suggests that viewing them as entirely separate may not be an accurate interpretation (McKoon, Ratcliff and Dell, 1986). However, as Menon (2002) states, the interdependence may be necessary but clearly the *functionality* of each type of memory is different, which supports the perception of the two types as at least in some ways separated.

SCHEMA-BASED MODEL OF LUDIC KNOWLEDGE CONSTRUCTION

A schema-based model of ludic knowledge construction that more clearly defines the role of the integration of prior knowledge into understanding and the decision making process is now proposed (Figure 5). With reference to Mayer’s (2001) model, sensory memory is retained to an extent in the form of sensory perception. Working memory is split into two primary components. Firstly, the Central Executive (CE), as per Baddeley’s (1992) model of working memory, which acts as a decision making component. Secondly, the Multimodal Situational Schema Instantiation (MSSI) is then added, which draws together the multimodal prior knowledge stored in long-term memory.

The CE is a process coordinator, involved in planning and decision making, handling ‘novel’ or demanding situations (e.g., the introduction of a new, more powerful enemy during a game) and in controlling or limiting habitual or ‘conditioned’ responses to situations. The CE operates on the MSSI. The MSSI provides all necessary information (procedural, semantic, and episodic) to make sense of and respond to the current situation presented to the player. The MSSI itself is informed by the multimodal contents (procedural, semantic, and episodic; visual, auditory etc.) of the three individual long-term memory stores. The MSSI can be equated to Neisser’s (1976, p.56) statement that “the schema is not only the plan, but also the executor of the plan. It is a pattern of action, as well as a pattern for action”. The MSSI is prone to a level of inaccuracy (in the same manner as episodic memory and recall is) based on the information that it is drawing from memory in relation to the perceived stimulus.

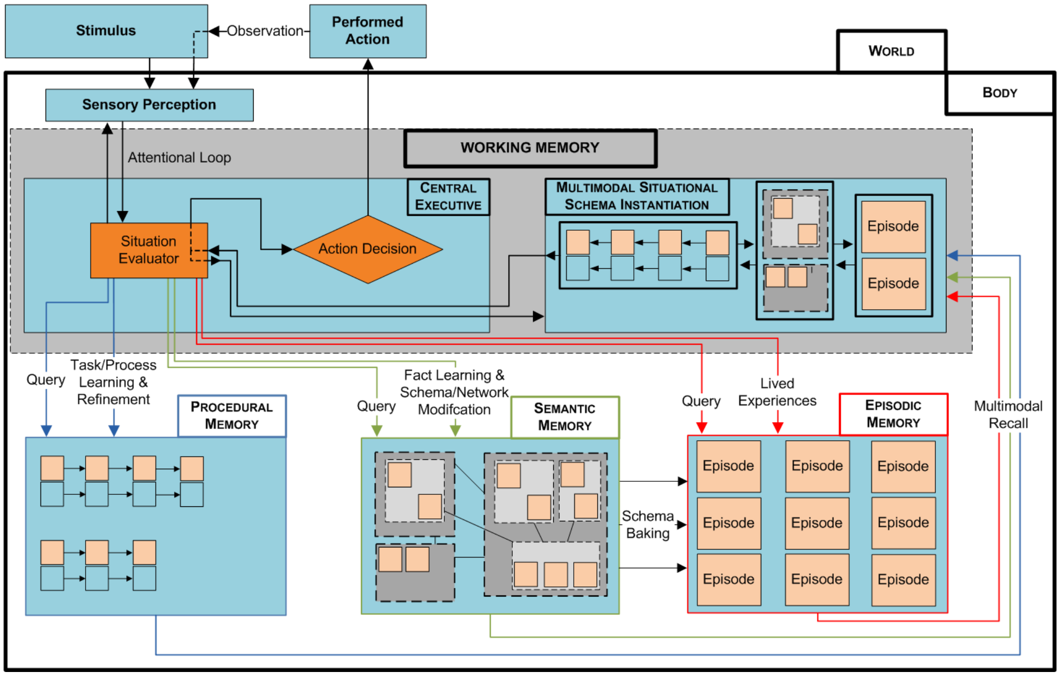

Figure 5: Schema-based model of player learning.

