Cognitive and Experiential Interestingness in Abstract Visual Narrative

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Abstract

Interactive intelligent agents use cognitive models to anticipate and simulate human behavior, and a fundamental pillar of human cognition and interaction is narrative. As a result, agents need to understand human comprehension of various types of narratives. A key component of modeling comprehension is the perception of interestingness of constituent actions and events in the narrative. In this paper, we briefly review previous theories of interestingness, drawn from cognitive psychology and narratology. We propose expanded computationally amenable theory of interest which takes into account both cognitive and experiential aspects of perceived interest. To empirically validate the theory, we present a narrative generator for abstract animations inspired by Heider and Simmel's experiments (Heider & Simmel, 1944). The generated animations are parameterized along the dimensions of our proposed theory. We present the results of a user study with this generative system and report on the effects of visual narrative parameters on perceived interest.

Keywords: story interest; cognitive interest; visual narrative

Introduction

What makes a story interesting? Attempts to answer this question have enjoyed periodic focus of researchers over decades, to the extent that story interestingness has been regarded as a neglected variable (Hidi & Baird, 1986). The benefit in finding the nature of interest is clear; in learning sciences, for instance, a better understanding of interestingness can result in an improved education (Silvia, 2006). Many areas of artificial intelligence, such as storytelling, games and interactive agents, heavily depend on the perceived interestingness of their narratives as well. But the question looms: which stories have a better chance of being perceived as more interesting to an audience?

Is there an intrinsic difference in the perception of interest when it comes to comparing various mediums of visual narrative, such as animations or games (Pereira Santos, Khan, & Markopoulos, 2016)? In this paper, we survey a number of theories of story interestingness and highlight gaps in research on this topic. We then introduce an expanded theory of interest, one that complements the dominant direction of investigation which is of cognitive interest based on one's experiences. Finally, we attempt to evaluate the role of various types of interest in a generated abstract visual narrative that is based on the classic experiments by Heider and Simmel's (Heider & Simmel, 1944).

Review of Theories of Interest

Interestingness has been a classic area of research in psychology. Berlyne's theory of interestingness (D. E. Berlyne, 1960, 1970), which was developed in experimentation with visual patterns, art and music, focuses on perceptual situational interest. Berlyne considered interest to be a monotonic function of collative variables, such as novelty, complexity, uncertainty and conflict. Later, Schank made one of the earliest attempts (Schank, 1979) in identifying the sources of story interestingness. With a goal of controlling inference sequences in a story understanding system, he counted the *unexpectedness* of story events, a measure of "personal relatedness" (events about those close to us), and a class of "absolute interests" (e.g., death, sex), to be the major causes of story interestingness. Absolute interests were also corroborated by other researchers under various name, such as "generically important topics" (Freebody & Anderson, 1986), or "human dramatic situations" (Wilensky, 1983).

Categorizations of Interest

In attempts to improve this theory, categorizing various types of interests was central to the research efforts that followed. A popular starting point in such categorization was the *source* of interest: is one interested in a stimulus because of an objective property of the stimulus, or because of predispositions in one's self? Based on attempts to answer this question, researchers have introduced categorizations such as *individual* and *situational* interests (Hidi & Baird, 1986), or *interestedness* and *interestingness* (Frick, 1992). Beyond the question of source, Kintsch (Kintsch, 1980) proposed two types of story interestingness: "emotional" and "cognitive". Emotional interest is created through the arousal function of certain events, and hence includes Schank's absolute interests. Cognitive interest, on the other hand, is mostly caused by the relationship between the incoming information and background knowledge.

These categorizations led to an almost exclusive focus on cognitive interest, given the assumptions that cognitive interest is a more universal measure and that it can more predictably attract readers and listeners to a story, regardless of the context. As a side effect, other possible sources of interest were neglected even more, and were often categorized broadly as "emotional" (Kintsch, 1980; Kim, 1999), or "topic" (Campion, Martins, & Wilhelm, 2009) interests.

