Interpretation as Play: A Cognitive Psychological Model of Inference and Situation Model Construction

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Abstract. Interpretation of narrative can itself be considered a form of play that is psychologically engaging and effortful. Previous work has provided initial considerations of the cognitive psychology of narrative interpretation, particularly of how players derive pleasure from understanding story. This paper elaborates on the specific processes involved in the comprehension of narrative, providing a review of discourse comprehension theories that culminates in a synthesised summary model of inference and situation model construction. The applicability of this psychological model to players of digital games is considered through comparison to participant descriptions of playing Gone Home. Prevalent themes reflect the relevance-determination of inference and demonstrate the activation of long-term memory in recall of expectations from personal experiences, games, and other media. This is briefly considered in application to storytelling in games and IDN. Future work in this area will focus on the operationalisation of this psychological understanding in practice in game design and storytelling.

Keywords: storytelling · digital games · psychology

1 Interpretation as Play and Cognitive Psychology

Scholars in digital games and interactive digital storytelling have considered interpretation of narrative as a form of play [1–3]. Upton [1] summarises this in discussion of story-focused digital games such as Dear Esther [4] and Proteus [5], offering that in the absence of expected gameplay mechanisms there is a compensatory complexity in their 'interpretive play' spaces. Comparisons can be made between narrative interpretation and play. Caillois' [6] understanding of play, for example, involves the acceptance of a temporary 'imaginary universe', akin to Huizinga's [7] 'temporary world' or Gray's [8] mental removal from the 'real-world'. Research on the experience of spatial presence in digital games has also argued for the construction, acceptance, and prioritisation of mental models [9]. In comparison to story, as discussed in this paper, perspectives on narrative interpretation broadly agree that comprehension of story also involves the creation and acceptance of mental models. Where play is considered to involve the creation and acceptance of a mental model, so is narrative interpretation. It is therefore argued that narrative interpretation can be considered a form of play in itself. In consideration

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of IDNs and story-focused games, this casts their prioritisation of narrative as a focus on facilitating interpretation as play as compared to facilitating strategic thinking in real-time strategies or tactical thinking in shooters.

These perspectives together indicate the cognitively involving and playful nature of narrative interpretation. Consequently, it has been previously argued that understanding the specific cognitive processes involved in narrative interpretation can assist with the design of games and interactive digital narratives (IDNs) that prioritise narrative interpretation as play [10]. A psychological understanding of narrative interpretation may also further discussion surrounding player response and critical reception. It is therefore important to explore relevant cognitive psychological theories, but to also convey them accessibly for academics and practitioners from other fields (such as game design and IDN).

This psychological approach to understanding games and IDNs builds on similar perspectives that utilise cognitive psychology such as working memory and schema theory in application to games research and design, such as Howell's use of learning theories towards 'disruptive' game design [11–13] and Pinchbeck's use of schema theory in understanding and designing story-focused digital games [14–17]. This also relates to cognitive narratology, which similarly considers narrative to pertain to the construction of mental models [18–20], though the present paper draws from discourse comprehension theories to elaborate on how these mental models are specifically constructed. In digital games and IDN, the present discussion of mental model construction is comparative to Young and Cardona-Rivera's work in the same area, drawing from similar theories of discourse comprehension theory to understand player experience of narrative [21, 22]. However, Young and Cardona-Rivera's work in this area has focused on the interplay of comprehension with affordances and player agency, and on the creation of computational models of salience for generative narrative systems. The present paper intends to elucidate on the cognition involved in narrative interpretation in the context of its facilitation as play in games and IDN. Comparisons may also be drawn between this discussion of narrative interpretation and Koenitz' perspective on IDN, where this paper can be considered to elaborate on the 'process' of Koenitz' SPP model of IDN [23, 24], bringing a psychological perspective to IDN that Koenitz' has previously encouraged [25].

Previous work has provided a summary of perspectives on how narrative information is understood through inference and stored in long-term memory, but then specifically investigated the psychological processes related to the experience of pleasure during interpretation [10], offering an understanding of how audiences enjoy story. This paper focuses on compiling and reviewing discourse comprehension theories in more detail to better elaborate on how narrative information triggers inference and is consequently sorted into mental models (or 'situation models') in long-term memory. This culminates in a summarised model of inference and situation model construction. However, theories of discourse comprehension pertain to text and film, with no explicit consideration of games or interactive digital narratives. The applicability of this model to players of digital games is therefore considered through analysis of participant descriptions of

experience of playing Gone Home [26] and comparison to the proposed psychological model, resulting in a more specific, novel model of inference and situation model construction contextualised in games and IDNs.