However, perception, thought and action can be viewed as an ongoing cycle. As Fuster (in Alloway and Alloway, 2013) explains, “the perception/action cycle is the circular cybernetic process of information between the human organism and its environment”. Disruptive design is also able to focus on the disruption of this cycle itself, as well as the disruption of the contents of the MSSI or the expectations that stem from it. The schema-based model can be viewed as representing the flow of information and the activation of model components through a single cycle. ‘Stimulus’ as stated previously is used here to indicate an instigator to action. Stimuli generally originate from outside of the body (i.e., from objects such as the game), although a stimulus may also be a *lack* of stimulus, as in a sensory deprivation environment.

Further to stimuli originating ‘naturally’ from the environment, the observed consequences of an action performed by the individual is also a stimulus (e.g. the observed outcome of attacking an enemy’s weak spot and the observed outcome of attacking their armoured areas). In this case, the stimulus may inform further action, such as to keep attacking the weak spot, or to stop attacking the armoured areas, but may also inform knowledge construction and modification (i.e. learning or enhancing understanding) in all three memory stores. This could be procedural knowledge construction based on the success or failure of previous actions, semantic knowledge construction based on newly perceived concepts and concept instance properties, and episodic knowledge construction related to the particular event just experienced.

A FRAMEWORK FOR SCHEMA-BASED DISRUPTIVE GAME DESIGN

Within the schema-based model, three particular modalities of potential disruption can be identified. *Encoding disruption* operates on the *initial encoding of information* regarding a new stimulus. Purposeful presentation of ambiguous stimuli (e.g. a previously unheard sound without an obvious source) to a player requires initial encoding to be based on existing knowledge. As previously described, such existing knowledge may be abstract (e.g. the ‘office schema’ example) and thus lead to inaccuracies in the newly encoded memory. Future encounters with that stimulus thus potentially require a greater degree of re-learning. Encoding disruption may also be achieved by preventing a player focusing attention on a stimulus (i.e. distracting the player with other stimuli).

Recall disruption operates on information recalled from long-term memory regarding the *perception* of game stimuli in terms of their properties, or the context in which they are presented. Purposely presenting players with previously encountered stimuli that behave differently or that have otherwise different properties to previous encounters (e.g. a non-player-character that unpredictably switches between ‘friendly’ and ‘hostile’) increases the likelihood of recalling information that is expected to be accurate but in fact is not. This will potentially require a greater degree of cognitive engagement regarding decisions made in relation to the stimulus, as well as potentially require frequent re-learning.

Lastly, *action plan disruption* operates on the *results of player inputs*. If initial encoding has not been disrupted and recall has not been disrupted, the MSSI should in theory contain an appropriate ‘action plan’. This action plan can be disrupted if the result of an action based on it does not correspond to previously experienced results of that action. This form of disruption has the potential to be particularly effective. Players may need to re-evaluate their understanding of the action they selected in a number of ways; whether they misinterpreted the stimulus, whether they decided upon an incorrect response, or whether they performed an appropriate response but the performance itself was incorrect.

These three modalities of disruption may operate on any of the three long-term memory stores previously defined following Tulving’s (1985) work. *Procedural disruption* may target knowledge of appropriate actions and processes applicable to a perceived stimulus. *Semantic disruption* may target knowledge of facts, concepts and concept properties and thus, the semantic understanding of objects and phenomena in the world. *Episodic disruption* may target lived experiences and include elements of both procedural and semantic disruption but contextualised with spatiotemporal information.

The MSSI formation provides the primary mechanism through which disruptive game design has an impact on the player’s gameplay experience. The MSSI is comprised of multimodal prior knowledge drawn from the different memory stores that attempts to provide the most appropriate and accurate context for understanding and responding to the current situation. Identification and recall of knowledge that is ‘most appropriate’ and ‘most accurate’ for a given situation must also be defined in order to present a usable framework for disruptive game design. This identification and recall process can be understood from the perspectives of both *encoding specificity* (Einstein and McDaniel, 2010, Tulving and Thomson, 1973) and *spreading activation* (Collins and Loftus, 1975).

Encoding specificity suggests that knowledge is stored along with contextual information in episodic memory and that recall is improved if the current context in which recall is occurring matches the contextual information stored at the time of encoding. Spreading activation suggests that stored information in memory is ‘activated’, or recalled, through a series of associative links between schemas and concepts. The initial stimulus activates directly relevant stored information, which in turn activates closely associated information, spreading outwards from the original activation point with activation strength decreasing the further from that point the activation process spreads.