Cognitive Interest

Background knowledge, as previously mentioned, was introduced by Kintsch (Kintsch, 1980), along with the degree of generated uncertainty, and "postdictability" (how well the information can be meaningfully related to other sections of the text). This view shapes an inverted-U function of knowledge and uncertainty for cognitive interest (where fully-known or perfectly unknown domains are both unlikely to generate interest). However, other researchers disputed the existence of a direct causal link between background knowledge and cognitive interest. For instance, Frick (Frick, 1992), conducted experiments that showed background knowledge to have no direct effects on cognitive interest; and instead, he concluded **a change in one's beliefs** to be the cause of cognitive interest.

Defined as the disruption of active expectations, Mandler (Mandler, 1982) believed **incongruity** to be the cause of cognitive interest. Under this theory, readers may implicitly assume particular schemata in every story (Bower, Black, & Turner, 1979), and hence, information that is incongruent with an assumed schema is considered to be a source of cognitive interest. It is worth noting that this view seems to be particularly close to Schank's unexpectedness, especially given his notion of story scripts (Schank & Abelson, 2013).

Conceptually close to the idea of postdictability by Kintsch, a **successful resolution** of incongruity, through a process called *reconceptualization*, was believed by Iran-Nejad (Iran-Nejad, 1987) to be the cause of cognitive interest. Iran-Nejad also associated cognitive interest with "extra cognitive operations", but this view was later deemed to be too broad by others (Kim, 1999).

Kim considered the **generation of inference**, which happens *as a result* of incongruity, to be more directly responsible for cognitive interest. Kim experimented with breaks in causal chains of stories to form "implicit" and "explicit" variants. As Kim points out, this theory is close to Kintsch's and Iran-Nejad's notions of postdictability and reconceptualization, but it does not require additional information in subsequent parts of the story.

Campion et al. later disputed Kim's theory in (Campion et al., 2009), and suggested that the causal breaks used in his experiments may have been a source of unexpectedness, which in turn could have caused cognitive interest. Inspired by Berlyne's notion of epistemic curiosity (D. Berlyne, 1962), Campion et al. focused on cognitive interest as a "motivation to know more". Through a series of experiments, they showed that cognitive interest is caused by **uncertainty**, which is in turn caused by the generation of **predictive inference**. Predictive inference, as opposed to inductive inference, involves a presumption about what will happen next in a story.

Visual Narrative Comprehension

In recent years, research in cognitive sciences has turned its attention towards visual narrative, such as those found in comics and films (Cohn, Foulsham, Smith, & Zacks, 2017). The concept of "visual attention", which establishes a strong link with interest, is at the center of this research. Notably, **building up expectations**, is assumed to be a key part of how visual narratives function in comics and movies (Foulsham, Wybrow, & Cohn, 2016). This building up of expectations is conceptually very close to some of theories of cognitive interest in narrative discussed above, especially predictive inference. The parallel between these lines of research could indicate an emerging theory of visual narrative comprehension that can further and better ground a variety of lines of research on narrative, including narrative generation for entertainment and interactive agents.

Interest as an Emotion

Based on appraisal theories of emotion (Lazarus, 1991), Silvia points out that interest is an emotion (Silvia, 2008). He suggests that interest comes from two appraisals (Silvia, 2005, 2006). First, is an evaluation of novelty-complexity, which can support previously proposed properties such as unexpectedness. Second, is an evaluation of comprehensibility or coping-potential; which involves one's belief in one's self to have the knowledge and resources to "deal with" an event (e.g. understand a complex or unexpected concept). It is worth noting that Campion et al. consider their theory to be compatible with the appraisal-based views of interest, and count the appraisal of coping-potential as a necessary condition for cognitive interest. They assert that uncertainty must both have a clear source, and be considered solvable by the audience, in order to cause cognitive interest (Campion et al., 2009).

