Mobile Drama in an Instrumented Museum: Inducing Group Conversation via Coordinated Narratives

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ABSTRACT
Museum visits can be more enjoyable to small groups if they can be both social and educational experiences. One very rewarding aspect of a visit, especially those involving small groups such as families, is the unmediated group discussion that can ensue during a shared cultural experience. We present a museum mobile system that perceives and analyzes group behavior and uses the result to adaptively deliver coordinated dramatic narrative presentations, resulting in the stimulation of group conversation. In particular, our drama-based presentations contain slight differences in content between the two visitors, leveraging the narrative tension/release cycle to naturally lead visitors to fill in missing pieces by interacting with friends and initiate a conversation. As a first step at evaluation, we present a study in a neutral environment centered around the effects of those differences in stories between pairs of participants, showing that listening to narratives with slight differences between them can significantly increase subsequent conversation.

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Narrative, Drama, Cultural Heritage, Multimodal Presentations, Experimentation, Human Factors.

ACM Classification Keywords

General Terms
Design, Experimentation, Human Factors.

1. INTRODUCTION
Bringing technology to bear on the task of improving the appreciation of Cultural Heritage has often taken the form of presentation aids for visitors during a museum visit, including audio material on portable devices and visual material through various forms of kiosks or special presentation rooms. In some museums, coarse-grained localization systems (one of the first was [3]) have been introduced that keep track of what area a particular visitor is in, so that one of several presentations recorded for that specific area can be automatically selected by the system. Systems have normally stressed informative presentations written from a curator’s perspective, and visitors’ reactions are then gauged to determine what they might be interested in. Research systems have also examined adapting informative material to single visitors, for instance [15,17]. A radically different approach is to stimulate visitor interest through well-known techniques such as drama or film.

From a scientific point of view, cultural heritage appreciation is an ideal area for exploring new concepts in research on responsive user interfaces. The combination of visitor mobility and cultural settings is conducive to studying issues such as novel types of user interfaces, intelligent presentations in multiple media, and educational and cognitive technologies for improving visitors’ experiences [16]. The integration of these technologies with models of human affect [12] points the way forward to inducing emotions in human participants.

So far most of the efforts in bringing intelligent interfaces to the museum setting have focused on the individual visitor. However, it is a known fact that people overwhelmingly visit museums in groups. [14] report that only 5% of visitors come to the museum alone while 45% come in organized groups, 20% with friends and 30% with children. Existing museum visitors’ guides do not encourage interaction among members of a group; on the contrary, they can even discourage it (Sottovoce [2] is a case of a technically simple counterexample; for a communications subsystem among members of a small group in the museum see also [9]).

When they are in small groups, interaction between visitors is important: the level and quality of conversation among small groups of visitors to a museum during the visit, or immediately thereafter, can be seen as a fundamental indicator of the success of museum presentations to a small group. Provoking conversation per se is a desirable goal within the process of learning in a cultural setting, as ethnographic studies have clearly indicated [11]. Our aim is to offer technology-based drama that helps foster...
conversation on the subject of cultural heritage among
members of a small group of visitors in a natural,
unobtrusive way. Furthermore, participants should be
motivated by the same aesthetic, emotional and cultural
qualities they might expect when going to see a dramatic
play at a major theatre.

Digital storytelling can address groups in ways that would
not be possible without technology. In particular it can offer
the possibility of providing individuals in a group different
viewpoints of a story at the same time, and to adapt to the
behavior of the group as a whole, rather than just individual
behavior. In our case the aim is not only to provide an
engaging story but also to influence individuals’ behavior
so they interact more with other members of the group. The
ensuing conversation is thus inherent in the nature of the
drama experience itself and the entailed engagement of
participants, rather than being due to some external goal
given to the group, like a treasure hunt or a puzzle.

Drama has been used in museums for quite some time as a
genre of narrative that engages the visitor. In museums,
dramatizations in historical settings using human actors
have been introduced (e.g., knights or musicians in a
castle), especially for children. In traditional theatre, as in
most museums that adopt the drama genre, the audience
identically observes the entire scene and together is exposed
to the actors’ words, actions and emotions. There are also
forms of modern theatre where different parts of the public
are exposed to different portions of the scene (e.g., a visual
barrier separating parts of the audience).

This idea can be extended further: to adopt distinct
narrations for different members of a small group while
they are observing the same scene\(^1\). By presenting different
group members with slightly different (either
complementary or contrastive) versions of the same
multimedia dramatic narrative and designing each
individual drama in a way that visitors are more apt to
notice, we believe they will notice that something is missing
and then act on that fact by asking their fellow group
members, actively leading to a more general conversation
about elements of the museum.