With this context-dependency and activation process in mind, ludic knowledge construction and recall can be categorised into the construction and recall of three broad *ludic knowledge types*. Knowledge related to the current game being played can be termed *intraludic* knowledge; for example, the properties of a particular gun in a particular game. Knowledge related to other games can be termed *transludic* knowledge; for example, more abstract knowledge relating to the ‘gun’ concept across multiple games. Lastly, knowledge that is not related to games can be termed *extraludic* knowledge; for example, knowledge regarding the meaning of the word ‘gun’ abstracted from any specific object or ludic context. These ludic knowledge types exist within each of the three long-term memory stores, resulting in nine categories of memory that can provide knowledge that informs the MSSI during a single cycle. These categories are defined and further explained, with examples, using a short case study of *Amnesia: A Machine for Pigs* (The Chinese Room, 2013).

Case Study of *Amnesia: A Machine for Pigs*

Amnesia: A Machine for Pigs (AAMFP) is a sequel to *Amnesia: The Dark Descent* (Frictional Games, 2010) (ATDD). AAMFP is a narrative driven, first-person survival horror game with gameplay focused on exploration of the environment to uncover and piece together the game’s story, while attempting to avoid enemies using stealth. Using two components of AAMFP, a game-based application of the previously described memory categories is explained, followed by examples of the implementation of different modalities of disruption.

Knowledge Types in Memory Relating to Game Mechanics

A key mechanic that enables the avoidance of enemies in AAMFP is a Victorian electric lantern that the player-character carries. Prior knowledge from different memory categories can be applied when attempting to understand the functionality and use of this mechanic. These categories, combining memory stores and ludic knowledge types, are summarised in Table 2, with examples of stored knowledge.

When players encounter the ‘Lantern’ mechanic in AAMFP for the first time, knowledge in the TRANS- and EX- categories will be recalled to provide a context with which to understand the intraludic mechanic. For example, from TRANS-P knowledge, the player may easily transfer understanding of the ability to equip and un-equip the lantern by pressing a key, as in other games. Those players with TRANS-P knowledge acquired through playing ATDD specifically (TRANS-E knowledge) may further transfer understanding of the default key with which to do this, as both games utilise the same control scheme. This requires minimal new learning as knowledge can readily be transferred from TRANS- categories and found to be effective in selecting appropriate

Knowledge Type **Memory Store**	**Intraludic** (in a specific game)	**Transludic** (in other games)	**Extraludic** (outside of games)
Procedural (Knowledge of how to…)	**INT-P** … equip/un-equip the lantern in AAMFP and the key required to do so.	**TRANS-P** …use similar mechanics in other games, such as equipping/un-equipping the similar lantern in ATDD.	**EX-P** … use a lantern in the real-world. May also include knowledge of using similar objects (such as a torch) in the real-world.
Semantic (Knowledge of Concepts and Concept Properties…)	**INT-S** …(e.g. within the player's 'lantern' schema, a concept instance for the 'AAMFP in-game lantern' with associated concept properties).	**TRANS-S** … acquired in other games (e.g. lanterns in other games may have the property 'requires fuel', which AAMFP's does not).	**EX-S** …acquired outside of games (e.g. a specific concept instance for 'my torch', with properties such as 'requires a 9V battery', or 'has an adjustable beam').
Episodic (Collections of knowledge…)	**INT-E** …relating to specific instances of using the lantern within scenarios in AAMFP.	**TRANS-E** …relating to using similar mechanics in other games in particular instances.	**EX-E** …relating to the process of interacting with similar non-game mechanisms or concepts in specific instances.

Table 2: Memory categories storing different information relating to the 'Lantern' mechanic in AAMFP.

actions with minimal adaptation. For players unable to rely on TRANS- category knowledge (for example if this is the first game a player has ever played, or if the player has not had experience playing ATDD), EX- category knowledge is employed. This may include relatable but not identical knowledge, such as using a battery-powered torch in the real world. This may enable the transfer of key semantic information about the lantern as an object (e.g. it can be on or off, it produces light) but may not allow transfer of relevant procedural knowledge, as a torch is not turned on and off by pressing a key on a keyboard. Once a player has encountered the 'Lantern' mechanic once, INT- category knowledge begins to form and be refined with experiences encountered as the player progresses through the game.

