AFFECTING DECISION MAKING: ELICITING EMOTIONAL RESPONSES DURING MAP READING THROUGH MUSIC

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ABSTRACT:

Long recognized in the arts, the influence of sounds and music on emotional reactions to visual stimuli remains remarkably unconsidered in cartography. Social scientists are increasingly aware that cognitive processing and decision making cannot be fully understood without accounting for affect. Geographic representations are often designed for decision making, but strategies for representing, incorporating and eliciting emotion in decision making have yet to be formalized with maps. Maps used in decision making are not often considered satisfactory to convey mood and emotion; is the mapped area scary, delightful, depressing, invigorating? The adjectives above, however, are frequently used to describe music; composers, musicologists, and even neuroscientists are aware of the conventions used in music to elicit these sorts of emotions. With the ubiquity of broadband Internet, widespread acceptance and use of web maps, and low cost of audio-ready computers, the time is ripe (or has already passed) to fold in conventions of music into the existing body of cartographic conventions. Here, we present a web-based experiment that investigates whether adding a music bed to a simple decision-making environment can influence decisions and, perhaps more importantly, influence the emotional reactions of subjects upon seeing (and hearing) the maps. In the experiment, subjects in three groups are shown identical visual stimuli (fictional city maps through an interactive interface) and asked identical questions about the city, including locating a place in the city to which they would most prefer to move. The sole difference among the groups was the type of music that played in the background as they made their decisions. This paper will describe and demonstrate the experiment and report on preliminary findings.

1. INTRODUCTION

It has been more than fifteen years since John Krygier (1994) suggested that the addition of abstract sounds on maps could enhance the communication (or even exploration) of geographic data by opening a cognitive channel, other than vision, though which humans readily absorb information. The abstract sound variables, as he called them, included the basic building blocks of music: pitch, loudness, timbre, attack and decay, and register, among others. While musical primitives can be theorized and shown to adequately represent geographic variables of various levels of measurement (timbre for nominal data, pitch and loudness for ratio data, for example), the abstract sound variables in effect replicate the visual variables, and serve as a framework for representing those things that (visual) maps already represent well. As such, they are useful for bivariate or multivariate maps, as Fisher (1994) used them in representing uncertainty with sound, and for creating maps for users with vision impairment (Golledge et al., 1994; Jacobson, 2002; Zhao et al., 2005; Rice et al., 2005). However, as we know, music, with its complex and systematic structures, is far more than the sum of its parts, and music, in contrast to abstract sound variables, has the potential to supplement – and not simply replicate – visual representations with meaning that, until recently, maps have never been thought to have. In particular, music has qualities that have long been known to elicit affective responses in listeners. It follows logically that the incorporation of music into maps, even in a rather simplistic way, might imbue maps with the capability of eliciting emotional responses about the place or phenomena represented on the map.

This paper reports on the development and implementation of a web-based experiment that tests whether a decision-making environment, like one that might be found in a visual-analytic context, can be supplemented with music in an effort to create an emotional response to a represented place, and whether that response is dependent on the type of music that plays. This research differs from past efforts in implementing sound in cartography in that sound will be used here not to directly represent data (as in "sonification" research), but rather, as it is used in cinema and other art forms, to establish a mood and possibly influence behavior.

2. BACKGROUND

2.1 Emotion and affect in cartography and visualization

Certainly, it should not be inferred from the previous paragraphs that (visual) maps do not, at present, intentionally or unintentionally elicit emotion. J.B. Harley (1987) wrote reflexively on the powerful memories and feelings brought about by a "scientific" ordnance survey map of his hometown, echoing the feeling that many of us get when perusing atlas maps of an exotic, or familiar, place. Schulten (2001) considers maps' roles in the development of the American "imagination" of the North American west, in a stream of literature about the power of maps to build territory and myth. Recent books by Harmon and Clemans (2009) and Abrams and Hall (2006) consider alternative visual representations of place that draw on, and draw out, emotion. Recently a new International Cartographic Association working group called "Art and Cartography" has formed that examines (among other things) the intersection of visual art and cartography and the power of the visual map to be artistic and appeal to both the left *and* right sides of the brain.

