Music in film and animation: Experimental semiotics applied to visual, sound and musical structures

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ABSTRACT

The relationship of music to film has only recently received the attention of experimental psychologists and quantificational musicologists. This paper outlines theory, semiotical analysis, and experimental results using relations among variables of temporally organized visuals and music. 1. A comparison and contrast is developed among the ideas in semiotics and experimental research, including historical and recent developments. 2. Musicological Exploration: The resulting multidimensional structures of associative meanings, iconic meanings, and embodied meanings are applied to the analysis and interpretation of a range of film with music. 3. Experimental Verification: A series of experiments testing the perceptual fit of musical and visual patterns layered together in animations determined goodness of fit between all pattern combinations, results of which confirmed aspects of the theory. However, exceptions were found when the complexity of the stratified stimuli resulted in cognitive overload.

Keywords: Music, meaning, film, semiotics, sound, temporally organized

1. INTRODUCTION

The ubiquity of media forms at this point in intellectual history demands attention by experimental science, however, the majority of research is focused on static visuals and in music on single tones or chords. The fact is that such stimuli are easily controlled in psychophysical experiments, and assumptions can be made about the orthogonality of variables. As experimental research has expanded into contextual variables, temporality, particularly in music, has finally been acknowledged to be on at least equal footing with issues of tonality and melodic structure (assumed to be an isochronous train of pitches in many theories). In fact, perception of pitch patterns with various temporal structures shows that rhythm emerges as primary to pitch in judgments of melodic similarity.[1] The layering of temporally organized musical variables and visual variables in multimedia is an important area of study still in relative infancy.

The need for further study arises not only to address relations between psychophysical studies of static stimuli and those with temporal context, but also to move towards the ecological validity that is the temporally dynamic real world of sensory perception. A convergent approach comparing and contrasting data from natural contexts such as film and abstracted contexts such as experimentally controlled animations is useful in understanding the perception of the layering, or stratification, of musical and visual elements in multimedia.

Tannebaum[2] conducted an early study of a play performance evaluated on semantic differentials (e.g. good-bad, interesting-boring, active-passive). The performance conditions were live, recorded live, or recorded in a studio. Phonograph recordings of music were played during these versions. Results indicated that the performance condition did not significantly change the ratings, however, the music selected altered the ratings, particularly for adjectives connected to potency and activity. As in many early studies, the music was not edited to eliminate issues of temporal accent (salience) congruence as a potential confounding variable. Results did demonstrate the ability of musical meaning to alter the meaning of the composite scene, that is, to dominate the visual and other dramatic variables. Marshall and Cohen[3] constructed stimuli that used an animated film of abstract geometrical objects and composed music (consisting of two themes - considered "strong" and "weak") varying in tonality, texture, tempo, and tessitura. Although music and visual alignment was the same across excerpts, accomplished through editing on video tape, no apparent attempt was made to establish structural accent alignment within the scene. Subjects evaluated the animation without music, the music without animation, and composites using strong and weak music using bi-polar adjective pairs of the

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semantic differential model (as above). Results demonstrated that music could influence the interpretation of the geometric figure's personality characteristics also in terms of potency and activity; music trumped visual elements in communicated meaning.

Lipscomb and Kendall conducted an early study using a Hollywood film.[4] They set out to model film music in terms of communication, suggesting that a film composer and film editor have implicit schemata or knowledge structures for combining visual and sonic elements. Therefore, the stimuli were drawn from a successful Hollywood Film, *Star Trek IV*[5] (music by Leonard Rosenman, who received an Academy Award nomination for the score). Five scenes were selected via a pilot experiment to avoid redundancy of visual and musical elements. The music intended by the composer with each scene was then edited into all other scenes, creating an intended example with four foils or lures. These edits were made by a panel of film composition student experts so as to align the visual accents within a scene to the music with the best possible fit within scene, thereby minimizing this variable. Subjects were asked to rate the goodness of fit of music to the film scene for all 25 combinations. It was found that the subjects could determine the composer-intended match beyond chance. For example, even in the hospital scene where the visual expressions and actions of the characters telegraphed tension and fear, the intended music in up-tempo major with its associations of comedy was selected by half the subjects.[6] To further explore these combinations, semantic differential ratings using evaluative, potency, and activity bi-polar adjectives were collected for music alone, video alone, and composites. ANOVA analysis demonstrated that subject ratings varied significantly when the music alone was changed across visual contexts, confirming again that the music can alter the "meaning" defined in terms of these adjective pairs. Principal components analysis resulted in activity and potency components, as in the previously detailed research. As Marshall and Cohen suggested, the evaluation (goodness of fit) in this case can transcend these meaning changes as a composite rating which incorporates activity and potency dimensions. These results led both Lipscomb and Kendall and Marshall and Cohen to postulate a comparator level of cognitive analysis involving associative as well as accent alignment congruence.[7]