In sum, the goals of our novel group-oriented approach,
integrating (a) group behavior sensors and reasoning and
(b) a coordinated narrative system for mobile devices based
on specific techniques for holding narrative tension, are: (1)
to have a positive effect on the group members’ view of
their museum visit, leading to a memorable group cultural
experience, and (2) have an impact on the quality and
quantity of ‘museum-oriented’ conversation. It is taken for
granted that the latter is a fundamental aspect of a
successful small group visit: conversation has been shown
by [11] to be the key aspect for learning in the museum.

\(^1\) To maintain the goal of fostering conversation, they should govern the
same content and be interconnected within a larger coherent story.

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![Image] Fig 1: Visual elements of a slightly varied dramatic presentation on two separate smartphones.

We have implemented a prototype multimedia drama
presentation system based on adaptive narration rather than
human actors, as shown in Figure 1. It is adaptive in the
sense that we can choose among many available
independent drama segments along three dimensions:
characteristics of the group of visitors, the specific evolving
context of their visit, and implicit input from the visitors
themselves. The system allows visitors to move freely
around the museum: multiple sensors and associated
reasoning provide the system with information about (a)
where people are or where they are moving to, through a
hardware-based positioning system, and (b) elements of
group behavior, including information about whether group
members are in proximity to one another, information about
anyone speaking or the length of conversational turns, and
(c) the inertial characteristics of the group, such as who is
the dominant member, and the group’s general
cohesiveness.

The starting point of our approach is the idea that good
drama can be an emotional hook for involving visitors, and
the enjoyment derived from the high quality of the dramatic
narrative, when combined with the raw emotion of being in
front of the actual artifacts, can produce a powerful
experience that participants will want to discuss.

**NARRATIVE TENSION MODEL**

If the differences in the dramatic narratives are superficial,
they may not be sufficient for visitors to notice them, and
noticeable but unmotivated differences may not lead to
conversation. We believe that taking advantage of the
tension/relief cycle inherent in dramatic narratives is one
way to stimulate interest and engagement in the outcome of
each drama and thus lead visitors to want to discuss what
they have heard without any further intervention.
Specifically, by removing or masking different information from the dramatic presentations that each visitor hears, the standard tension/relief cycle is broken and the visitors must turn to conversation with other group members to gain resolution.

As an example of how missing information affects tension and resolution, consider this simplified example of a dramatic audio presentation being delivered to one visitor:

Sailor 1: Do you remember when that storm came?
Sailor 2: Yeah, as soon as the waves rose, <garbled>

Here the listener realizes that the narrative is not yet finished and that it is in a state of high tension, i.e., the story line is unresolved (we are waiting for both the answer to the question and the effect of the waves on the ship). In typical narratives, this phase of tension is later released as the story moves along. In this work, we investigate the effects of not relieving that tension when small groups are hearing nearly identical stories.

The background for our hypothesis that missing information and narrative tension have a marked cognitive affect on people who are following a story is found in prior work with user studies like [1] (where curiosity is the term used to indicate this latent motivation):

“Curiosity is produced when the audience knows that some information is missing; there is an information gap. This mystery creates tension as the narrative unfolds. Because the audience knows just enough to recognize that some information has been omitted, he or she wants to know what was omitted.”

Alwitt performed two experiments on television viewers watching commercials, the first showing that curiosity was correlated with missing information, and the second that recorded real-time reactions showed that viewers were more curious when there was something unexpected.

More specifically, we hypothesize that narrative is such a fundamental, internal cognitive process that visitors will subconsciously be driven to be curious about resolving the information missing from the dramatic narratives we have presented to them. By ensuring that group members are in close proximity after selected pieces of critical information have been gapped out, we also ensure that group discussion is the easiest way for them to recover that information.

While the tension/relief cycle is very natural in narrative, selectively withholding information from some members of a group but not others is not a natural situation (i.e., someone speaking in person to a group can’t say one thing to one and a different thing to the others, while a computer can if the group has earphones). Group members should be made to understand that the key to resolution is in the hands of some other member of the group, in a natural way. Audio cues and the device’s display provide several solutions for hinting to members about whom in the group was exposed to what information (e.g., one character might say “Ask your friend if it isn’t true”, or a message on the screen might say “Your friend is listening to the captain” when you know you are listening to a different character).