2 Reviewing and Comparing Discourse Comprehension Theories

Earlier work summarised that new narrative information is initially processed by a 'working' memory [27] (a temporary memory store that sorts incoming stimuli and directs attention) that assesses its relevance and determines how it may integrate into existing understanding in long-term memory. Many psychological theories agree that narrative information is integrated into mental models in long-term memory [28–34]. Long-term memory is also typically considered to consist of 'schemas' [35–37]; associative clusters of relevant memories that may collectively activate in response to stimuli. For example, individuals may have schemas associated with specific genres (horror, fantasy etc.) or mediums (games, film etc.) that represent expectations informed by experiences of those genres or mediums that can be activated in response to associated stimuli. Gone Home's initial ambience (the darkness, the storm, the empty house), for example, may likely activate schemas related to horror, priming players' expectations of typical horror games or media.

While earlier theories considered how text and its meaning were cognitively represented in mental models [29], further research established the more specific concept of situation models. Situation models are posited to represent the discourse as a whole, as compared to purely textual or 'surface' representations, representing concepts in the text and their interrelations, integrated with prior knowledge [31, 32, 34]. For example, the text representation of the novelisation of The Hitchhiker's Guide to the Galaxy [38] would be the words themselves. Their interpreted meaning would then be represented in situation models, including events and characters and their interrelations, such as Arthur's relationship with Ford, Ford's alien identity, and their escape of Earth's demolition on an alien spaceship. The usage of the term 'situation models' persists in more contemporary discussion of discourse comprehension [31, 39, 40], as does their proposed applicability to narrative media generally [41], and is therefore a commonly accepted perspective with which to understand how narrative information is stored in long-term memory.

Van Dijk and Kintsch's [32, 42] Construction-Integration model lays many of the foundations of discourse comprehension theories, elaborating on the activation of relevant memory (and suppression of irrelevant memory) in current narrative understanding and broader long-term memory in response to new stimuli. This activation of memory, or inference, determines how information is then integrated in the construction of a coherent situation model of the discourse. A lack of activation is associated with incoherence and may result in more effortful ('controlled') inference with wider activation.

Gernsbacher's [43, 44] more medium-agnostic Structure-Building model (as compared to Construction-Integration's focus on textual discourse) elaborates on the same concept, focusing on the dynamics of activation in response to stimuli. Gernsbacher discusses the enhancement of the strength of association between activated memories in response to relevant stimuli, and the suppression of irrelevant memory and stimuli.

This broadly suggests that activated memory is more likely to be activated again, with increased activation resulting in a stronger association between memory and stimuli. This is echoed by neurological perspectives on brain plasticity that indicate that neural pathways between memories are strengthened when activated [45, 46]. Gernsbacher further posits three processes for mental representation creation: laying the foundation of the structure; mapping new information into the structure (comparable to van Dijk and Kintsch's integration); shifting to new structures when mapping is insufficient. Gernsbacher's key addition to van Dijk and Kintsch's model here is the proposal of a network of multiple mental models, being substructures within a larger structure, that collectively represent a broader narrative.

Zwaan et al.'s Event-Indexing model [33, 34] adopts the concept of situation models and similarly proposes successive connected situation models for larger narratives with multiple, more distinct events akin to Gernsbacher's model. In contrast to Construction-Integration and Structure-Building, in that situation models may contain multiple events and information (termed as 'entities' and their respective 'properties'), the Event-Indexing model focuses more on how coherence is established through the monitoring of five 'event indices' that link events: temporality, spatiality, protagonist, causality, and intentionality. Any discontinuity detected in these indices in the current situation results in the situation model being updated. If multiple changes are detected, this may indicate a new event has been encountered, resulting in construction of a new situation model. Discussion of the segmentation of a narrative into events also suggests that situation models may contain predictive information of how events may change [47].

In comparison to Event-Indexing's prioritised indices, additional studies and theories suggest that causality is typically prioritised in the determination of coherence. In comparison to the event indices, the Causal Network model [48–50] suggests more broadly that situation model construction is primarily achieved through causal inferences. This is further suggested in studies that show causally connected information is more likely to activate in response to stimuli [41, 51, 52]. Causally relevant information may be events that are causes or consequences of other events. However, aspects such as where and when events occur, or characters goals and intentions and how they may influence or react to events can also be causally relevant [49, 53], hence the Event-Indexing model's five event indices are still potentially relevant to causality.

Lastly, Hofer et al.'s [9] 'book problem' acknowledges that audiences can experience spatial presence in more traditional media. Considering that the construction and prioritisation of mental models of a virtual environment are proposed by Hofer et al. as key to the experience of spatial presence, the construction of situation models during narrative interpretation is directly comparable. In comparison to Zwaan's 'spatiality' event index, and studies that suggest that situation models contain spatial information [54, 55], narrative situation models and spatial mental models can be considered significantly associated, though it is uncertain if they are interchangeable.

