Embodied Reading: A Multisensory Experience

Susana Sanchez
Keio University, Japan
su_saps@hotmail.com

Tilman Dingler
Stuttgart University, Germany
tilman.dingler@vis.uni-stuttgart.de

Heng Gu
Keio University, Japan
heng.gu@network.rca.ac.uk

Kai Kunze
Keio University, Japan
kai.kunze@gmail.com

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Abstract
Reading fiction is a silent activity, where readers come to know imaginary worlds and characters from the book's pages. However, we perceive the natural world with more than our eyes, and literature should be no different. Thus, an embodied reading experience is proposed, adding sound effects and haptic feedback to allow readers to listen and feel the narrative text. This paper presents a preliminary prototype for multisensory narratives and an experimental methodology to measure embodiment in literature. Results for the subjective assessment of immersion and user experience from 15 participants in three modalities: haptic, sound, both combined are discussed.

Author Keywords
Embodied cognition; haptics; sound effects; reading.

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H.5 Information Interfaces and presentation [H.5.2 User Interfaces]: Haptics; Auditory (non-speech feedback.)

Introduction
The study of literature is a scholarship that corresponds to literary theory. Different schools focus on different aspects of literature to discuss and write about writing. One school is the reader-response criticism that views literature as a performing art where readers create their own text-

related performance. However, literature does not allow for an embodied experience. The phenomenologist Schütz argues that literature provides us with a 'monothetic' meaning, since it relies on idealizable and objectifiable semantic content that makes it time-transcendent, sign-oriented, and conceptual [30]. To truly conceive reading as a performing art as the reader-response criticism claims, we need to look for a 'polythetic' meaning. For instance, theatrical performances are a form of storytelling that do not rely on semantic content. Folkerth finds that in theatre, meaning is time-immanent, fully perceived in an embodied experience of the moment, with its stage, sound effects and lighting [13]. In this way, plays transmit a polythetic meaning, allowing audiences to experience within the embodied consciousness and not as an object of consciousness. Nonetheless, we find that literature, as with theatre or music, is consumed throughout time. In order to perceive the fullness of the narrative text, one must follow its linearity. As such, literature shares some characteristics with other forms of narrative that allow for an embodied experience, but it is not yet capable of providing a polythetic meaning, as print has made this form of narrative silent and only perceivable by the eye.

This paper proposes the use of sound effects and haptic feedback as literary tools to convey an embodied experience of the written word, presenting (1) the initial exploration to create an embodied reading experience using sound and haptic feedback and (2) an experimental setup to measure embodiment in a multisensory experience.

Embodied Reading

Cognition is embodied when it is dependent upon the physical body, when aspects beyond the brain play a significant role in cognitive processing [10]. To achieve an embodied experience we designed narrative texts with the addition of sound effects and haptic feedback as multisensory interventions. The multisensory feedback was designed to provide the reader with a second and third channel through which to perceive and process the contents of the literary narrative. The design process consisted on testing a mix of auditory and haptic information to provide simultaneous information that supported the narrative text. Bertelson calls this simultaneous information *valid co-occurrences*, where the sensory information coming from one event is perceived by different sensory systems [3]. In a multisensory reading experience these co-occurrences could influence the interpretation of read actions by adding information available in other senses, resulting in an intermodal redundancy. During these co-occurrences, the sonic and haptic cues could operate in what Tribble calls a cognitive ecology of multidimensional content, related to the reader-response criticism, where literature can serve to remember, hear, feel, think, and imagine. [31]

We worked with the author Carla Novi, redesigning four of her original short stories, making sure to select the appropriate haptic and sonic cues that supported the narration. This was an artistic process, comparable to sound design for theatre, and in line with the creative process of writing fiction. For instance, some multisensory information was designed to be inferential. In one of the four short stories, for example, rain is not described in the text, but the author agreed to create an embodied experience with haptic and sonic cues to support the emotional stance of the main character, who is running for his life. In urban settings rain is often used to symbolize misery and discomfort, and to create an embodied experience of this discomfort a tactile perception of impulse, pops or clicks, was used to create the illusion of short bursts that resembled drops of water, mixed with sound recordings of a rainy day.

Haptics
A wide variety of haptic effects can be achieved using vibration patterns to simulate sensations and textures using sound. The TECHTILE Toolkit allowed us to use sound files to simulate sensations and textures, using a surface transducer [28]. This technology was incorporated into an add-on to augment an e-Reader [15]. Besides the surface transducer the add-on also incorporated a small speaker.