2. Theory

After completion of the above study, the author (R. K.) noticed several aspects of the prevailing models: 1. Association, an apparently learned behavior and the foundation of much behavioral theory, was at the heart of the tendency for music to change the meaning of a given visual scene. A common association was between major and minor music and positive and negative events; this pairing has been studied and confirmed with children; 2. The congruence or alignment of accent structures, studied extensively by Lipscomb,[8] was also perceptually important; 3. There is a comparative aspect linking relations between these variables in the musical and temporally structured visual domains resulting in a composite rating of goodness of fit or connected to aspects of attention. Studies of memory retention for visual and dramatic cues within film demonstrate the interaction of these components. Boltz[9] states that "Results revealed that relative to a control group with no music, positive and negative music significantly biased viewers' interpretation and subsequent remembering of a film in mood-congruent fashion (p. 427). " An earlier experiment by Boltz also demonstrated that memory was enhanced for film music combinations where the music foreshadowed incongruently, and where music and visuals were mood-congruent without foreshadowing.[10] Therefore, a model incorporating issues of meaning via models in semiotics, is hypothesized to be useful in extending and expanding research. Earlier approaches of the author are expanded and extended below.[11,12,13]

Dowling and Harwood's *Music Cognition* [14] approaches music and emotion from such a semiotical orientation (in part, see Chapter 8), incorporating concepts from the writings of Leonard Meyer[15] and Charles Peirce[16]. Each approach can be simplified into a 3-part taxonomy (Figure 1). In Meyer meanings arise from *referentialism*, which is the associative aspect of music. Another meaning, called *formalism*, stems from a listener's explicit knowledge of facts about music, such as the formal structures (e.g. Sonata form) or historical information (e.g. the year a piece was composed or first performed). A third, and essential, type of meaning is that which arises from within the music itself, which he called *embodied meaning*. Embodied meaning results from expectations and their resolution (or lacked thereof) generated by patterns within the music itself.

Peirce may be credited with one of the first models of semiotics, which he called logic. His 3-part taxonomy includes *index, icon*, and *symbol*. Although it is tempting to connect the first and last concepts directly the Meyer, above, there

are subtle differences which space precludes analyzing here. Important in Peirce is the concept of *icon*[17], where a signifier has a pattern resemblance to the signified. Thus, whereas the word *cat* denotes by an arbitrary association to the signified object, a smiley face with lines drawn away from its circumference connotes its signified object, that is, it *suggests* a cat because of its form. Computer icons are thus formed similarly. The power of music to have meanings that are, at times simultaneously, referential, iconic, and embodied is intimately related to its use with temporally organized visuals and can form a basis to understand film music.

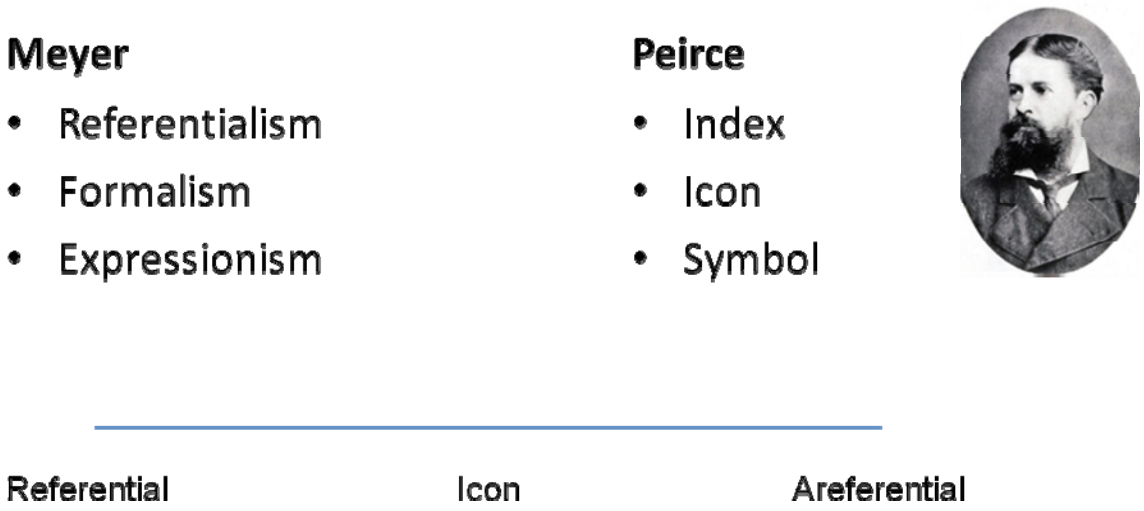


Figure 1. The semiotic concepts used in the current study. See text. Image of Charles Peirce is public domain (http://www.photolib.noaa.gov/htmls/theb3558.htm, found Feb. 21, 2010. See also http://en.wikipedia.org/wiki/Charles_Sanders_Peirce).