Although these discourse comprehension models differ, their shared focus on mental representations (most commonly 'situation models') suggests a significant degree of compatibility, as demonstrated in similar syntheses of discourse comprehension models in cognitive psychology [53]. The widely discussed process of activating memory to

determine the relevance and coherence of stimuli for integration into existing or new situation models can be generalised and synthesised into a combined model of inference and situation model construction.

2.1 Summarising and Integrating Theories of Discourse Comprehension

Discourse comprehension theories can here be summarised and integrated into a singular understanding of narrative interpretation. Situation models are constructed through the combination of information provided by the discourse (e.g., novel, film, game), existing narrative understanding, and long-term memory more broadly. Situation models can contain a large amount of complex information, such as the speaker or narrator, character intentions, relationships, opinions, emotions (as suggested by van Dijk and Kintsch [32]) or events, entities, and properties suggested by Zwaan et al. [34]).

When constructing situation models, audiences are aiming to establish a coherent understanding of the discourse [56–58]. Certain kinds of information are posited to be prioritised in establishing coherence. For example, Zwaan et al.'s [33] five 'event indices' that are monitored and updated when any change occurs (temporality, spatiality, protagonist, causality, intentionality). Alternative perspectives, such as the Causal Network model, emphasise the importance of causality specifically during the construction of coherent mental representations of discourse [49]. Memory that is causally-relevant is more likely to activate in response to new narrative information [41, 52], suggesting that causal narrative information that connects the events, characters, and properties of a narrative is prioritised during interpretation.

Situation models can be constructed incrementally and gradually, as new information is introduced and integrated into current understanding, or globally when new situation models are required when new information cannot be easily integrated [32, 33]. For example, Zwaan's event indices and theories of event segmentation [47, 59, 60] propose that the detection of changes in the current situation would result in updating that aspect of the situation model, although the Causal Network model would suggest a more general consideration of limited causality, and Gernsbacher's Structure-Building model would abstract this more broadly to limited activation and poor mapping of the new information to the existing stored information. Conversely, significant changes to a narrative situation may indicate that a new situation is being perceived, such as between levels of a game or chapters in a novel, resulting in the construction of new situation models, or recall of a prior, more relevant situation model. In conjunction with Gernsbacher's substructures [43, 44] and the similar events of the Event-Indexing model, this suggests the construction of successive, connected situation models that collectively represent a larger narrative, with the current narrative situation being the focus of attention and retrieved in working memory.

Various perspectives on situation models delineate how the activation of memory dictates how new information is integrated and how situation models are therefore constructed and updated [32, 43, 44, 53, 58, 61]. When encountering stimuli, this triggers a spreading activation of memory (of both current narrative understanding and broader long-term memory schemas) that is cohesive or associated with the stimuli to determine the coherence and relevance of new information for its potential integration into current narrative understanding. As discussed, information that is causally connected to

the incoming stimuli [50, 56] or was more recently encoded [62] is more likely to be activated. The activation of relevant memory also increases its likelihood of further activation in response to additional stimuli and inhibits the future activation of less relevant memory [32, 44, 63].

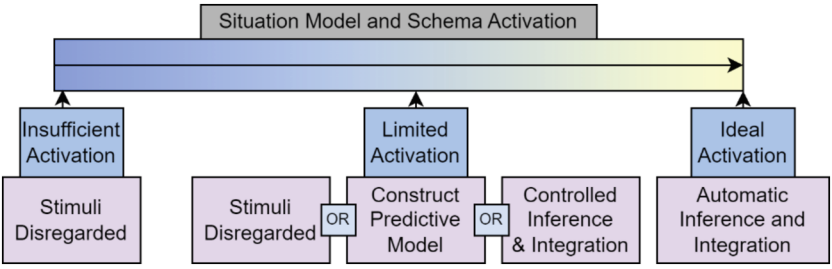

Fig. 1. Ideal, Limited, and Insufficient Activation of Memory

If there is ideal activation, in which enough memory is activated to determine relevance, this new information is then successfully integrated into the situation model (see Ideal Activation in Fig. 1 above). Limited activation may result in the creation of a new situation model. Given prior discussion of event segmentation [59], event-indexing [33], and structure-building [43, 44], this may result in a series of related situation models representing current narrative understanding in long-term memory. For example, a significant change, such as a new scene in a film or level in a game, may be less immediately relevant, result in less activation, and trigger the construction of a new situation model. Theories also suggest that with limited activation, predictive situation models may be created that can be later confirmed or disregarded when new information is found [47, 64, 65]. However, if activation of memory is inadequate for automated inference and integration of narrative information, then an effortful process of controlled inference involving the purposeful and conscious activation of memory may occur [53, 66]. This more controlled inference triggers additional activation that may therefore allow for the integration of the narrative information. Lastly, if activation of memory is particularly insufficient, then the stimuli may instead be considered irrelevant, and ignored without integration or further controlled inference. The determination of when controlled inference is attempted when activation is limited varies based on individual differences between audiences, such as in their specific experiences and expectations with games or stories. Van den Broek [57] further suggests individual, personal standards of coherence. The potential activation of memory and the likely outcomes are depicted in Fig. 1 above.