Encoding Disruption could be achieved by presenting players with game components that are challenging to contextualise when first encountered through reliance on TRANS- and EX- category knowledge transfer. Changing the properties or presentational context of seemingly established components within the same game (thus disrupting INT- category knowledge) provides a basis for Recall Disruption and, potentially, Action Plan disruption as well if the changed component responds differently to player actions previously performed towards it.

Previously (Howell, 2011, p.7) it was suggested that disruptive game design may aim to make small changes to a large number of different game components, *or* make large changes to a small number of different game components. This suggestion hides an additional layer of complexity however. It is not merely the small or large changes made by the designer, nor is it the amount of changes made that are important. Rather, it is the perceived notable and/or lasting impact of the changes made, from the player's perspective, which is of particular interest.

For example a disruptive design element may be minor in terms of the work required to implement it but may have a significant impact on the player during gameplay. Similarly, a disruptive design element may require comparatively more work to implement to achieve a less notable, or less long-lasting impact on the player. Each of these scenarios (as well as low workload, low impact, and high workload, high impact scenarios) has potential to be put to practical use with different aims in mind. The following examples demonstrate two such practical implementations within AAMFP.

Disrupting Player Knowledge of Enemy-Proximity Warning Mechanic

Other than performing the function of allowing the player to see in dark environments, the lantern also serves as a warning device that can alert the player to nearby enemy threats. It does this by flashing at different rates and intensities depending on enemy proximity. This particular mechanic may be contextualised by players using similar mechanics in other games (e.g. the radio in *Silent Hill* (Konami Computer Entertainment Tokyo, 1999) that emits static based on enemy proximity), but this relies on players having specific TRANS- category knowledge from specific games. Thus, it is likely that a degree of new learning will have to occur in order to *initially* integrate this AAMFP mechanic.

However, once the mechanic is introduced and a range of INT- category knowledge has been formed, the game presents scenarios to the player which actively disrupt the 'rules' of the mechanic as previously encountered (i.e. recall disruption; the disruption of established properties of a game component). The lantern begins to exhibit its flashing behaviour in areas that do not appear to contain an enemy threat. The link between enemy proximity and lantern flashing rates in some areas that do contain threats also becomes less clearly defined, with intense flashing not always meaning that an enemy is very close to the player, for example. These changes to the mechanic are presented in segments (as opposed to being 'random') which means that players are potentially able to re-learn the 'rules' (and thus reformulate their understanding) of the mechanic as they move between segments. Allowing players an opportunity to actively re-learn and form new knowledge is critical, even if the newly formed knowledge is only accurate for a short time. If knowledge is disrupted in a seemingly random manner, players may become frustrated due to perceiving any attempt to learn as futile.

As identified in the schema-based model, different types of knowledge construction occur in relation to each of the three memory types (procedural, semantic and episodic). Disruption of knowledge increases the likelihood of different *methods* of knowledge construction needing to be undertaken by players. These can be defined using the terms provided by Rumelhart and Norman (1976, 1981); *accretion*, *tuning* and *restructuring*.

Accretion-based knowledge construction as previously described is incremental, modifying existing stored information with minor adjustments or adding supporting information. Tuning-based knowledge construction occurs when the structure (rather than just the content) of a schema network must be modified in order to support new information. Lastly, restructuring occurs when information cannot be satisfactorily accommodated through accretion or tuning and requires the creation of a new high-level schema specifically for the new information. Disruptive game design can thus be considered as an approach that encourages a greater number of occurrences of tuning and restructuring, rather than a reliance primarily on accretion-based learning, a property of ‘conservative’ design.

The enemy-proximity warning mechanic demonstrates a game component that encourages a low level of accretion-based knowledge construction (e.g. adding a new concept instance to the ‘lantern’ schema to describe the ‘AAMFP in-game lantern’) alongside more cognitively engaging tuning-based knowledge construction (e.g. linking the ‘AAMFP in-game lantern’ concept instance to the ‘warning system’ and ‘flashing light’ concepts upon discovering that functionality during gameplay.