Referential meaning is associative. A common associative meaning in music for both concert and film is a national anthem or patriotic tune. In the film *Footlight Parade*[18], for example, the musical score consists of arrangements of *Yankee Doodle* and *Anchor's Aweigh* (among others) while the image in Figure 2 forms. This can be called extra-referential in that the associative meaning is external to the film itself; those attending the movie are expected to already know the musical themes and their patriotic connections. In concert music, the *1812 Overture*[19] is an example. Other film scores that extensively use extra-referential meanings within their structure include *Casablanca*[20] and *Gone with the Wind*,[21] both with music by Max Steiner. The use of major and minor tonality to associate with positive and negative events is also an example of extra-referentialism. There is no particular reason why major is positive; it is an arbitrary association. Therefore, in *Casablanca* the French National Anthem is associated with the French Resistance and is in major, while the German national anthem is associated with the occupation and is scored in minor.

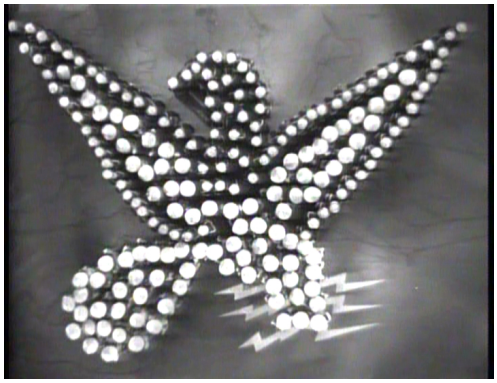


Figure 2. Still from *Footlight Parade* (1933).[22] Patriotic tunes elicit extra-referential meaning.

Intra-referential meanings are associations within the film itself, a technique called *idée fixe* or *leitmotiv*. Thus there is the five-note theme that is associated with the aliens in Williams' *Close Encounters of the Third Kind*[23] score, or the simple minor-second motive with the shark in *Jaws*[24], or the theme associated with the title character in *E.T.: The Extra-Terrestrial*.[25]

Iconic meanings arise from pattern similarity and suggestion. Some writers use the word *gesture* to refer to how these musical structures connect to visual structures. I identify several common icons, among others: *Ramps*, which monotonically increase or decrease in a musical (loudness, texture, pitch, etc) or visual (size, distance, height) variable; *arches*, which first increase and then decrease, and *bursts*, which are called a stingers in film composition parlance.

Instead of maintaining the 3-part taxonomic structure of these semiotic models, it is best to conceive of a continuum of referentiality, from referential (associative), through icon, to areferential (embodied). In fact, many different sources of composer-intended meaning can be active simultaneously and can be dynamically changing during a given scene within a film. Perceived meanings are hypothesized to be similarly dynamic, with attentional focus via learned schemata resulting in those intended meanings that are salient and received by the observer. An audience's perception of the composer's and film maker's/editor's intent will necessarily be varyingly veridical with the audience's perception, not fixed in psychophysical isomorphism. Simply put, culture (e.g. shared explicit and implicit knowledge) is at work informing the communication process.

E.T. The Extra-Terrestrial, music by John Williams, provides an excellent example of these processes at work. The bicycle chase scene includes music that maintains syntactical congruence (with the use of an opening 3/4 + 3/8 meter to maintain connection to the pedaling of the cyclists),[26] and also incorporates pitch contours that iconically follow the motion of the cyclists. Figure 3 is a still from this sequence; the music is a pitch arch that follows the cyclists over the hill, and is thus iconic relative to the visual motion. Such icons serve to reinforce and draw attention to the central activity. Although the character E.T. appears in this sequence, it is not until a close-up later in the sequence that the intra-referential theme associated with his character re-appears.

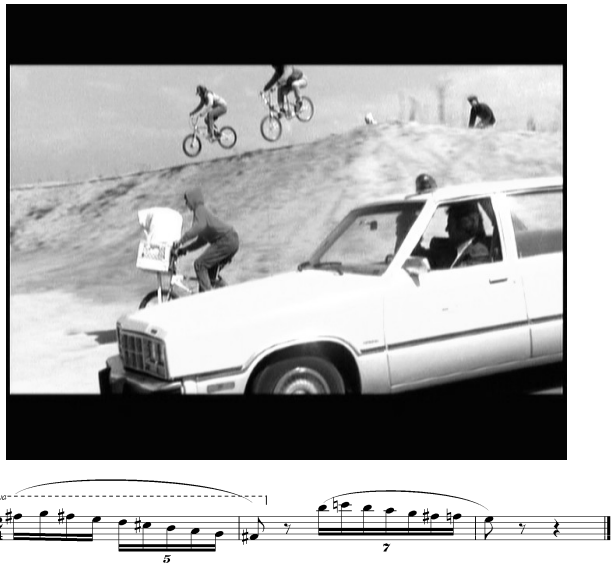


Figure 3. Pitch contour arch in the music follows the bicycle visual arch over the hill. Still from *E.T. The Extra-Terrestrial*.[27,28]

A dissonance and loudness ramp appears before the cyclists visually ramp upwards. The E.T. intra-referential theme appears and the accompanying music lines maintain the syntactical accent structure of the pedaling throughout. The intervals of the theme become greater (approaching and reaching an octave); the pitch height of the line iconically accompanies the rising of the cyclists. Thus, we have intra-referential, iconic, and congruent (syntactical) meaning all at once (Figure 4).