**DRAMATIC PRESENTATIONS**

Museums typically consist of a large number of exhibits organized thematically in a number of different exhibit halls. Visitors can choose which route to take between the different exhibit halls, making it difficult to deliver a standard chronologically ordered drama. We thus deliver a series of short, self-contained dramas in front of major exhibits and another series of very short connective phrases that link the dramas together, all based on visitor position in the museum. Each such drama builds upon the overall tension in the story rather than upon a particular story element that came before.

Using specific techniques described below, we have deliberately created dramas where the narrative tension in that drama cannot find relief within itself. For this something external is needed, such as the different information experienced by fellow members of the small group while listening to a very similar dramatic presentation, and direct conversation as a means to convey that information to the other members.

To maintain overall cohesion and avoid confusion among visitors, narratives with unresolved tension are not used all the time, but instead in certain types of dramatic presentations. The types of audio presentations we have designed for visitors are:

- **Primary drama segments**: 1 to 2 minute-long self-contained dramas with a cast of characters and an identifiable plot, written for a particular exhibit. Immediately after the completion of a primary drama segment, there is a short observation period of the behavior of the group members, and the results of that observation are used to select a set of linking segments and a technique (described below) to employ for the next primary drama segment.
- **Secondary drama segments**: similar to primary drama segments but about 1 minute long, do not have a plot, and are not followed by an observation period. They serve to introduce the visitors to an exhibit hall, artifacts of lesser importance, or to new characters who will play a role in later dramatic presentations.
- **Linking segments**: Because each drama segment is independent and are played in the order they walk around the museum, visitors hearing a sequence of dramatic presentations may experience disjointedness without some means to tie the scenes together. Multiple linking segments, lasting about 10 seconds each, are strung together between drama segments to provide continuity and to help make the experencers perceive that the system is reacting to their behavior.
Fig 2: Composition of dramatic presentations

A series of drama segments follows a similar organization to the standard model [5] of narrative plot in general: an introduction followed by repeated instances of rising and lowering tension (development), followed by a climax and conclusion. In our model (Figure 2), the introduction, climax and conclusion remain constant, while the cycles of rising and lowering tension consist of a primary drama segment together with possibly multiple secondary drama segments, followed by a series of linking segments.

In our current museum implementation, the characters and situation are introduced at the museum entrance, further tension is added by presentations as the group walks towards the first exhibit hall, and then within each separate exhibit hall, a set of primary and secondary segments are presented followed by linking segments as they move to the next exhibit hall (i.e., each hall is one cycle of the loop in Figure 2). As they return at the end of the visit, the final dramas are presented and terminate when the group arrives once again at the museum entrance.

To manipulate narrative tension within a primary drama segment, we have to-date developed three techniques to provide for variation in the dramatic audio content. Each technique is applied to a primary drama segment, and is realized either by modifying a standard dramatic segment or by simple manipulations of the recorded audio of a drama.

- Audio "blurring": selected portions of a conversation are not understandable because some source of natural noise (seagulls screaming, the sound of waves breaking, etc.) interferes with the spoken dialogue (see the example in Fig. 7).

- A one-sided telephone conversation effect (named after the book “Mr. Mani” that uses this style [19]): the audio of only one dramatic actor can be heard. In the dramatic realization this may be due to distance, being on the phone, or in a nearby room. Pauses, music or sound effects are inserted as appropriate to indicate the other character whom we can’t hear is speaking. When using this technique, other museum group members may hear the second actor rather than the first, and the device’s screen shows icons representing both actors and who is listening to which character.

- Content change due to point of view: When two or more characters are onscreen, we can change the audio

<table>
<thead>
<tr>
<th>Sailor 1:</th>
<th>Captain:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huge waves!</td>
<td>Oh just look at the crew they gave me. And on my first expedition. I wanted a better crew but no, too expensive!</td>
</tr>
<tr>
<td>Sailor 2:</td>
<td>Carpenter:</td>
</tr>
<tr>
<td>A storm’s coming!</td>
<td>Kid, come with me, we have to search for boards for repairs. Bring my toolbox!</td>
</tr>
<tr>
<td>Sailor 3:</td>
<td>Carpenter:</td>
</tr>
<tr>
<td>Now you arrive?</td>
<td>Look what I have to work with! Why couldn’t the captain find someone more experienced. Where is the captain, anyway? I can’t do everything myself!</td>
</tr>
<tr>
<td>Captain:</td>
<td>Carpenter:</td>
</tr>
<tr>
<td>What are you all shouting about?</td>
<td>Now you arrive? Get everyone to help move the ballast, we’re sinking!</td>
</tr>
<tr>
<td>Captain:</td>
<td>Sailor 2:</td>
</tr>
<tr>
<td>What, what are you doing? Stop!</td>
<td>Captain:</td>
</tr>
<tr>
<td>Captain:</td>
<td>Carpenter:</td>
</tr>
<tr>
<td>The ship, it’s leaning over!</td>
<td>Quiet! Get to your places! Carpenter, go check your repairs. They aren’t holding up too well.</td>
</tr>
<tr>
<td>Sailor 3:</td>
<td>Sailor 2:</td>
</tr>
<tr>
<td>Water is coming on board!</td>
<td>Not here, up there!</td>
</tr>
<tr>
<td>Captain:</td>
<td>Sailor 3:</td>
</tr>
<tr>
<td>Lost, lost! Everyone jump!</td>
<td>The boards are coming loose!</td>
</tr>
<tr>
<td>Captain:</td>
<td>Carpenter:</td>
</tr>
<tr>
<td>Where’s that carpenter? That hole will sink the ship!</td>
<td></td>
</tr>
</tbody>
</table>