Yet with the astonishing technological advances that have made music more ubiquitous now than in all of history (Hargreaves and North 1997), remarkably little attention has been given to the addition of music – and of sound at all – to the map, and in particular to its potential ability to provide maps with emotion. The notable exception is the work of Brauen (2006) and Caquard et al. (2008), whose essays and experiments in dynamic maps using sound consider the cinematic qualities of maps as storytelling devices, and supplement maps with non-abstract sounds such as political speeches, airplane engines, and natural sounds. Sound plays a significant role in their studies, as spoken language, scores, songs, and sound effects play significant roles in film.

In their dynamism, maps used for visual analytics or communication are far more filmic than ever before, and understanding the drama of the moving image has allowed cartographers (or, perhaps more often, graphic designers who are not cartographers) to create startling, moving, and affecting representations. In the few years since Aitken and Crane (2006) called for an invigoration of affect in geovisualization, we have seen the explosion of digital globes, interactive satellite imagery, and crowd-sourced geotagged photographs, video, and content, all of which appeals to users at a visceral and often inspirational level.

Cartwright et al. (2004) stressed the role of multimedia GIS and multiple senses in his vision for geographic visualization. Data used in geovisual analytical problems is no longer solely quantitative, and often an important consideration in analysis of information is the mood or tension present in the situation at hand (Thomas and Cook, 2005). In a security scenario, for example, a place may be at a higher risk for a terror attack if the rhetoric is already at higher-than-normal levels of anxiety and antagonism.

In the multimedia age of present cartography, the dynamic aspect of maps is often exploited to show phenomena in sequence. Dynamic maps change and are experienced over time, so it follows that, particularly for maps that are designed to be experienced over time, some of the dynamic arts – music, film, dance, or even video games – for which time, pacing, rhythm, and sequence are vital to their appeal – are now particularly suitable for consideration when designing geographic representations.

2.2. Sonification and data communication

Sound has long been undervalued in analytical situations, particularly those that involve computers (Kaper et al. 1999; Preston and Fowler 2004). Limits to the adaptation of sound are technical: mass communication of knowledge since the scientific revolution has been, first and foremost, accomplished through media such as books, graphs, tables, and journals that are visual and not aural. Most computers until only a decade ago did not have sound cards, and only in the last several years have we seen a convergence of forces (personal computers, high-speed Internet, and technology for creating and storing sounds and music) that make aural representation and dissemination of information practical and widespread. Such a convergence is coinciding with the increasing need to comprehend vast quantities of information (Kramer et al. 1997).

Sonification is an interdisciplinary field that has arisen that studies ways in which data can be transformed into an acoustic signal for the purposes of facilitating communication or interpretation of data (Kramer et al. 1997). Psychologists and neuroscientists (Handel 1989; Gray 1977), composers and music theoreticians (Tipei 1989; Xenakis 1992), computer interface designers (Marcus 2006; Gaver 1997), and domain-specific researchers are all interested in designing tools to communicate or explore their own information in innovative ways (Pereverzev et al. 1997; Hermann and Natkemper 2001).

There have been successful experiments that show that humans can recognize patterns through changing parameters of sound (Yueng 1980; Bly 1982; Wenzel, et al. 1990), and in some cases, sounds revealed information that was undetected visually (Pereverzev et al. 1997; Flowers 1997). The multidimensional nature of sound, and the abilities of humans to perceive and understand these dimensions, make sound a reasonable medium for the encoding of relatively complex information as might be found in applications of information and/or geographic visualization. This idea is far from new: Geiger counters and sonar are two scientific applications where abstract information is expressed through sound. User interface designers have, over the last two decades or so, explored the use of sound to make computers accessible to the visually impaired or useful to individuals whose "eyes and hands are busy" (such as drivers using in-car navigation systems).