Interests Interact. Studying interest in various stimuli is greatly affected by the context in which a given stimulus exists, much like day-to-day stories people tell, which are very situated and do not happen in a vacuum of our choosing. When a story is about violence (e.g., Will the hero survive a bomb?) interests are generally higher, regardless of the particular properties in any entailed event or object. This is in line with Schank's idea of absolute interests discussed earlier. Furthermore, and as another example, people's predispositions about particular common themes of life can generate or guide various kinds of interests as well (e.g., Will someone cheating win or lose a race?). This ideas is communicated by other researchers as well (Rapp & Gerrig, 2006). And yet, to the best of our knowledge, there has not been a theory attempting to formally connect such experienced-based interests to the generation of cognitive interest in the comprehension of narrative.

Experiential interest

Given the blended nature of comprehension discussed above, one's prior experiences and biases seem to have a significant role in perceiving a narrative, or a stimulus inside a narrative, as interesting. Hence, recognizing these experiential interests better, and studying them in conjunction with cognitive interest, may help further our understanding of the topic and perhaps facilitate a better computational generation of interest in stories.

We attempt to define experiential interests as follows; *a type of interest one may hold in an external stimulus (e.g., a story) that can only be realized in the context of an audience's natural properties, identity and preferences, prior experiences and interactions.* We believe that experiential interests will play a central role in generating narrative for social and situated storytelling applications, especially in situated settings where memories and prior experiences are accessible. We will introduce a taxonomy for various types of experiential interests. These types outline a decreasing range of universality, such that type 1 is the most universal (least individualized) and type 5 is the least.

Taxonomy of Experiential Interest

Below, is one taxonomy for the Experiential Interest.

Type 1. Instinctive Interests: called "absolute interests" by Schank (Schank, 1979), instinctive interests have roots in our nature. Examples: death, danger, power, sex, etc.

Type 2. Common Themes: these interests are common personal or interpersonal themes of life that happen to many individuals, and their existence and the usual circumstance around them is known by most. They might vary from culture to culture, and from generation to generation, but there also exists a great deal of consistency about many of them, across cultures and generations. Examples: being an underdog, growing up poor, being bullied in school, etc.

Type 3. Topic Interests: we use "topic interests" (in contrast to (Campion et al., 2009)) to specifically refer to *subjects* that constitute areas of general interest for individuals. Topic interest are a part of each individual's slowly developing identity and personality. Examples: geography, sci-fi movies, fireworks, etc.

Type 4. Reminiscence: stories that are, intentionally or unintentionally, and directly or indirectly, reminiscent of one's past, are often of significant subjective interest. Reminiscence may occur about memories of *shared experiences* as well. There is a growing body of research in cognitive and social psychology that has underlined the importance of such storytelling in self-development (McLean, Pasupathi, & Pals, 2007), social relationships (Alea & Bluck, 2003). Examples: first dates, a road trip with an old friend.

Type 5. Implicit Familiarity: as the most personal kind of experiential interest, this type represents experiences such as déjà vu, in which a meaningful but not necessarily fully recognized connection between stimuli and personal memories is established (Brown, 2003). Memories causing this type of interest in an stimulus are likely to be abstract and affected by emotional states. Example: a red rose reminding one of a personal experience.

Personal Relatedness We believe that Schank's idea of personal relatedness is embedded into different types of experiential interest, given their range in being individualized. For instance, a premise in type 4 is the subjective significance of memories, and hence, Schank's example of cutting child's toenails (Schank, 1979) fits well here.

Heider and Simmel Experiments

In a classic 1944 study (Heider & Simmel, 1944) by Fritz Heider and Marianne Simmel, participants were shown an animation involving three moving geometrical figures, Fig. 1[1]. The study consisted of three experiments, in which participants were asked to describe or answer questions about the animations. Nearly all of the participants of the three experiments interpreted the pictures in terms of actions of animated beings, typically people, who faced challenges, defended their loves, and helped the needy, among other things. Heider and Simmel's study highlighted the phenomenon of apparent behavior for the first time (to the best of our knowledge).