Figure 4. Flying, a still from E.T.: The Extra-Terrestrial.[28] See text.

As in *E.T.*, the orchestration of a melody can provide accompanying melodic and textural strata that emphasize visual motion. In the Scarecrow Dance sequence from *The Wizard of Oz*,[29] the orchestration provides an iconic descending pitch ramp as the dancer falls into Dorthy's arms (Figure 5). The entire score is replete with such iconic elements, and of course incorporates intra-referential themes such as that for the Wicked Witch of the West. In fact, the first appearance of Miss Gulch on the bicycle in Kansas has congruent accent patterns (syntax) between the music and pedaling not dissimilar to that found in *E.T.* as outlined above.

Figure 5. Still from the "Scarecrow Dance" scene from *The Wizard of Oz* (1939).[30] The orchestration includes an iconic descending pitch ramp as Ray Bolger's character falls.

2. Previous Experiment

A previously reported experiment[31] was designed to empirically verify the ability of musically-trained subjects to use the continuum of referentiality. Six graduate ethnomusicology students were given a handout that described the semiotical concepts of referentiality discussed above. This textual description included no still nor film excerpts. A randomized set of 30 second stimuli were presented. The experimenter chose these stimuli to span the continuum. Five film excerpts and a television broadcast of an Olympic figure skating event were chosen. Two excerpts were hypothesized to

represent the extremes of the continuum*:* *Footlight Parade*[32] (the sequence outlined earlier) was designated referential (labeled REF1 in the results that follow); The "Cool Dance" sequence from *West Side Story*[33] was hypothesized to be syntactical (SYN1). The iconic center was represented by the galley rowing scene from *Ben Hur*.[34] Positions along the continuum were the "inside the ship" sequence from *Close Encounters of the Third Kind*[35] (ICREF1: Iconic with referential elements) and two excerpts that included elements of syntax and iconicity (the skating sequence and the Bach scene from *Fantasia*,[36] labeled SYNIC1 and SYNIC2). Subjects rated the stimuli on a continuous scale labeled "referential--icon--areferential."

Results are presented in Figure 6. Repeated measures Analysis of Variance (ANOVA) showed statistical significance for the main effect ($F(5,25) = 8.11$, $p < .0001$). Tukey-a post hoc analysis of mean differences revealed that all of the means in Figure 6 were statistically different from one another except for the two SYNIC composites ($p < .05$). Although generalizability is limited by the highly-trained subject population, this best-case scenario modestly confirms that the continuum is useable.

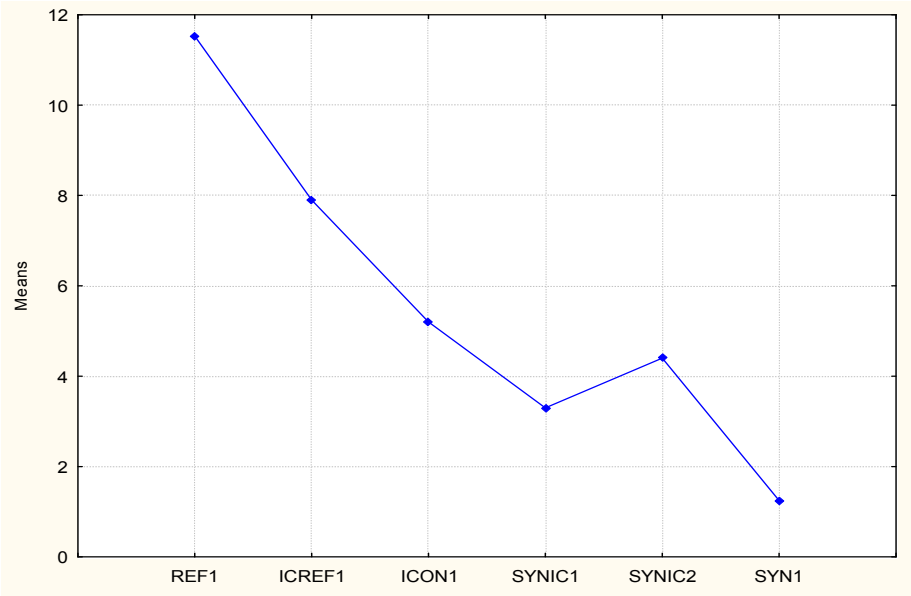


Figure 6. Mean ratings for six audio-visual stimuli along a continuum of referentiality. From Kendall, R.A. "Empirical approaches to musical meaning," *Selected Reports in Ethnomusicology*, 12, 97 (2005).