However, music is differentiated from the abstract sounds, such as those in sonification, sonar, or Geiger counters, in the way the separable elements of sound (like loudness, timbre, and tempo) combine, and in the relationships that form between them. These combinations and relationships give way to higher-order structures such as melody, harmony, meter, and key (Levitin 2006). These musical concepts generally have not been considered with respect to maps; Krygier's (1994) framework dealt primarily with the properties of sound (though "order" might be considered a form of melody).

2.3. Music, social psychology, and affect

Studies relating to the psychological effects of music have a very long history, primarily in terms of its ability to have social influence (Farnsworth 1954) and impacts on learning (the famous "Mozart effect," for example; Hall 1952, Fogelson 1972). Music has a particularly important role in society; the field of social psychology, which investigates the "reciprocal influence of the individual and his or her social context" (Hewstone and Manstead 1995, 588), sees music as playing a crucial part in communication, even across cultures that do not share a common verbal language[1] (Hargreaves and North 1995). Of the many ways music has been studied by psychologists (including physical perception of tones and rhythm, ethnomusicology, music in development), particularly relevant in this study are ways that background music can elicit emotional responses and influence behavior.

There is strong evidence that different types of background music have different effects on people. In studies to investigate this, music is typically characterized along a continuum from sedate to stimulating (Gaston 1968, Hallam 2002). In many cases, background music has a positive influence on learning (Hall 1952, Scott 1970), but not always, and that the type of background music is a key consideration. Music that is highly "arousing," that is, likely to cause excitement or anxiety, is positive to a certain level (Baumgartner 1992) and then, not surprisingly, can overstimulate, cause distractions and have a negative effect (Crozier 1997).

Much current research on the influence of background music on emotion and behavior is carried out to study how consumers react to auditory stimuli, for example, in stores (North and Hargreaves, 1997). For example, Milliman (1981) discovered that background music of a slow tempo tends to lead supermarket shoppers to spend more time in the store and to make more purchases than when faster music is played. Similarly, Areni and Kim (1993) compared the influence between classical and pop background music in purchasing habits of wine shop customers. They showed that while classical music makes people buy more expensive wine than pop music, but not more wine.

As in the above cases, independent variables in studies of background music tend to alter basic properties of music that have been theorized and shown to arouse different affective responses. Baumgartner (1992) has reduced the moods and emotions related to music to two basic axes: degree of pleasure (playful, cheerful, joyful to tragic, mournful, solemn), and degree of arousal (vigorous, triumphant, exciting to tranquil, sentimental, soothing). This followed Bruner's (1990) characterization of affect from background music designed to influence consumer behavior. It is Bruner's generalizations of music that might arouse "excitement," "tranquility," and "sadness" that were used in the design of the music for the experiment reported in the following sections.

3. AN EXPERIMENT

We have designed and constructed an experiment that seeks to investigate the question of whether a place can be imbued with emotional meaning through its representation on a map with the addition of music. Our experiment requires subjects to make several decisions and judgments about a city, using a custom-built "decision-making environment." In addition, after the decisions have been made, subjects are also asked about their emotional reaction to the city they just studied to answer the decision questions.

[1] however Gregory and Varney (1996) have performed cross-cultural studies that show that the emotional responses to music of people vary significantly among different cultural backgrounds.

Data gathered for each respondent consists of answers to four analytical decision questions and a word list of emotions that express their feelings about the place. The data will be analyzed for similarity of answers among three aggregated groups, categorized according to the type of music that was heard in the background (the "music bed") while the subject was participating in the experiment.

Our hypotheses for this study are the following, that among the three groups

- H1: there will be no significant differences among analytical decisions made,
- H2: there will be significant differences among response times to the decision questions, and
- H2: there will be significant differences among word lists describing their feelings about the place.

3.1. The experimental design

To investigate the above hypotheses, we carried out a web-based survey. Subjects, who, in the pilot phase reported here, are recruited through the author's geography classes, are instructed to visit a web site, hosted by the university. Upon entering the web site, subjects are randomly assigned into one of three groups (A, B, or C). After an introduction, the decision-making environment is revealed, and, depending on the group to which the subject was assigned, one of three music beds is played in the background as the survey proceeds. The music bed assignment thus comprises the control variable, as all other aspects of the experiment are kept as similar as possible among the subjects (since this is not a controlled lab setting, distractions or other variations among subjects is unavoidable).