Beyond simulating existing textures, haptic stimulation can also create compelling tactile experiences that do not naturally occur. Special haptic effects have great potential applications as literary tools in certain genres of fiction. For instance, authors write verbal cues to their readers to infer certain situations and emotions from the text, such as a "blush" or a "sweaty hand", to tell their readers a certain character is in love, without writing it explicitly. Instead of using textual cues, for example, readers can infer the emotion of love, if they could feel the heart palpitations of the named character. This cross-modal cue could provide an embodied experience of a positive emotion, where the reader can actually feel the body of the fictional character.

Sound Effects
We perceive our surroundings not only with our eyes, but also our ears. Sound design is used to create artificial ambience, allowing audiences an embodied experience. The quality of sound to convey information and emotion is well exemplified in movies. Moreover, Lopez, a major in medieval theatre, is carrying out a pilot study to replace audio description in films for the blind with acoustical information [20]. Focused on sound effects, surround sound, and sound layering, she has developed an audio film that can be followed by a visually impaired audience, without the need of a narration track.

The field of ecological psychology proposes that the physical nature of a sounding object, the means by which it has been set into vibration, and the function it serves to the listener, is perceived directly without any intermediate processing [27]. Even though this approach seems to contradict information processing, where recognition is a multistage process between perceptual qualities of sound source, abstract representation in memory, meanings, and associations, the ecological approach is concerned with the invariant properties of the sound [26]. For instance, one is able to recognize someone's voice even if this person has a terrible cold. Thus, the ecological approach might involve an understanding of why sound effects, even when they are synthetic, can produce a natural perception.

Multisensory Book
Four original short stories were supplemented with haptic feedback and sound effects to design the multisensory book.The haptic feedback and sound effects trigger when the eye gaze of the reader is over the text, marked as span region where the multisensory feedback was embedded. To do this we used the Gaze Track Plugin for the Processing IDE developed by Augusto Esteves, along with an off the shelf eye tracker mounted on the e-Reader (See Figure 1). The reader's gaze acts as the input of location in the text to trigger the multisensory feedback [5]. The Processing applet pulls prerecorded .wav files from a library, which were specifically designed for the haptic or audio channels. Subsequently, the signals are split between two stereo channels: left channel for .wav files for haptic feedback, and right channel for .wav files for sound effects. The surface transducer and speaker in the add-on, which allow the multisensory book to be possible, are connected to the e-Reader through a stereo jack that splits the output into vibration (left) and sound (right).

Figure 1: Augmented e-Reader with eye tracker, surface transducer, and speaker.

Evaluation

The multisensory reading experience was evaluated to detect if the haptic feedback and sound effects created an embodied experience. This was done with an immersion questionnaire and a user experience questionnaire. The experimental methodology was based on interoception, as it links cognitive and affective mechanisms to embodiment [8]. The insula, a part of the brain within the interoceptive network balances cognitive, sensory and behavioral processes [16, 9]. Emotion is represented in the anterior insula, which deals with all subjective feelings, and constitutes the 'sentient self' in a 'global emotion of the moment' [11]. Moreover, interoception awareness requires selective attention to a particular stimulus in order to experience it [12, 21]. Attention is an important factor in immersion, thoroughly studied in gaming, where the demand for attention is greater in immersive experiences [7, 19].

Figure 2: Experimental setup using the augmented e-Reader for an embodied reading experience.

Procedure

For the evaluation 15 participants (7 women, 22-42 years) were asked to read four short stories, one story for each condition. The short stories were assigned in a latin square design, so none of the participants would read the same short story in the same condition and sequence. Each participant was provided with the e-Reader augmented with the transducer and speaker add-on, and eye tracker (See Figure 2). The eye-tracker had to be calibrated for each participant once. There was an initial explanation to all participants about the procedure and embodied reading experience. They were always reminded of which condition they would experience next. After reading each short story participants completed the immersion and UX questionnaires. After reading the four short stories participants were debriefed.

Materials

Four short stories, of approximately 1,000 words each, were divided into four conditions: 1) Normal reading; 2) Sound effects; 3) Haptic feedback; 4) Sound effects and haptic feedback combined. The first condition was used as baseline, while the second and third were designed with only one extra sensory modality, sonic or tactile. The last condition was designed for a richer multisensory reading experience. The conditions with extra sensory modalities had between two to four embedded interventions, either of sound, tactile sensations or a mix of both. These stories were presented on the augmented e-Reader with the surface transducer, speaker, and eye tracker. The immersion questionnaire was applied following the methodology of Kunze et al. and Jennet [24, 19]. Ten statements were taken from the IEQ and modified to measure reading tasks, each statement was evaluated on a scale from one to three for levels of: empathy, interest, imagery, attention, enjoyment, frustration, time, difficulty, boredom, and disinterest. In the same survey Hassenzahl's bipolar verbal scale anchor was added, using fifteen anchors to evaluate, with positive or negative adjectives user experience.