Fig 3: A sample pair of dramatic scripts with conflicting points of view of two main actors.

so that the dialogue heard reflects the point of view of one of the characters over the others.

Figure 3 contrasts two different points of view from a single scene where an ancient sunken ship on display in the museum is re-enacted.

EXAMPLE SCENARIO

Initially, a group of 4 visitors arrives at the museum for the purpose of using the dramatic system. Upon registering their smartphones with a communications server, the group is presented with a training video near the museum entrance (Fig. 4, A) quickly followed by an introduction to the drama and its characters (Fig. 4, B). The main theme of the dramatic presentations (in our case, the Hecht Museum in Haifa, Israel) is a crisis of confidence of an archaeologist upon receiving an international award for his work in pursuing archaeology and presenting artifacts in context in the museum. The drama theme both introduces the topic of the specific exhibit before visitors in an affective, engaging way, and asks fundamental questions about ethical, scientific and methodological issues in the archaeologists world. The introduction is written as a radio interview in which the archaeologist breaks down while discussing his work, leaving the studio abruptly in a huff.
Almost immediately afterwards (near Fig. 4, B), telephone calls are simulated on the devices, and the visitors hear worried phone calls between him and his family and colleagues, adding to his stress. Here, visitors get the first hint that they will not be hearing the same presentations, as each person hears a phone call with a different person. At Fig. 4, C1 or C2, the visitors and the archaeologist character are introduced to the “muse” character, who besides further increasing his stress, will accompany the archaeologist through the rest of the story.

The visitors may next move together (in a direction of their choice) near an exhibit associated with a secondary drama segment (e.g., Fig. 4 D, F or H) where they hear a short identical presentation, or else an exhibit connected to a primary drama segment (Fig. 4, E, G or I). At the location of each primary segment, the group simultaneously hears the drama with one of the techniques above applied, so that each visitor hears the same drama but with something slightly different. The system determines which technique to use automatically, perhaps based on the amount of talking they have engaged in so far or other factors, and then presents that drama.

After each primary drama segment, the group is free to move around and is meant to have a brief conversation (hopefully the drama and selected technique are successful at inducing one). The system with its sensors observes them to determine whether they did indeed talk, how much, who participated, etc. Following this they again move around freely and are exposed to one or more linking segments that attempts to connect what they just heard to the specific area of the museum where the visitors are moving to.

For instance, one of the primary drama segments centers on a discussion between the archæologist and a colleague about the meaning of one of the important artifacts (Fig. 4, E) in relation to the interpretation of why it was created and for whom. As the visitors begin to leave that area to go to another room (e.g., Fig. 4, near H or F), they might hear a multisentence linking segment (1) by other dramatic characters about why interpretations are important to archaeologists, (2) where a character describes the visitors’ reaction to what they heard, such as whether they talked to each other, (3) a sentence that links the artifact just seen to another artifact in the room which they have been detected entering, or (4) a mix of the above.

As the visitors move from one primary drama segment to another, the system continues to observe the group behavior (proximity, position and voice level of each member), adapt the technique being applied, and adapt the linking segments based on the observed behavior.

SYSTEM

The system for presenting dramatic narratives to multiple museum visitors has been implemented with smartphones as platforms for the user. Currently, dramas have been produced for half the intended sites with substantial work by the Department of Theatre at the University of Haifa. Each visitor uses one device (in our case an HTC Magic Google phone) equipped with a large color screen, WiFi connection, earphones, and various internal sensors. (Any smartphone with the requisite hardware will work, and it may be either their own or one supplied by the museum.) Each phone can communicate with those held by other members of the visitor’s group, as well as a coordinating server, and has access to position, proximity and voice information coming from other group members’ sensor devices (see below) via the WiFi connection.