2.2 Summary Model of Inference and Situation Model Construction

The model of inference and situation model construction (Fig. 2) integrates and summarises these theories of discourse comprehension as an extension of Baddeley's model of working memory [27]. This provides an understanding of how individuals engage with and interpret narrative information, integrating numerous existing psychology theories into a more accessible model for scholars and practitioners in the fields of digital

games and IDN. In this summary and integration, some specificity of prior models of discourse comprehension are abstracted.

Stimuli, or narrative information in this specific context, is coordinated via working memory, here shown with a central executive that organises incoming stimuli into short-term stores (i.e., visuospatial sketchpad, episodic buffer, phonological loop) for further processing and sorting into long-term memory. As suggested by van Dijk and Kintsch [32], Gernsbacher [43], and Zwaan et al. [33], this triggers the currently relevant situation model to be recalled in working memory. Abiding van Dijk and Kintsch's initial model, and echoed in following models, working memory and long-term memory is activated to determine the potential relevance of the incoming stimuli. Insufficient memory activation determines the stimuli as completely irrelevant or incoherent and is ignored or forgotten. Ideal activation of memory determines relevance, and the information is integrated into the situation model (here shown as a nested structure within long-term memory). The specific information that may be considered, or prioritised, as relevant may differ and is uncertain, and so the event indices offered by Zwaan et al. are not specified in this summary model, opting for a broader causal prioritisation as suggested in the Causal Network model.

If activation is limited, then more controlled activation of memory may occur and result in additional activation (controlled inference) and consequent integration into the situation model (as posited by van Dijk and Kintsch and Gernsbacher), or the creation of a new situation model (e.g., if activation was less optimal because the situation had changed as posited by Zwaan et al. and Gernsbacher). Alternatively, limited activation of long-term memory may result in the construction of predictive situation models for later activation, confirmation, and integration into the situation models [65].

For example, when playing Gone Home, a player may encounter a new piece of information in a letter. This information triggers activation of their understanding of Gone Home's narrative so far, and their memory pertaining to experiences of similar games and stories, personal experiences, and other relevant long-term memories. First, this may result in ideal activation and allow for the new information to be determined as relevant, and thus sorted into situation models. Second, it may result in insufficient activation and be disregarded. Third, it may result in limited activation and trigger controlled inference, activating more memory with more effort. In relation to the model of optimal arousal regulation [10], controlled inference is suggested to result in greater shifts in arousal, and thus potentially more pleasure.

3 Assessing the Relevance of the Model and Theories

Theories of discourse comprehension largely pertain to text or film, with no consideration of comprehension of narrative in games or IDN. While the same psychological processes are likely utilised in understanding story in a game or IDN, it is not guaranteed. Consequently, a study of players' experiences of Gone Home can assist in providing an initial indication of the relevance of the reviewed psychology.