Results

Due to technical problems we had to exclude the data from two participants. A One Way ANOVA test between conditions was conducted for immersion ($F = 3.16 > Fcrit = 2.79$), and UX ($F = 3.04 > Fcrit = 2.79$). There was a significant effect between groups in immersion levels as [$F(3, 48) = 3.17$, $p = 0.033$], and UX [$F(3, 48) = 3.04$, $p = 0.038$]. Post hoc comparisons using Tukey HSD test indicated levels of immersion baseline condition ($M = 0.46$, $VAR = 15.93$) were significantly different from sound ($M = 5.08$, $VAR = 10.7$), haptic ($M = 3.46$, $VAR = 16.10$) and sonic and haptic ($M = 2.23$, $VAR = 19.69$) and UX baseline condition ($M = 2.76$, $VAR = 3.36$) was significantly different from sound ($M = 4.23$, $VAR = 1.69$) and haptic ($M = 4.23$, $VAR = 1.02$) but not for sonic and haptic ($M = 2.92$, $VAR = 2.91$).

Discussion

The UX results indicate that the mix of haptic and sonic feedback was more disruptive to the reading experience than using only sound or tactile cues. We contend that the disruptions of sound and haptic feedback can act as literary tools that, if properly managed, can prove to be more empowering to the story than what was interrupted (Moreiras, 2001). However, the disruption seems to work better if only done through one more channel instead of two. There is also an indication that sound results in higher immersion than haptic or the mix of sound and haptic feedback. This might be related to the ability of sound to carry non-verbal information, contributing for a significant experience by structuring perception when associated with images and meanings. There was in indications of this in the debriefing sessions, where some participants reported that even when they could not immediately relate the sound to the text, as they progressed in the story they could remember and associate those sounds to what was read before. We suggest this is because both sound and literature are consumed across time, to understand a piece of music or a narrative text one needs to link all available information. Finally, if the cues were triggered before the participant was reading through the passage, because of erratic eye movement, the asynchronous cue caused expectation, where some readers tried to read quicker to know what the sound meant.

Reading Behavior

The results presented in this work-in-progress are from the subjective assessment of immersion and user experience. However, this work does not finish here, as during the experiment the participants' eye gaze was recorded using the

eye tracker. Studies suggest engaged reading shows a stable progression through lines and paragraphs, whereas in non-engaged reading gaze, is chaotic [24]. This pattern is consistent with previous studies using garden paths, grammatically correct sentences that start in such a way that the reader's interpretation turns out to be incorrect. These types of sentences show long eye gaze regressions to the beginning of the sentence, or ambiguous regions in the text, to correctly extract meaning [14]. It is widely assumed that as a text gets more difficult, readers make longer fixations, shorter saccades and more regressions. For instance, the rate of regression is higher in young children, poor readers, and dyslexic readers [29].

Additionally, participants were asked to wear a prototype of J!NS MEME smart eyewear. With this wearable device we retrieved data of: fit status; eye movement up, down, left, and right; blink strength and speed; roll; head movement in *x*, *y*, and *z*. The smart eyewear integrates Electrooculography, electrodes to detect eye movement, along with an accelerometer and gyroscope to monitor head movement [17, 1]. In fact, the smart eyewear has been used to monitor reading habits [23, 22] and behaviors [18, 25]. With data from the eye tracker and smart eyewear we will continue exploring applications for interactive reading, such as embodiment. Future work consists in the data analysis of eye activity reading in the four conditions: normal reading, sound, haptic, sound and haptic, in order to understand how the experimental embodied reading experience affects reading behavior. Eye gaze recordings will be compared with the data collected from the smart eyewear to find new possibilities for reading interactions.

Related Work

The Human Computer Interaction community has put a great amount of effort to enhance reading, from interactive storytelling, to note taking, and digital paper augmentations [6, 2, 32]. Very close to our approach is te work done by Yannier et al., who used haptic feedback to improve children's reading by making stories more memorable. They focused on young children, early reading, and on improving the learning rate [33]. On the other hand Biedert et al. studied ways to enhance reading experience. The EyeBook [4], which uses the Text 2.0 framework [5], is a reading interface that detects the area being read, generating sounds. However, until now, we have not found work evaluated between suitable interventions to produce an embodied experience.

Conclusion

In this paper, we presented an experimental approach to an embodied experience of literature, introduced a prototype for an augmented e-Reader for multisensory narratives, and an experimental methodology to measure embodiment in reading tasks. So far, we have taken the first steps to explore how embodiment could enrich written language, where mind and body perceive the narrative. We believe the multisensory approach could lead to a more memorable reading experience, transporting readers to fictional worlds they can physically experience.

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