When visitors are walking around the museum and not hearing a presentation, a map is displayed (Figure 5, left side) that smoothly turns to the direction they are facing via the phone’s inbuilt compass. The location on the map is updated whenever the underlying positioning system locks on to them, and a picture of what they should see in that area is displayed above the map. Colored circles representing both available (blue) and already seen (pink)
dramatic presentations are also shown on the map so that visitors don’t wander around in frustration trying to find the next exhibit with a presentation. Each dramatic scene plays only once.

In addition to the positioning system, we use server software written in Java running on a laptop to connect the smartphones to the hardware sensor suite, and the smartphones use custom software written in Google’s variant of Java for the Android operating system with the Eclipse IDE. The resources required consist of pictures for each dramatic character, each area, and the map with all area coordinates; audio files, because they are quite large and with multiple variations, are saved on an SD card in the smartphone. Once every second the server bundles the various positioning, proximity and voice level updates from all visitors and sends a copy of the update to each phone, allowing the phones to know details of the rest of the group.

**Hardware Sensors**

*Ambient intelligence*, where an environment is sensitive to the presence and actions of people via sensors, is a key concept in our setting. Sensors are a fundamental component and provide three vital functionalities in the museum environment: visitor position detection, mobile proximity of one person relative to another; and reporting the level of their conversation (voice activity). The wireless sensor network [10] takes care of different kinds of proximity and uses Zigbee [20] technology. It is based on:

- **mobile nodes**, called **blinds**: small devices carried by visitors that detect when they are within range of fixed radio beacons or other mobile devices and report that information to a server; have a weak, line-of-sight signal;
- **beacons**: stationary, battery-operated radio beacons placed near an exhibit that emit a code number allowing the blinds to tell the server which exhibit they are near;
- **network gateways**: WiFi relays that allow mobile nodes and beacons to connect to the server while remaining physically independent from each other;
- **data server**: serves as the connection between the physical hardware devices and applications that need to use positioning, proximity and voice information.

The central data server includes a reasoning component which provides higher level information to the presentation devices. Proximity to beacons is important for finer positioning when close to a specific exhibit and is seamlessly integrated into the general positioning system.

Besides positioning, two other characteristics of the detection system are specifically important for our purpose:

(a) **proximity among mobile agents**, which serves as the basis of the capability of locally understanding when a group of people are together, and (b) **individual voice activity detection**: directional microphones (pointing towards the visitor’s mouth) are integrated into the blind nodes, and the difference in intensity of the audio signal between two blind nodes in close proximity indicates whether the source is the wearer or someone else. Further analysis can help determine basic characteristics of the conversation, such as who is talking to whom, how long the conversational turns are, who has been talking the most, and when turn-taking is occurring.

Proximity among people and information about voice activity form the basis for the system to reason about the group characteristics and state. The system can also determine when people continue to stay together, and whether at an expected moment, such as immediately after the presentation of a dramatic segment, whether visitors engage in conversation, and if so who is participating.

Group behavior detection is fundamental because in the system this is one of the most important elements for providing implicit input to the system, and also for assessing for the system the effectiveness of the adopted techniques (see also [4]).

Group activity has been the object of some research, but to our knowledge this research has not emphasized the mobile aspect. One of the closest works is by Kim and colleagues [8], who used a portable device called the "sociometric badge" to monitor speaking activity and other social signals in a team. Their work is not in combination with sophisticated positioning and their aim is mainly meant to give feedback to individuals about the overall group behavior. They report on a graphical representation of the group behavior on a private display. However, their goal was completely different from ours: by reflection on their individual behavior, as represented on the display, participants were shown to better respect turns and to reduce overlaps in their speech.

**Dramatic Presentations**

We are taking advantage of the hardware capabilities of modern smartphones to create an integrated, collaborative dramatic presentation (Fig. 1) as museum visitors move around the museum. Particular presentations can be triggered by a variety of timers or sensor inputs (see the next subsection), such as locational beacons, proximity to museum exhibits or other group members, or the amount of speech by an individual or the whole group. Once the group members are determined by the locating system to be at a position with an unseen drama (either all detected by the system at that position, or one member detected there while the others are in proximity to that person), the presentation begins.