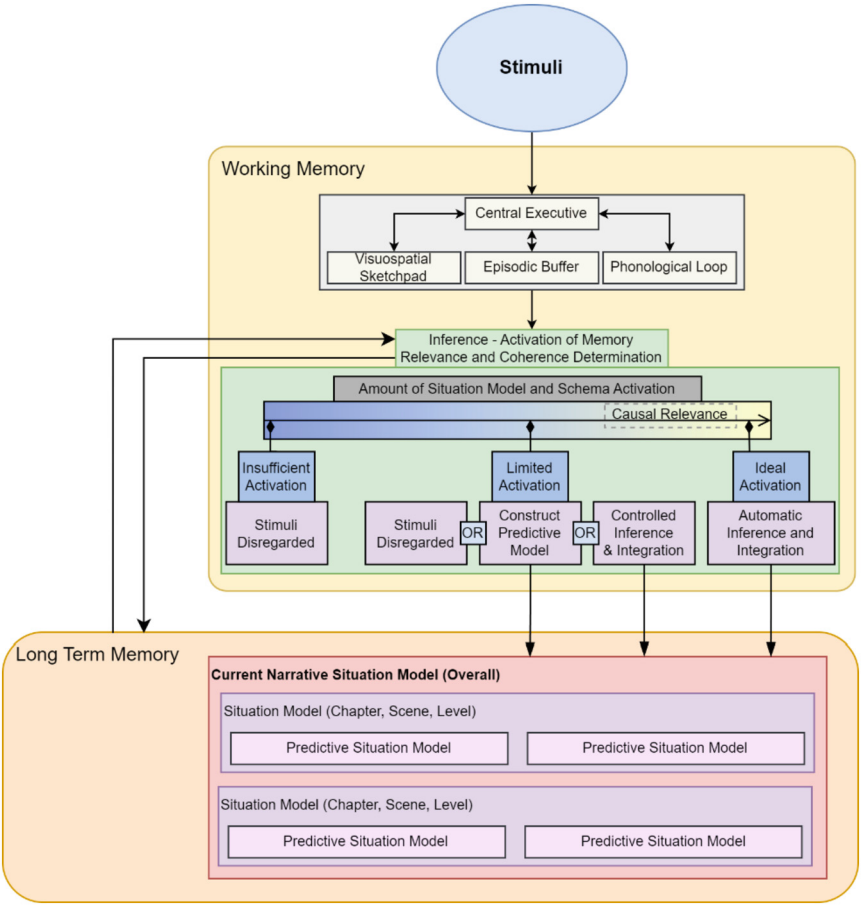

Fig. 2. Model of Inference and Situation Model Construction

3.1 Method

Fifteen participants each played fifteen minutes of Gone Home, a game that encourages players to explore an empty family home filled with environmental clues as to the events of the story and whereabouts of the family. Gone Home tells a story of an American family, particularly the youngest daughter Sam, through a variety of methods, with audio narration, environmental storytelling, and through letters, diaries, and notes. Gone Home was chosen as a story-focused digital game with a short enough length that participants would be able to experience a reasonable portion of the story in 15 min.

Data was collected with stimulated recall [67, 68], and retrospective think-aloud. Participants watched a recording of their play and described their experience. Stimulated recall and retrospective think-aloud are methods encouraged in games studies [67] and UX [69] that were chosen here to ensure proximity to the lived experience but avoid

impacts on user experience found in situated think-aloud strategies [70–72] due to splitting participant attention between multiple cognitively involved activities (playing Gone Home while vocalising their thoughts and feelings).

These experiences were thematically analysed [73–76], resulting in 11 themes and 40 sub-themes. Themes were considered significant due to the frequency of their codes across the participant group, or due to the number of relevant codes and sub-themes within a particular theme.

3.2 Results

The most prevalent theme was Forming Expectations, with frequent discussion amongst participants (f = 241) about their predictions of the story. These involved multiple potential outcomes being considered ("…she either died, or was kidnapped, or possessed"), and also often centred around uncertainties discovered in the game, such as a school locker in a bedroom or a TV left on in the living room, potentially indicative of the limited, non-ideal activation of memory [65] and the predictive situation models proposed by Zacks et al. [47].

Engaging with Story was also a prominent theme, both in determining relevance and understanding the story as a cohesive whole. 10 participants (f = 20) discussed their attempts to determine the relevance of new information ("…even though it's like such an irrelevance thing and irrelevant piece of information…") ("there's little bits of things that I keep finding everywhere which don't have any use other than just to show you what your family is like"). This is likely indicative of the process of inference, with the activation of memory being utilised to determine the relevance of stimuli. Similarly, seven participants (f = 30) recalled, in detail, their understanding of the story as they'd discerned so far. This is also reflected in the discussion of establishing context, with seven participants (f = 12) similarly attempting to attain a broader understanding of the game ("I needed the context of who they were, what their relationship was to my character and to the world that this was building"). The desire for context pertained to what was occurring in the story and why, but also to their specific purpose in the story, such as why they were there and what they were meant to be doing as part of this. This reflects the discussion of a desire for coherence in discourse comprehension theories [56–58], but also indicates some additional aspects to players' desires for coherence in the context of digital games and IDNs.

Much of the focus in 14 participants recall of the story centred on the characters (f = 165), with information such as their emotional state ("…she's shying away from it, but she knows it's important, she's just embarrassed"), their relationships ("Janice is probably the mother", "I know the sister is Sam"), and of who the protagonist or player character may be ("I'm starting to think I'm Katie now"). This is reflective of Zwaan et al.'s [33] protagonist and intentionality (with emotional states often being related to a character's actions), and also demonstrates proposed priority of causal relevance during inference [27–31].