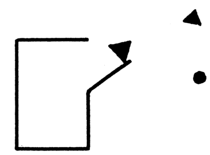

Figure 1: A still image of the animation used in (Heider & Simmel, 1944). The shapes moved around, while the "house" was stationary, with the exception of its "door".

This experiment has motivated and informed researchers in many areas of study, such as social psychology (Abrams & Hogg, 2006; Burr, 2015; Kelley, 1973), the psychology of art (Arnheim, 1956) and the psychology of narrative (Sarbin, 1986), among many others. Although storytelling was not the main focus of Heider and Simmel, this study reveals the primacy of our narrative-based world view. Participants created stories about love, revenge and bullying, and deduced actions, goals, intentions, and personalities, from simple movements of abstract shapes. The principle of attributing mental states to highly abstract stimuli has been corroborated in other studies, such as in (Dik & Aarts, 2007).

Why Study Interest in Abstract Visual Cues? Understanding interest and comprehension when it comes to abstract visual narrative has direct links to visual narrative comprehension (as discussed earlier), and hence may help in developing more engaging visual narratives. Moreover, studying interest in an abstract stimulus may help our understanding of it to be free of potential nuances of various mediums and complex stimuli (e.g., games or elaborated interactions).

A Simple Generator

In order to study the effects of various types of interestingness in abstract visual narrative, and to explore the possibility of

[1] To watch the animation shown to participants of the study in (Heider & Simmel, 1944), please refer to https://www.youtube.com/watch?v=n9TWwG4SFWQ

a controlled process for the generation of interest in such setting, we designed a new system. Using the Unity engine, and based on some input values, our generator creates new animations similar to the one used in Heider and Simmel's study (Heider & Simmel, 1944).

Our input involves two numeric values in (0, 1) range, representing a relative but quantified measure of cognitive and experiential interests. As seen in Fig. 2 [2], the generated animation was consisted of 3 geometrical shapes with fixed size and changing locations, and a large fixed rectangle which included an opening, resembling a "house" and its "door".

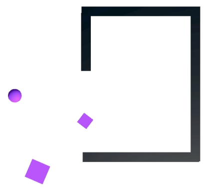

Figure 2: A still image of the animation used in our generative system. The shapes changed their behavior, both independently and relative to each other, according to the generative system's decision, based on the input. Other than moving, the shapes did not change in their appearance.

The generator used a behavior library, and a simple logic, to choose various behaviors based on the pair of input values. In each instance, generating an animation involved: **1)** choosing the appropriate behaviors from the library based on input values; **2)** assigning behaviors to the shapes; and **3)** some level of randomness in the movements of shapes (while starting and end points were pre-programmed). An overview of the system, hence, is as seen in Fig. 3

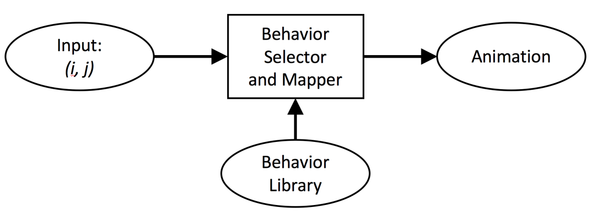

Figure 3: An overview of the generative system.

Behavior Library

In our current implementation, our system supports a number of behaviors that are associated, based on the theories discussed in earlier sections, with cognitive and experiential interest. These behaviors and their descriptions are listed in Table 1 below.

Input Values and Behavior Selection

Currently in our system, the pair of input numbers can each take a value from the set $\{0, 0.5, 1\}$. In Table 2, a number of possible combinations, along with compatible behaviors that may be picked by the behavior selector, are shown.

[2]For an example of the animations generated by the system (condition 6 in our study), please refer to `https://www.youtube.com/watch?v=gB2okx77YcI`

Table 1: Associable shape behaviors in our study.