During each presentation each visitor listens to their audio channel while they see on their own phone’s screen (Fig. 1) a small photographic image at the top that represents what they should be looking at while listening. Below that, they see a set of images representing the main and supporting characters speaking in that drama, along with a short description of the character and information about who or what the other group members are hearing. For instance, if a young visitor named Antonio is listening to the ship’s captain, his little sister might be listening to the ship’s carpenter while seeing a message saying “Antonio is
hearing the Captain”. We keep the screen’s graphics deliberately simple (1) to enable visitors to quickly understand who is hearing which characters, and (2) to encourage visitors to spend more time watching the artifacts themselves rather than their smartphone screens while listening to the audio content.

Our dramatic scenario is set in multiple rooms of the museum. A team of writers from the university drama department created a set of scripts (representing an hour’s worth or recorded speech) involving historical characters relevant to the museum’s collection, as well as modern characters such as an archaeologist who helped find many of the objects in the collection. The modern characters are intended to explicitly engage the museum visitors, while the historical characters are engaged in activities that evoke their prior roles or poke holes in the archaeologist’s theories by telling the visitors “what really happened”.

To ensure that museum visitors have something to discuss, we use the specific techniques described above to show each visitor the same underlying dramatic display but with slight variations in content. During the observation period, we sum voice levels (see “Hardware Sensors” Section) over the entire observation time to produce an average talking level. If this average is above a threshold value we assume that the current technique is working and retain it for the next drama; otherwise we switch to a different technique to see if it will have better results next time.

The combination of variation in the audio content of dramatic presentations and adapting to the information derived from hardware sensors like position and voice detection allows for significant flexibility in getting visitors to discuss their museum experience. For example, the system may use a particular technique that has resulted in more conversation in a particular group’s history.

Finally, to reinforce to the group members that they are seeing a drama rather than hearing about dry scientific facts, we impart familiar expectations from drama and theatre, such as the bell chimes used to warn of the start of the next performance, animations of red curtains opening and closing on the display screen before and after a performance, images of the actors, and occasionally, applause. Figure 5 (right side) shows an example of the curtains opening at the beginning of the presentation; the phone also vibrates at this point to gain attention, but then once a drama is begun, the images are static and only the audio is active (our assumption is that video or animation would distract a visitor from the exhibit).

**NARRATIVE TENSION EXPERIMENT**

As mentioned in the introduction, the specific goal of the design and implementation of the museum experience prototype, besides the engagement and pleasure of participating in the drama, is to have museum visitors freely engage with each other in discussions during their visit. In order to be able to assess the success of this goal, we need some measure of duration and quality of conversation that occurs after a specific stimulus (here, listening to coordinated parallel dramatic presentations). We hypothesize that applying one of the three techniques (audio blurring, one-sided conversation, or point of view change) will result in measurable differences in conversations immediately after hearing a dramatic presentation compared to when both subjects hear the exact same narrative.

We thus designed an experiment to test this conversation hypothesis (Fig. 6). We had pairs of English speakers (accustomed to speaking in English with each other) listen to recordings of dramatic narratives in a small room free of distractions using a smartphone equipped with earphones (thus they could not hear what the other was hearing, although they might discuss what they heard later). Each pair heard a single training story to familiarize them with the process, followed by four stories ranging from one to two minutes and adapted from Aesop’s fables (Fig. 7). In order to keep the subjects on task (here they needed an artificial motivation, which in the deployed system comes instead from engagement with the drama and the museum itself), they were told they would be asked two questions about each story. One was about a specific element of the story content such as “Who won the race?”, followed by a fixed question for each, “What was the moral of the story?”

Each pair was randomly assigned to one of four conditions: the three techniques described above (blurring, Mr. Mani, point-of-view) plus a baseline condition where both participants heard the same story. In each condition, the pair heard four stories with the same technique applied in each. Five pairs were assigned to each condition, for 20 pairs overall. The stories were recorded in different character voices by one of the authors not involved in conducting the experiment itself.

The experimenter first read a short introduction to each story, helped them begin simultaneously, remained until the story finished, and then left the room for three minutes. Participants were told they could do anything they wanted during that time, but were encouraged not to handle the smartphones (they didn’t). They were not explicitly told to talk or to not talk. After the three minutes, the experimenter returned, asked the two questions, and then repeated the procedure for the next story. The participants were told that the session would be recorded.

**Fig 6:** The experimental methodology.
The Dog and the Wolf

NARRATOR: A starving wolf was hunting in the woods when he passed by a House-dog locked up in his master's yard. The Dog said:

DOG: Hello, cousin! I knew how it would be: your irregular life will soon be [the ruin of you]. Why don't you work steadily as I do, and get your food regularly given to you?