In discussion of characters and forming expectations, participants also frequently refer to their own personal experiences and expectations, indicating a frequent recall of

their long-term memory during interpretation. When discussing characters, five participants (f = 14) considered their own personal experiences in relation to those characters ("I can relate to that, how that feels, you know my parents said to me, just try to make friends"). Participants recall of long-term memory ranged from broader semantic connotations ("it was like a caution or warning, a radioactivity sign, I knew that it was important"), to other media ("I found myself thinking, is this the Cabin in the Woods?"), to games more specifically ("I've played so many games, I've seen the set-up before"). Recall of games was the most likely relevant experience to draw from, with ten participants (f = 27) discussing their expectations informed by their experience with games.

3.3 Discussion

Results indicate the relevance of the proposed psychological model of inference and situation model construction. The theme Determining Relevance is immediately comparable to the process of the relevance-determining inference central to discourse comprehension theories and the summarised model of inference and situation model construction. The prevalence of this theme demonstrates the activation of memory in attempt to integrate new information. The theme Recalling from Memory similarly demonstrates the activation of long-term memory specifically, but also elucidates the memory and schemas that are likely recalled during gameplay. Firstly, participants discuss personal experiences, such as specific life experiences or specific related games and media. However, participants also recall their broader expectations stemming fromspecific experiences, with frequent recall of semantic connotations as well as expectations of genre and medium. In contrast to the discussed discourse comprehension theories, and the resulting summary model of interpretation and situation model recall, this data offers much more specificity as compared to the more indistinct reference to long-term memory activation.

Participants' desire for context tentatively reflects the underlying need for coherence suggested in discourse comprehension theories. Van Dijk and Kintsch's Construction-Integration and the Casual Network model are of particularly relevance here, each suggesting a desire for coherence during discourse comprehension, though the latter offering prioritised causality. Participants' recall of Gone Home's story does reflect this prioritisation of causality as proposed in the Causal Network model, but also does elucidate on the kinds of memory typically considered as causally relevant. Given Gone Home's focus on character, it is unsurprising that much of participants' recall of the story pertains to its characters – however, there is frequent focus on character emotions and their relations to one-another. This is comparable to Zwaan's proposed event index of intentionality. Similarly, participants often discussed the identity of the central character, prompting discussion of Sam and Katie alongside consideration of their player-character. Participants' consideration of context also often involved an understanding (and recall) of the game's setting, with common discussion around the time in which it is set, and on the house in which the characters reside. Firstly, this lends support for Zwaan's event indices (temporality, spatiality, protagonist, causality, and intentionality), with each of these being subject to discussion by participants, though some more than others (particularly causality, protagonist, and intentionality). Secondly, the common consideration

of the player-character indicates additional 'index' that players of games and IDNs may prioritise during inference and situation model construction.

Forming Expectations also reflects the common sources of participants predictions, such as recall of comparable media and games, but is further indicative of limited activation of participant memory during inference. As emphasised in Construction-Integration and Structure Building, and as represented in the summary model, limited activation of memory may result in either more effortful, controlled inference to activate additional memory, or in the creation of predictive situation models. The expectations formed by participants reflects the latter, with expectations often being predictions of the story of Gone Home. The discussion of expectations alongside uncertainties found in Gone Home may also reflect controlled inference.

In comparing the results of the study with prior models of discourse comprehension and the integration of these models in a summarised model of inference and situation model construction, the various processes and aspects of discourse comprehension theories can be seen in participants' experiences of Gone Home. While this firstly contextualises these theories in games and IDN, participants experiences have also provided additional specificity as to how these cognitive processes operate during play of games and IDN. These can be integrated into a final, novel model that aggregates prior theories of discourse comprehension theory with games and IDN-specific considerations found in the study.

Amending the prior summarised model of inference and situation model construction, Zwaan's event indices are included as part of inference to indicate the type of memory that may be prioritised during activation of memory. The commonly recalled forms of long-term memory have also been integrated, both with episode-specific memories and their schematic counterparts. For example, specific game experiences may be recalled, as can game-related schemas. Broader semantic connotations here indicate the schematisation of more specific life experiences; as demonstrated in participant response to Gone Home, for example, recognition of a radioactivity sign can lead to recall of broader connotations of danger.

3.4 Limitations

It is acknowledged that retroactive think-aloud may result in memory decay in participants as their recall occurs after the lived experience [77, 78]. Stimulated recall was employed to assist with recall, but this may still result in inaccuracies in participant descriptions.

While the use of Gone Home has provided useful comparisons to theories of discourse comprehension, this is only so far representative of the experience of one game. While these findings may be generalisable outside of the context of Gone Home, this is still limited, and further studies should examine this psychology in the context of other narrative games and IDNs. Similarly, the study examines participants experience of a story-focused digital game, and therefore unsurprising that responses are reflective of experiences of narrative. Further research should also compare experiences of games that are not story-focused to allow for the comparison of the presently discussed psychological models in scenarios in which it would be less likely reflected.