The enemy-proximity warning mechanic is then an example of low workload, high impact disruption. The implementation of the mechanic, once the initial game code for detecting enemy proximity and handling the lantern flashing was in place, only required simple adjustments to parameters when players entered and exited different volumes within the game’s environments. However, the impact of disrupting knowledge of this mechanic can be felt by players throughout the entirety of the game as players move between segments which manipulate the mechanic’s ‘rules’ in different ways. This demonstrates ongoing recall disruption and thus, ongoing restructuring, throughout the entire play time of the game.

Disrupting Player Knowledge of Euclidean Space

A second AAMFP example focused instead on high workload, high impact disruption can be identified in the occasional use of ‘impossible architecture’. This takes the form of apparent non-Euclidean environments (whereby corridors, rooms, walls and doors shift their locations, or connect to one another in configurations that change and distort as the player progresses) and also, at a simpler level, objects and entities that appear and disappear seemingly without cause (what can be referred to as ‘object consistency’).

Shifting corridors occur only a few times during the entire game and only significantly affect the environment on one occasion, approximately half way through the game in the ‘Tunnels’ level. This placement allows enough time for players to form apparently accurate schema-based intraludic knowledge regarding the nature of the physical, spatial properties of the game world. When faced with a situation in which corridors and rooms shift and reconfigure themselves, players are unable to use INT- category knowledge to contextualise it; a further example of recall disruption. They are unlikely to be able to use TRANS- category knowledge (although such architecture shifting is not wholly original and thus may have been experienced before in other games; see *Antichamber* (Bruce, 2013) for example) and are unable to use EX- category knowledge because such behaviour is impossible in reality. This therefore requires significant re-learning of the physical laws of the game world and thus adjustment of INT- category knowledge. The change in physical properties of the game world is not based on any clear ‘rules’ or contextualising information; there is no definitive in-game explanation for the change. Thus, the initial encoding of this new physical property knowledge is based on ambiguous information, providing an example of encoding disruption. This newly formed knowledge is now recalled to the MSSI during further gameplay. While such architectural shifting is not used to the same extent at any other point following this, the re-learned knowledge creates expectations of it possibly occurring again, thus potentially influencing how players play from this point onwards.

Disrupting knowledge of the spatial properties of the game world demonstrates a game component that has a high probability to require restructuring to occur in order to facilitate knowledge construction (e.g., if it is the first time (in their ludic and non-ludic experiences) that a player encounters the concept of 'non-Euclidean' architecture). This example of disruption can be seen as high workload, as it requires significant work to implement within the game engine. It is high impact due to its disruption of multiple knowledge types (i.e. it cannot be immediately contextualised (by most players) using INT-, TRANS- OR EX- category knowledge). 'Impact' more generally may be considered in terms of immediate gameplay impact (e.g. shifting architecture), lasting gameplay impact (e.g. consistently manipulating the parameters controlling the lantern mechanic), or lasting cognitive impact, such as changes being made to the player's expectations that influence future game experiences both in the current game being played and in other games that the player may play.

CONCLUSION AND FUTURE WORK

A proposed cognitive model and theoretical framework through which to implement a disruptive game design approach has been presented. This approach disrupts schema-based player knowledge and expectations of in-game stimuli (i.e. anything in a game that requires a player to actively attempt to understand its meaning). This may include such things as game mechanics, game entities (e.g. weapons or enemies), the game's narrative, or an element thereof. The three modes of disruption identified operate on knowledge stored in the three long-term memory stores. The modes of disruption influence the player's ability to utilise varying degrees of *intraludic, transludic* and *extraludic* knowledge and thus have an impact on the methods of knowledge construction the player is required to perform during gameplay. The framework aims to offer a perspective for considering the broader concept of 'conservatism' in game design by promoting games that require greater cognitive engagement from players via a higher rate of learning and re-learning, or re-evaluation, of knowledge during gameplay. This in turn provides a greater opportunity for such games to meet the higher level cognitive needs of players, than other 'conservative', highly 'player-centric' or highly 'accessible' games.

Ongoing work aims to analyse and assess the player-perceived and player-reported impact of the disruptive game design approach employed in the design and development of AAMFP. The results of this analysis will provide evidence as to the future potential use of such a design approach. There is also potential to investigate the concepts presented via the schema-based model of knowledge construction and recall (i.e. modes of disruption, ludic knowledge types and methods of knowledge construction during gameplay) as a means of analysing, rather than designing, games. Such analysis may provide insight into design issues in other games such as player frustration, confusion or misunderstanding of game components.

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