WOLF: I would have no objection, if I could only get a place.

DOG: I will easily arrange that for you. Come with me to my master and you shall share my work.

WOLF: I will come happily. But Dog, what has happened to the hair on your neck?

DOG: Oh, it is nothing. That is only [the place where the collar is put on at night to keep me chained]. It chafes a bit, but one soon gets used to it.

WOLF: Is that all? Then good-bye to you, Master Dog!

Fig 7: Script for one of the stories in the evaluation, with blurred audio bracketed and numbered by hearer.

One worry before the experiment was that the subjects’ attention might wander while listening to the stories, and it would be impossible to tell whether this was the case. However, an analysis of the correctness of the responses to the questions indicates that almost all subjects indeed paid attention to the task. The fewest correct responses were recorded by those in the “Mr. Mani” condition, which is understandable as pairs in that condition hear only half of the story itself as compared to other conditions.

Measures
In order to determine whether a given technique is successful or not, we need a way to measure the conversation (or lack of it) immediately after the experimental manipulation. Since the experimenter returned to the room after 3 minutes for each story, the data for analysis consist of 4 hours (20 pairs x 4 stories x 3 minutes) of audio (the amount of raw audio is significantly larger). We created a simple classification scheme and hand-annotated 5-second intervals (for a total of 960 data points, and while blind to the condition) with one of the following category codes:

1. Silence – absence of talking, but not other sounds
2. Off-topic technical content – discussion of the experiment, its apparatus, or procedure
3. Off-topic other – any conversational topic not covered in #2 and that wasn’t relevant to the story
4. On-topic, moral – discussion of the fable’s moral
5. On-topic, story – discussion of the story just heard

<table>
<thead>
<tr>
<th>Talk</th>
<th>Identical</th>
<th>Content</th>
<th>Mr. Mani</th>
<th>Blurring</th>
</tr>
</thead>
<tbody>
<tr>
<td>NoTalk</td>
<td>67%</td>
<td>94%</td>
<td>89%</td>
<td>88%</td>
</tr>
<tr>
<td>OnTopic</td>
<td>38%</td>
<td>49%</td>
<td>35%</td>
<td>63%</td>
</tr>
<tr>
<td>OffTopic</td>
<td>62%</td>
<td>51%</td>
<td>65%</td>
<td>36%</td>
</tr>
<tr>
<td>OnTopicTalk</td>
<td>57%</td>
<td>51%</td>
<td>39%</td>
<td>72%</td>
</tr>
<tr>
<td>OffTopicTalk</td>
<td>43%</td>
<td>49%</td>
<td>61%</td>
<td>28%</td>
</tr>
<tr>
<td>RelevantTalk</td>
<td>66%</td>
<td>57%</td>
<td>53%</td>
<td>79%</td>
</tr>
<tr>
<td>IrrelevantTalk</td>
<td>34%</td>
<td>43%</td>
<td>47%</td>
<td>21%</td>
</tr>
</tbody>
</table>

Table 1: Differences in proportion of conversation

6. On-topic, related content – discussion of themes brought up by the story, but not about the story’s characters or events

The worst outcome for our hypothesis would be silence, while the best outcome would be 3 minutes of discussion of on-topic, related content.

Quantitative Results
Our main hypothesis is that there will be differences between the amount of conversation in the baseline story and each of the three conditions where one of the techniques had been applied. This hypothesis is borne out by the results in the “Talk” vs. “NoTalk” row of Table 1, where in each of the conditions there was a statistically significant increase in the amount of conversation compared to silence (“Talk” is defined as categories #1-5, while “NoTalk” is category #6).

The “OnTopic” vs. “OffTopic” row indicates what proportion of the conversation was about the story (i.e., categories #4-6 vs. #1-3), where the Blurring condition had significantly more frequent conversation of the type that museums might want to encourage.

The remaining two groupings focus on conversation by removing silence from consideration. “OnTopicTalk” (#4-6 vs. #2-3) is the proportion of talking that was topical vs. not topical, while “RelevantTalk” (#2,4-6 vs. #3) is a measure of topical conversation plus discussion of the experiment (we include this because many test subjects were interested in either the smartphone technology or in discussing for instance what the purpose of the experiment was, and did so as asides within larger discussions of the story). In both cases, the Blurring strategy induced significantly more topical conversation than the other strategies.