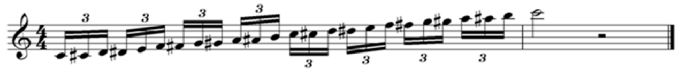
Previous research has largely dealt with the associative aspects of music, identified as mood or affect, and its effects of subject perception of audio-visual composites. The area of iconicity is less well researched, although some efforts in domains outside of film are noteworthy. The concept of a musical gesture has been defined as "...human body movement that goes along with sounding music...."[37] and has been recently studied using new technologies in performance and conducting among other areas. This research, particularly that of Clynes' sentics,[38] often resembles the iconic aspects articulated in this paper, a concept called physiognomics, where patterns suggest, as in the aforementioned "weeping willow." The experiments which follow employ animations to determine if the hypothetical iconic archetypes are rated for best fit in the match between visual motion and melodic pitch pattern. The projected research design, modified here, can be found in a previous publication.

3. Experiment 1: Monophonic Icons

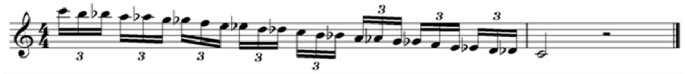
3.1 Methods and Materials

Stimuli based on the iconic prototypes of ramp, arch, undulation, inward and outward spins were generated from combinations of pitch patterns and with Powerpoint animations. The length of each stimulus was 2.5 sec, with 1.25 sec on the final note with the animation stopped. Music was generated using the Sibelius 3 notation software. MIDI files were converted using the Kontakt Silver software synthesizer with sampled concert piano timbre into .wav PCM files. Two computers were used to conduct the experiment. Animations were presented on a Dell desktop computer. Subjects rated the stimuli on a second Dell laptop computer running the author's Music Experiment Development System by using a mouse to rate the degree of music/visual fit on a 100 point visually continuous scale.

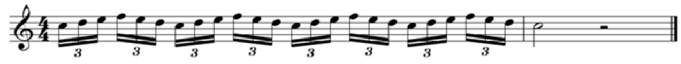
There were two random orders of the 56 composite stimuli assigned, creating two groups. Group order 'A' data have been analyzed and are presented here. 16 undergraduate subjects participating for credit in music classes at UCLA generated the data presented next. Statisitical analysis was a within groups repeated measures ANOVA, 8 x 7 levels with the 56 composite audio/visual stimuli of all combinations of music and visuals. Figure 7 provides music notation of the seven melodic pitch patterns. Figure 8 provides still pictures of the animation with lines indicating the trajectory. It should be noted that the arch music visuals are different from the undulation as follows: Musically the arch pattern starts and returns to the tonic and the visual pattern starts from the center of the figure and moves up and back to that origin. The undulation pattern moves up and down through these musical and visual points. Figures 9 and 10 illustrate combinations of visual and music patterns, the first being the hypothesized connection, the second being one of those that are hypothetically mismatched.



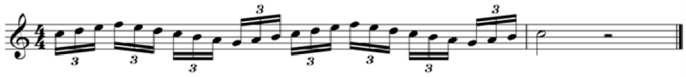
Ascending Ramp (RpAs)



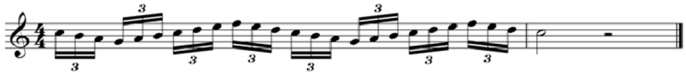
Descending Ramp (RpDe)



Arch (Arch)



Undulation Up (UnUp)



Undulation Down (UnDn)

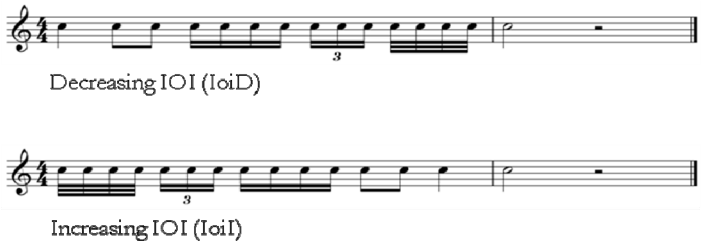


Figure 7. Pitch patterns generated with synthetic piano timbre with abbreviations used in the results.