In the first part of the experiment, questions such as "Where in the city is the highest risk for your house to be burglarized?" are answered by clicking directly on the map. Data recorded for this portion of the experiment includes the coordinates (x, y) that are recorded, as well as the time necessary to make a final decision. The mean centers and standard distances based on these coordinates can be gathered for each group and difference-of-means tests can be performed to assess the significance of the differences in decisions. Additionally, mean response times can be obtained and analyzed among groups.

After these four "analytical" decision-making questions, the decision-making environment disappears, the music fades to silence, and a final question appears. This asks subjects to choose from a set of nineteen adjectives, listed in random order, that indicate their emotions regarding the city they had just considered. These nineteen adjectives, listed in section 4.3 below, were chosen based on Plutchik's exhaustive categorization of emotions (Plutchik 1980). Data recorded for this portion of the experiment consists of a word list, which then can be summarized (e.g., "68% of Group A's emotions express *anticipation*") and difference-of-proportion tests can be performed to assess the significance among the differences in emotions expressed.

3.2. The music beds

The three beds for groups A, B, and C, respectively, conformed to the framework developed by Bruner (1990), which describes music in terms of a combination of musical characteristics (similar to the abstract sound variables of Krygier (1995) and to the musical primitives as applied to maps more recently by Edsall (2008)), specifically mode (major/minor), tempo (fast/slow), pitch (high/medium/low), rhythm (firm/steady/uneven), harmony (consonant/dissonant), and volume (loud, soft). Rather than treating each of these as an independent variable (which would require thousands of combinations), Bruner groups these primitives together, suggesting that, for example, "tranquility" is elicited with music that is major, slow, medium, steady, consonant, and soft.

Using these groups, the author used LogicPro in the University of Minnesota's digital music lab to create three music beds - .mp3 files of less than one minute duration, designed to loop indefinitely while the subjects completed the survey. The first was relatively slow, major, medium in pitch, firm in rhythm, open/consonant in harmony – a combination Bruner (1990) theorizes elicits feelings described as "serious." We might expect that adjectives that align with serious – anxious, content, envious, lonely – are more likely in this group. The second was relatively fast, major, high, uneven, and consonant, thought to elicit "excitement." Finally, the third was slow, minor, low, steady, and dissonant, a combination that aligns with "sadness."

3.3. The decision-making environment

In general, the decision-making environment (Figure 1) consists of six maps of an unnamed US city (the city is in fact Kalamazoo, Michigan, chosen because of its medium size, clear delineation of land use types from the aerial images, its simple gridded layout, and the expected lack of familiarity among Minnesota college students with the city). The six maps are the same scale, extent, and location, but each represents a different thematic variable, thus simulating a simplified GIS interface with very limited functionality.

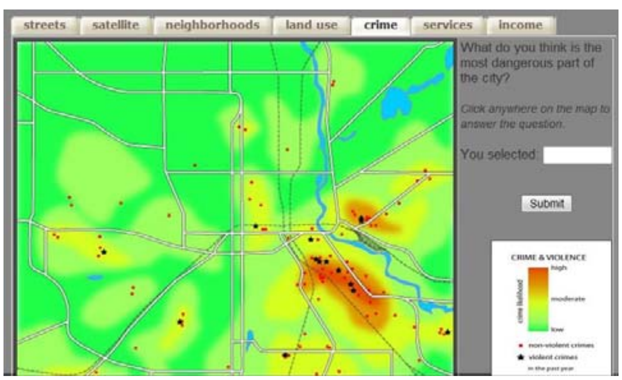

Figure 1. The decision-making environment for the experiment.

The interface for querying these maps is a simple tab structure, similar to a contemporary web browser; subjects can click on one of the tabs to change the map view to a different theme. Themes cannot be displayed at the same time. While this is admittedly a far less functional environment than one might expect to find in an expert-oriented visual analytic scenario, the subjects for our experiment are assumed to be at best novice users of GIS and it is important to keep them from being frustrated by a complex GUI.