Discussion
We conclude that the hypothesis on the increase in amount of conversation after the application of any of the three narrative variation techniques is confirmed: all three
techniques induce more conversation; in fact, they talked almost the entire three minutes we allowed them after each story, compared to two or three minutes for the baseline condition. But of the three conditions with techniques that create differences, only blurring induces significantly more on-topic conversation. The other two techniques, Mr. Mani and content change, have significant differences in talking overall, but not in topical talk (the Mr. Mani condition actually saw less topical talk, even more so when silence was removed from consideration).

The next step is to hold the same experiment in an actual museum setting in order to remove any artificial motivation and to see if the effect carries over to a distracting, sometimes noisy real environment like a museum.

RELATED WORK
Like the Affective Guide [12], our system is a story-telling tour system for visitors to cultural heritage sites. Affective Guide is a PDA-based system that uses GPS to trigger storytelling episodes via text-to-speech as a user walks by a specific location. A 2D virtual tour guide on the PDA (an animated head) speaks out loud each story, whose length is determined by an emotional model. The emotional model is included in an attempt to lessen the frustration users feel when interacting with non-adaptive systems. Whereas Affective Guide is used in outdoor settings and is intended to be a testbed for the underlying emotional model, our system is mainly intended for museums as a way to encourage discussion of the interesting exhibits that visitors come across. Both systems use pre-written scripts, although in our system each segment is one part of the overall story rather than a single self-contained story.

Façade [13] is a story-based interactive drama game intended to show the video game community that there are other approaches beyond shooting enemies and looking for resources within explorable worlds. The game consists of an animated set of married characters controlled by the computer who interact with a “friend” character controlled by the user. Language and gesture are used as the principle interactive mechanisms, and a drama manager uses a weighting algorithm to determine the next step of the drama given the user’s input. Unlike our system, Façade can produce original stories given differences in user input, whereas our system is highly scripted and variations occur between the major elements of the drama, although these variations are also driven by user input and behavior.

Drama in a mobile setting is something that has appeared some time ago. Multiple synchronic scenes, each visible only to a subset of the spectators, which would then move to another location, were in the tradition of some forms of popular theatre already in the Middle Ages. Some concepts have come back in contemporary theatre (e.g. in Luca Ronconi’s Orlando Furioso, 1969). In more recent times the concept has found a natural match in communication and positioning technologies. Mobile Urban Drama has been introduced [7] based on cellular phone technology and standard, readily available positioning in the open: GPS, WiFi and tags for very close detection of hotspots. The user is the main character and actors’ voices are heard through the cellular phone. The user is directed to different positions in a city and has to look for specific spots and information. Real actors integrate the scene. The concept, though, is not particularly based on interaction within a group of users. And certainly it does not include the idea of location based technologies and coordinated narratives with specific techniques oriented toward favoring face to face natural conversation in a small group.

A large number of prototype museum guides have been developed that seek to present historical or educational material to museum visitors either in an adaptive way that focus on what the guide thinks a visitor might be interested in. Sotto Voce [2] instead looked at social interaction as a primary design goal, namely, how group members can influence each other as a means to improving education or retention of museum knowledge. Thus Sotto Voce allowed group members to hear the audio from each others’ PDAs by explicitly selecting an “eavesdropping” button on their own user interface. However, to the best of our knowledge, no research on museum guides has yet addressed how to change the behavior of group members as they explore a museum.

CONCLUSION
In order to produce a system that can realize the tension variation hypothesis, we had to implement three main aspects. First, a complex group behavior detection system, based on the use of a sensor network integrating an interior positioning system, with the capability of detecting proximity among people and voice activity. Second, a system for planning coherent story segments and coordinating multiple presentations that delivered through personal devices in a coordinated manner, where the planning system must adapt to the group behavior. Third, the material presented composes a drama, and as such it has to have high production values, interesting content, and good aesthetic and emotional quality; in particular a key aspect is the use of specific techniques in the combined individual-oriented narrations, which are a catalyst to immediate face-to-face conversation.

A system prototype has been realized and is undergoing further experimentation at the Hecht Museum at the University of Haifa. As mentioned earlier, the message in the end is that there is no single truth, and that the picture requires an integration of different points of views and perceived aspects. The ensuing social behavior in the group echoes the message of the drama. Seriously evaluating the overall result will take a long time, and only a final system with no flaws, as for any theatrical representation, can really keep grown up visitors engaged. Altogether, initial feedback indicates that there is a serious prospect, from technological, artistic and applied points of view, for novel sophisticated storytelling combined with ambient
intelligence for groups. Furthermore, the fact that here we showed conversation significantly increased as a result of the use of narrative variation techniques gives us strong reason to believe it deserves further exploration.

ACKNOWLEDGEMENTS

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