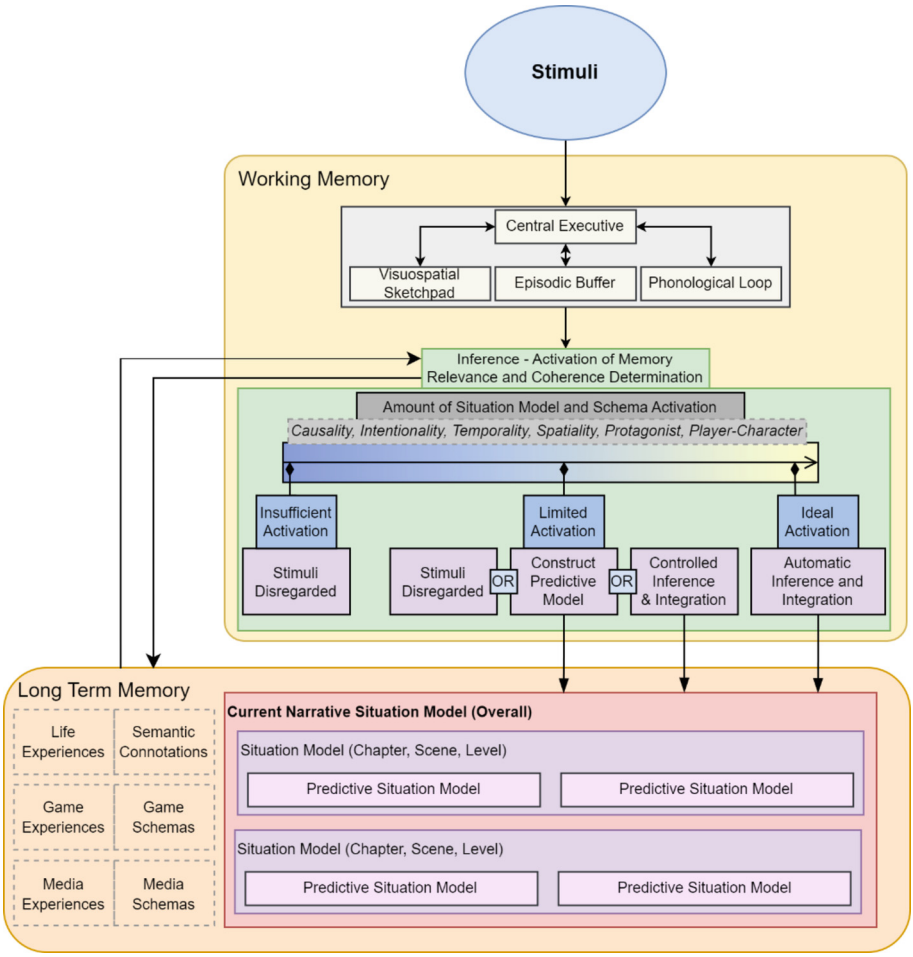

Fig. 3. Updated, novel Model of Inference and Situation Model Construction

4 Relevance of Discourse Comprehension Theories to Game/IDN Design

The model of inference and situation model construction, in conjunction with the prior proposed model of optimal arousal regulation [10], offers an understanding of how players interpret narrative and how this process is pleasurable. Research suggests that mediating the activation of memory during inference to encourage controlled inference should result in larger shifts in arousal that trigger a pleasure response in players. The practicality of this psychology can therefore be considered in approaches to game and IDN design that encourage controlled inference to facilitate interpretation as play.

Mediating the activation of memory to encourage controlled inference largely pertains to limiting the memory available to be activated, or providing incoherent stimuli

that will result in limited activation. For example, omitting pertinent narrative information results in less available memory, central to narrative techniques such as twists and mystery. This can be seen in Gone Home, with the reason behind the absence of Katie's family being initially omitted. When their whereabouts are instead gradually implied through the letters and notes within the environment, the limited information provided therefore has little corresponding cohesive memories to activate in current situation models. Controlled inference is instead required to piece together these smaller incoherent narrative fragments into a more salient situation model, as demonstrated in the varied recall and predictions in participants' responses. Omission, limitation, and ambiguity of narrative information are therefore common to existing approaches to design, such as in the environmental storytelling (in which context is deprived and requires the collective interpretation of disparate aspects of an environment) and epistolary narrative (in which limited information is spread between multiple correspondences) utilised in Gone Home.