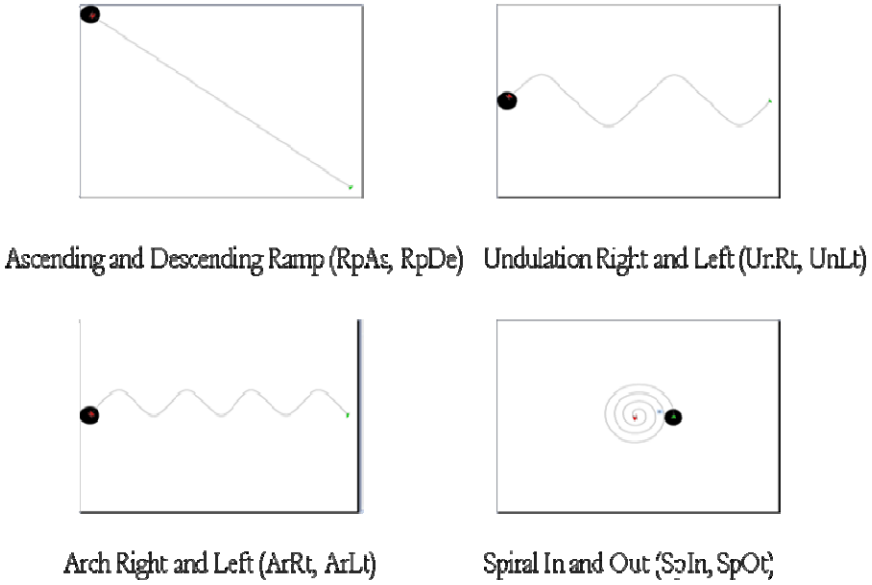


Figure 8. Animation patterns with labels (executed in both directions)

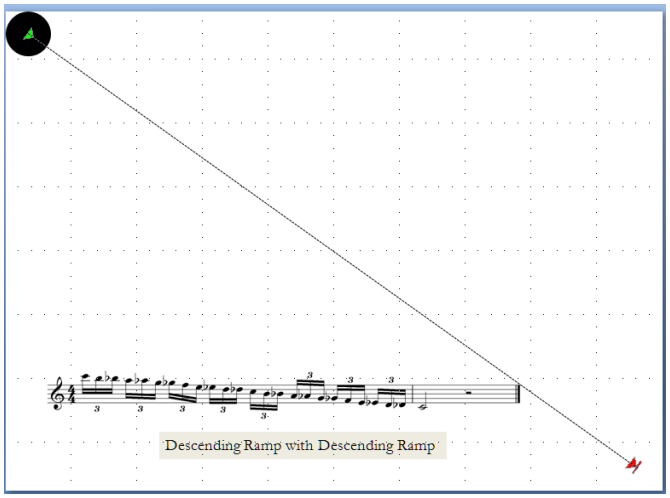


Figure 9. The descending ramp animation paired with the descending ramp music.

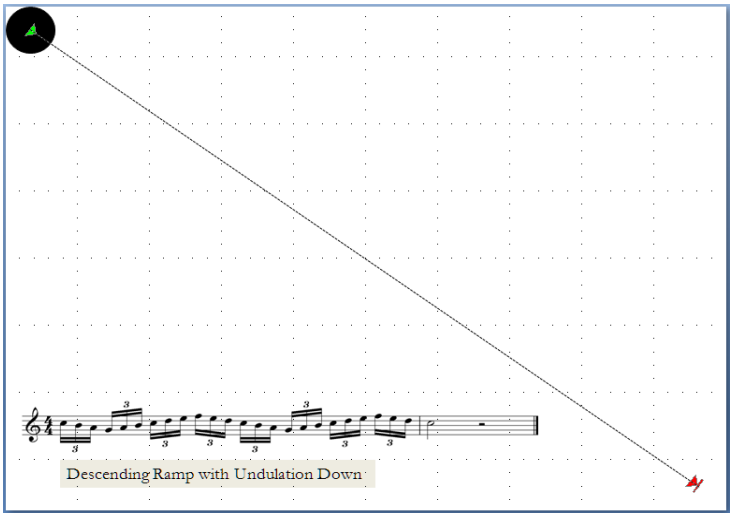


Figure 10. The descending ramp animation with the undulation down music.