Random Movements (no intended interest association): fully random movement is the most basic type of behavior of the system, during which, shapes move continuously at a constant speed and on random linear lines. They do not leave the screen, cannot cross the boundaries of the home rectangle (but can enter and exit through its door), and do not overlap with each other.

Chase (experiential): In this behavior, the larger square will randomly select one of the smaller items, and chase it. The movements of the smaller item will be in random mode. The distant between the two items will change periodically to suggest tension. The chasing does not end, unless explicitly timed, or combined with other behaviors. The chasing behavior is a case of type 2 in experiential interests.

Corner (experiential): This behavior involves the larger square cornering one of the smaller shapes, randomly selected, in one of the three available inner corners of the home rectangle. The cornering behavior is also a case of type 2 in experiential interests.

Break-wall (cognitive): This behavior can enable a shape to ignore and cross the boundaries of the home rectangle. When followed after a period of time where walls are respected, or when observed that other shapes cannot do the same, this behavior is expected to cause cognitive interest.

Teleport (cognitive): This behavior can enable a shape to jump between any two locations of the screen, instantly, without traveling the line connecting them. When followed after a period of time without it, or when observed that other shapes cannot do the same, this behavior is expected to cause cognitive interest.

A User Study

Using the generation system described before, we conducted a user study to assess the perceived story interestingness of the generated animation. Such evaluation depends on the findings of Heider and Simmel (Heider & Simmel, 1944), in that it assumes the shape movements to have a high chance of being perceived as a story.

We generated animations for 6 conditions, which corresponded to using different input values, as seen in Table 3. Each video was between 30 to 35 seconds long; starting with 4 seconds leading time of Random Movements for all shapes and in all of the conditions. The study was consisted of 8 experiments, each presenting the participants with a binary choice between two of the conditions above. The 8 experiments are seen in Table 3 below.

In a between-subject setting, we presented our participants of each experiment with the two associated animations, in a random order. We then asked the question "which animation was a more interesting story?". We recruited 60 participants for each experiment, through Amazon Mechanical Turk.

Our hypothesis was an increased perceived interestingness with greater sums of i and j, and crucially, with a preference for j (experiential interest). For instance, in all experiments, any intermediate condition would be perceived as more interesting than c1 (baseline), but less interesting than c6. Moreover, we hypothesized that c3 and c5 would be perceived as

Table 2: Input value and compatible behavior combinations. (i, j) denotes the pair of numbers representing cognitive and experiential interests respectively. In all cases, when a particular shape is not involved in any active behavior, it shows the Random Movements behavior.

(i, j)	Behaviors
(0, 0)	With no desired level of cognitive or experiential interest, Random Movements behavior will be selected for all shapes.
(0, 0.5)	This input combination causes one of the behaviors associated with experiential interest (Chase or Corner) to be randomly selected and invoked, for an eligible shape.
(0, 1)	This input combination causes both of the behaviors associated with experiential interest to be selected, and sequentially executed (simultaneous execution would require additional shapes or altered roles). With the current behavior library, this involves a case of chasing, followed by cornering.
(0.5, 0)	This input combination causes one of the behaviors associated with cognitive interest (Break-wall or Teleport) to be randomly selected and invoked, for a random shape.
(1, 0)	This input combination causes both of the available behaviors associated with cognitive interest to be selected, and sequentially or simultaneously executed for one or multiple shapes.
(1, 1)	This maximal input combination involves Chasing, Cornering, Wall-break and Teleport. Experiential and Cognitive interest behaviors can happen simultaneously or sequentially, depending on behavior limitations; however, sequential combinations might cause less confusion.

more interesting than c2 and c4 respectively, and lastly, c3 as more interest than c5.