Omission and ambiguity are key to approaches to storytelling, as has been previously discussed in regard to arousal regulation [10]. For example, Pinchbeck discusses withholding narrative events in Dear Esther, with the intent to encourage players to 'fill the gaps' [79]. As players explore the Hebridean island, the semi-randomised narration of letters to Esther avoids communicating specific narrative events and instead provides descriptors of characters. Instead of explaining the fate of the character Paul, Paul is instead described in conflicting ways, such as 'Paul was drunk' or 'Paul was sober', but never indicating what Paul does or how he connects to Esther. Barlow [80] demonstrates this in his approach to telling a story 'using the player's imagination' in Her Story [81] (a crime fiction game that involves sifting through a police database of interview footage), noting approaches such as omission (by withholding the detective's questions), twists (omitting key details to later confuse and surprise), non-chronology (showing interviews in non-chronological order and therefore withholding causality), and contradiction to challenge the player's narrative understanding. As with Dear Esther's Paul, contradiction is a seemingly effective method for providing intentionally incohesive, conflicting information that would require further inference to resolve.

The examined psychology can be seen in approaches to storytelling, both old and new. Hemingway's iceberg theory [82, 83] similarly purports for the withholding of information which would also likely result in limited memory activation. More recent perspectives also echo this, such as Glinblat et al.'s [84] reparative play and the provision of intentionally incomplete or disparate artefacts that invite players to 'repair' and assemble meaning for themselves. Arjoranta's 'interpretive challenges' [85] likewise discusses ambiguity and contextuality to make narrative interpretation more challenging, comparable to the effortful controlled inference presently proposed, with ambiguity and withheld context again limiting activation during inference. Discourse surrounding poetic games [86–90] proposes the use of 'defamiliarization' to subvert expectations of narrative, structure, and interaction to facilitate poetic gameplay and encourage narrative interpretation. In comparison to discourse comprehension theories, this can again be seen as a method for encouraging controlled inference, with the subversion of expectations here resulting in limited activation of expectations in long-term memory and relevant schemas specifically (such as expectations of genre or medium).

A full review of approaches to game and IDN design that relate to the proposed psychological understanding of narrative interpretation is beyond the scope of this paper, but these examples emphasise the relevance of this psychology to understanding approaches to practice and its potential use in game and IDN design. Further research should consider how the proposed psychological models can inform approaches to storytelling in games and IDN in future.

5 Conclusion and Future Work

Considering interpretation as a form of play is a potentially useful perspective with which to examine existing media and creating new stories. A significant aspect of furthering this perspective is therefore developing a greater understanding of how audiences specifically interpret narrative, particularly in the context of digital games and IDN in which existing theories of discourse comprehension do not explicitly consider.

This paper has offered a review of existing perspectives on discourse comprehension. This initially provided a summarised, aggregated psychological model of inference and situation model construction, conveying how new narrative information triggers an activation of existing understanding and long-term memory to determine its relevance for integration into existing understanding. Analysis of participants' experiences with Gone Home has provided a tentative indication of the relevance and applicability of this psychology to digital games and IDN specifically, with much of the themes and specific discussion reflecting the reviewed discourse comprehension theories and the resulting model of inference and situation model construction. This has resulted in a novel version of the model that includes games and IDN-specific aspects provided by participant experiences. In summary the key contribution of this paper is the review of discourse comprehension theories, their comparison to the experience of a story-focused digital game, the novel model of inference and situation model construction that integrates the findings of each of these, and finally the initial consideration of how this psychology may influence game and IDN design.

In conjunction with the model of optimal arousal regulation, these provide a more accessible and relevant assimilation of cognitive psychology that outline how players seek and interpret new narrative information, and how this may be enjoyable. Future work should further endeavour to understand the psychology of narrative interpretation, but also seek to better operationalise this psychology for the context of both practice and critical analysis. Further work will investigate specific approaches for intentionally facilitating interpretation as a form of play, particularly methods for encouraging more effortful controlled inference to increase shifts in arousal and consequent pleasure. While this is more immediately relevant to practitioners in storytelling, IDN, and game design, this would also be of benefit to understanding existing approaches to practice.

It is also argued that theoretical approaches to practice should then be contextualised in the active design and development of real-world artefacts, such as digital games or IDNs. There are a variety of potential influences, caveats, or constraints that apply in practice, particularly in commercial game development, and it is useful to assess the applicability of findings and proposals pertaining to practice in their intended environment. Presently, this is being explored through the development of White Lake, a

story-focused digital game set in an ambiguous white void, that intends to facilitate interpretation as play by encouraging controlled inference in players. The ongoing aim of this research is to understand the psychological experiences of players with which to develop approaches to storytelling in game and IDN design, and to contextualise findings in commercial games development.

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