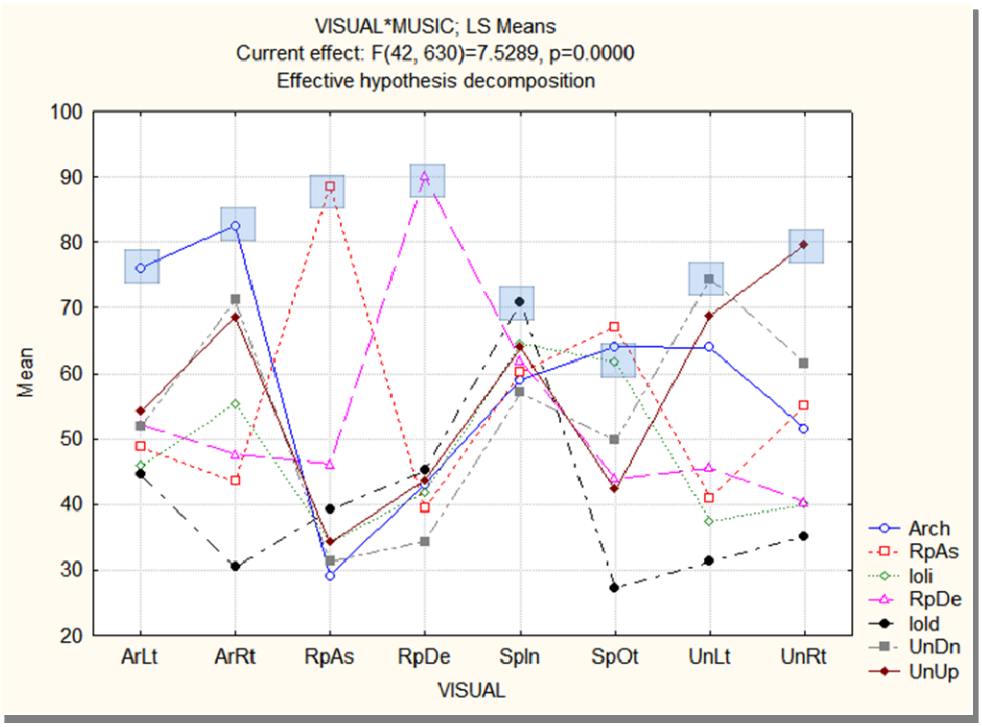


Figure 11. Interaction of visual and musical patterns. The experimental hypotheses of best fit are highlighted.

3.2 Results

Repeated measures ANOVA found statistical significance ($p < .001$) for the main effects of visual animation pattern and melodic pattern. Of interest to the hypothesis of the present model is the significant ($F(42,360) = 7.5289$ $p < .0001$) interaction effect, which is graphed in Figure 11, above.

In general, the hypothesized combinations (arch with arch, ramp with ramp) matches with significantly higher mean fitness scores. However, the spin in and out conditions do not match well, nor does the undulation pattern starting at the right side of the screen visually (perhaps suggesting perceptual bias for left-right spatial perception, a result worth additional attention). In this latter case, the hypothesized musical pattern was an undulation starting downward, since that is the initial visual motion, but this was simply rated no better than the upward pattern. This is somewhat expected, since no direct pitch analog of left motion exists; clock time in music moves inexorably forward.

The visual undulation moving from left to right, the last mean in Figure 11, does match well with the musical undulation up, again suggesting that left-right visual motion was more easily discerned relative to the musical undulation with these relatively rapidly changing shifts in visual and pitch contour through time. However, the arch patterns left and right are well matched since the musical pattern is identical in both cases, starting from and returning to the tonic, thus not requiring a specific distinction regarding the initial direction. Future research should include visual and musical arch forms that start downward as well as upward.

4. Experiment 2: Contour

4.1 Methods and Materials

Melodic contour is defined in terms of pitch inflection points, that is, changes of direction (up or down) in melodic motion. Previous research has demonstrated perceptual salience, or accent, at the point that a pitch pattern changes direction. The analog in animation would be changes of direction in space through time. This pilot experiment pairs a single monophonic pitch pattern, the arch, with visual patterns that include the arch pattern of the previous experiment with a circle, triangle, square, pentagon, hexagon, and a stair pattern (a variation of the ramp with direction changes corresponding to pitch inflection points in the melody). The hypothesis is that visual and audio composites that align accent points will form good fits. Visual patterns with odd numbers of vertices, such as the triangle and pentagon, cause a mismatch between contours. The circle has no physical inflection points at all. Empirical data suggests that groups of temporal units are bounded by the sound onset with groupings that favor even divisions of time. The arch pattern therefore provides M. M. quarter note = 96 beats/min structure with inflections at the eighth-note (8 total accents) before returning to the tonic on a long time interval. Subdivisions of this pattern of eight would thus be hypothesized to fit maximally in the visual and auditory domain.

Three music-major subjects participated in this pilot study. There were seven audio-visual combinations. Subjects rated a random ordering of these stimuli on a continuous scale as in the previous experiment.

4.2 Results

Mean response results are graphed in Figure 12. The exact match between arch visual with arch musical pattern received the highest fit rating. For this pattern, the inflection points as well as the contour were identical (it should be noted that the visual arch likely could be a triangle signal shape producing equal results, an area for further research). The square animation has changes of direction that correspond to a melodic inflection point at the musical tonic; this was next highest rated, though statistically the same as the circle. The circle animation has no inflections, except that implied by dividing it into four quadrants at ninety degree intervals. Whether subjects implicitly did this cannot be discerned from this study. It is well known that perceptually pitch is (at least) two-dimensional and circular, with the scale wrapping back to the same pitch class, the tonic. As these were musically trained subjects, perhaps pitch circularity trumped the lack of contour inflection correspondence, an area for future research.