Results and Discussions

The results of the experiments are seen in Table 4. In all experiments, except for numbers 2 and 4, the hypotheses are confirmed with statistical significance. Experiment 6's result is borderline significant (p-value=0.046 with a one-tailed test, or 0.092 with a two-tailed), and as such, experiential interests do appear to be marginally more prominent than cognitive interests, at least in the context of our study. But crucially, the highest levels of interest are achieved when the two are combined. Overall, the results show that the generative system has been successful in creating animations (seen as visual narratives) that are perceived as interesting, along the dimensions of interest theories.

Comparison between various quantities for cognitive interest is confirmed (experiment 5), however, this is not the case for experiential interest (experiment 4). We suspect that a longer length of Chase or Corner behaviors in condition 2 was more highlighted and perhaps dramatic, for our participants, than the combination of the two occurring in the same amount of time. Although, given that the null hypothesis of experiment 4 is not significantly confirmed either, it is possible that the experiential interest has such a large effect even in small intended quantities, that differentiating between values requires more elaborated animations and behaviors.

Table 3: The experiments in our study, the conditions ('c') at comparison in each experiment, and the input values used for the generator. (i, j) denotes the pair of numbers representing cognitive and experiential interests respectively.

Exp.	Conditions involved	Respective input values
1	c1 vs. c3	$(0,0)$ vs. $(0,1)$
2	c1 vs. c5	$(0,0)$ vs. $(1,0)$
3	c1 vs. c6	$(0,0)$ vs. $(1,1)$
4	c2 vs. c3	$(0,0.5)$ vs. $(0,1)$
5	c4 vs. c5	$(0.5,0)$ vs. $(1,0)$
6	c3 vs. c5	$(0,1)$ vs. $(1,0)$
7	c3 vs. c6	$(0,1)$ vs. $(1,1)$
8	c5 vs. c6	$(1,0)$ vs. $(1,1)$

Table 4: Participant preferences (approx. percentages) and p-values from a one-tailed binomial test, for all experiments.

Exp.	Preferences (out of 60)	p-value
1	43 (72%) for c3	$<$ **.001**
2	33 (55%) for c5	.26
3	46 (77%) for c6	$\ll$ **.001**
4	35 (58%) for c2	.12
5	45 (75%) for c5	$\ll$ **.001**
6	37 (62%) for c3	.046
7	43 (72%) for c6	$<$ **.001**
8	52 (87%) for c6	$\ll$ **.001**

Conclusion and Future Work

In this paper, after an overview of the previous research on interestingness, we attempted to further our understanding of it by introducing an expanded theory which takes into account both cognitive and experiential aspects of interest. With a focus on abstract visual narrative, we then attempted to incorporate this theory in the generation of simple animations inspired by Heider and Simmel's classic experiments (Heider & Simmel, 1944). We detailed the generation of these abstract animations, and reported our results of a user study which sought to investigate their generation of interest in users, and validate the proposed theory.

We believe that these results can help underline our belief that experiential and cognitive interests are not mutually exclusive, and studying the effects of various types of interest on each other (as attempted in (Rapp & Gerrig, 2006) and discussed in (Campion et al., 2009)) can open the door to a better understanding of complex interest dynamics enjoyed by various stimuli.

We plan to use these results and understandings to create more sophisticated generative models that can engage users in highly interesting abstract visual narratives. For instance, using the notable work in (Roemmele, Morgens, Gordon, & Morency, 2016), which attempts to automatically recognize the abstract motions as actions, we can train models to generate unique and new animations given a particular interest profile. By incorporating more of experiential models, along with a situated user model, we can aim at creating subjective and personalized interests as well.

This line of research using abstract visual narrative, not only can be fruitful for visual interfaces, such as visual games and interactive visual storytelling, but it can also help us ground our language-based research on interest in better theories of cognitive psychology. Deep machine learning models (particularly Recurrent Neural Networks), have made it rather easy to generate new text and discourse with some levels of coherence, but we are investigating approaches to incorporate more psychological theories in this realm and perhaps yield a more fruitful, more informed approach.

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