The six maps that are available to the subjects through the tabs are (1) a basic major-arterial street map, with polygons of parks, cemeteries, and other features partially and generically labeled; (2) a "satellite" image, similar to those in common web mapping applications; (3) a land use map, with general classifications of "residential," "public open space/non-residential," "industrial," "commercial," and "forest/agriculture"; (4) a choropleth census tract map showing median household income, (5) a services map, showing point locations of police stations, shopping centers, hospitals, and schools, and (6) an isarithmic crime map, showing crime risk intensity, overlain with point patterns showing both violent and non-violent crimes in the past year. The data on the maps is synthetic in order to simplify decision making, and because the decisions themselves are less important than the differences in those decisions among the groups.

In addition to the tabbed interface and the six maps, legends for the maps are also provided in the lower right of the window. Above the legend, after the experiment begins, a question appears, with instructions to click anywhere on the map to indicate an answer. Map coordinates (in arbitrary units) are displayed, and subjects click a "submit" button to record their choice.

3.3. The survey

After an initial welcome screen and electronic IRB consent pages, the subject is told that the purpose of the experiment is to assess the interactive map environment for facilitating decisions about a city. We do not disclose that the independent variable of the experiment is the music bed, but we do ensure that the subject has the speakers (or headphones) of the computer turned up and functioning properly: on the third page of the survey, the subject is required to "check the audio," pressing a button that not only plays a brief music file but also gives verbal instructions (not visible or written) on how to continue with the survey. If the audio is turned down, or isn't functioning, the subject would not know how to continue (by clicking on a specific yellow bar in the lower right of the window) and would likely exit the experiment.

After the audio is confirmed and the subject proceeds, an audio file with a greeting and instructions about using the interface plays. To ensure that the subject understands the tab functionality of the interface, the audio instructs to click a tab to see what happens. After the user does so, a sample question appears: "where on the map is an industrial area?" The subject is instructed that there may be more than one possible answer to all of the questions, submits an answer (not recorded), and starts the survey.

The survey consists of four questions in increasing order of complexity:

1. Where in the city is the downtown commercial area?
2. What do you think is the most dangerous part of the city?

3. Which shopping center is most likely used by the wealthiest residents?
4. If you were moving here and wanted to raise a child here, what area of town would you most likely purchase an existing home?

The first question can be answered with one map and is essentially a value-identification problem; the second is more complex, as it involves a personal judgment ("danger" can imply crime risk or, potentially, risk of an automobile accident, or of becoming lost, among other possibilities). The third requires comparing at least two maps, and the fourth represents a rather complex multi-criteria problem where the subject feels he or she has a personal stake in the decision.

After the fourth question is answered, subjects are asked the following:

> Imagine this city overall, and think about how you feel about it having looked at these maps. Click on one or more of the words below that you think best finishes the following sentence: **This city would make me _________ if I were to visit.**

This is followed by a list of 21 items arranged in three columns. The first 19 are the following adjectives, arranged in random order from subject to subject:

> amazed, angry, annoyed, anxious, content, depressed, disgusted, envious, excited, frightened, frustrated, hopeful, isolated, joyful, lonely, passionate, relieved, satisfied, unhappy

The twentieth item on the list is a check box labeled "feel no particular way," and the twenty-first is a check box labeled "some other way," with a text box enabling the subject to add his/her own adjectives.

Finally, the last page, an "exit interview," asks subjects to click a choice of radio buttons

- o I kept the sound up during this experiment
- o I turned down the sound as I was exploring the maps

and an invitation to add any comments about the experiment. This allows us to track if the music was distracting enough to hinder the map reading and decision making tasks, and remove the responses of subjects who worked in silence from the analysis.

4. RESULTS

At the time of writing, the experiment was still "live," and we remain in data collection. A report on the pilot experiment, its data, analysis, and results, will be presented orally at the meeting and a written report will be made available in the session as a supplement. Please contact the author for up-to-date information.

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