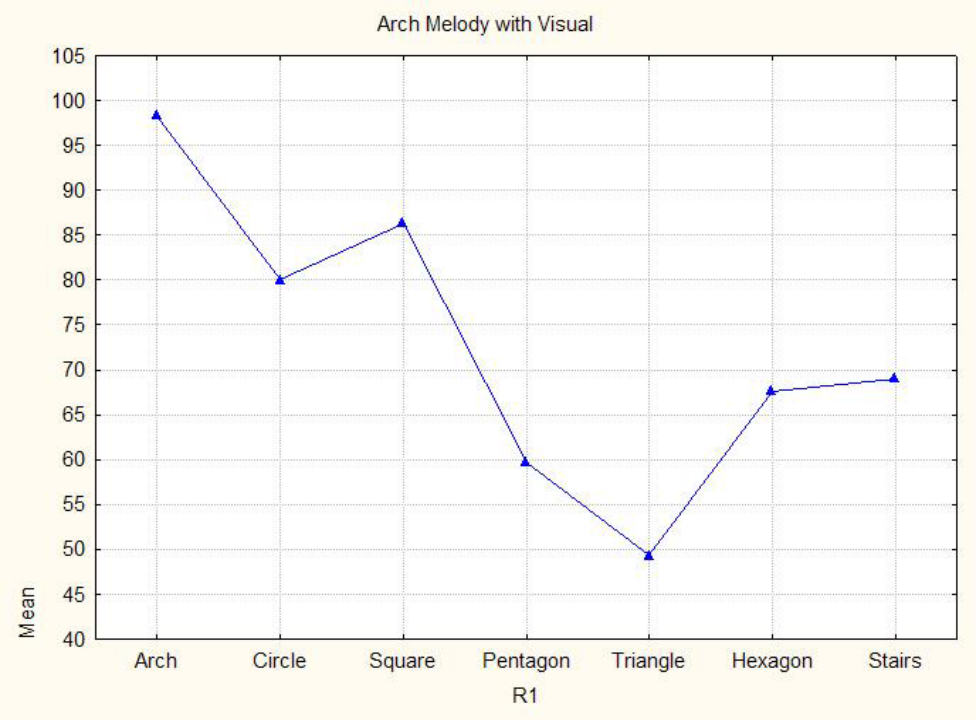


Figure 12. Results of experiment 2.

As hypothesized, the pentagon and triangle received the lowest ratings. The stairs and hexagon, with visual inflections at each melodic inflection point, were rated better in fit than the triangle and pentagon, but less so than the square, circle, and arch. This suggests, but does not prove, that the combination of tonality (loyalty to tonic) which occurs in the pitch pattern four times before the last tone (and stopping of the animation), further accentuates the temporal divisions. This division (quarter = 96) is very close to that of "personal tempo," the tempo that on average people spontaneously tap to,[14] making the division of the circle into four equal quadrants "natural." The fourth scale degree is at the eighth-beat position, and is weaker in resulting accent. Therefore the concept of contour theory coupled with melodic charge (position of a tone within the diatonic system) may provide a means to model the magnitude of inflection points in the visual and musical domains.

5. Conclusions and Future Directions

Additional experiments are being conducted using polyphonic isochronous pitch patterns , timbral markers, and layered animations. Initial results suggest that stratification of patterns that have temporally rapid accent structures result in highly variable subject responses. Often, only combinations musical and visual patterns with the least number of contour changes, the ramps, can be attached to timbre cues in music and color cues in the animations. Very quickly there appears to be a cognitive overload using the types of patterns discussed herein when they are polyphonically and multi-visually stratified.

This series of experiments moved from edited film excerpts, through semiotical theory for musicological analysis, to empirical experiments based on animations abstracted from forms similar in real film and animation. The convergence of results demonstrates that association, pattern similarity in iconicity, and temporal congruence all work to establish the symbiotic relation between musical and visual temporally organized structures.

Further research will need to be done to determine how the magnitudes of variables interact. For example, varying elements of distance in space, number of inflection points through time, and their interaction with association

components such as major and minor tonalities would extend these studies. At this time, it is not possible, nor warranted, to accept one or another model of music and film as most useful. Taxonomic approaches, implying a magnitude threshold for the salience of one variable over another, have not been adequately empirically tested. The present experiments suggest that elements of a multidimensional model based on continua can lead to an evaluative perceptual response. Further studies with real film, rather than abstractions in animation, need to converge on the extent to which different subject populations, approaching film with different knowledge structures (schemata), employ different strategies in decoding the intended meaning of the film's creators. What is abundantly clear is that the interrelation of visual and musical variables in film is not arbitrary (as was suggested to me by an industry insider), but is purposeful, based on principles of communication, and thus amenable to study through both musicological and empirical theory and model building.

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