Cognitive psychology meets art: exploring creativity, language, and emotion through live musical improvisation in film and theatre

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ABSTRACT

Creativity is primarily defined as a mental phenomenon that engages multiple cognitive processes to generate novel and useful solutions to problems. There are two core problem-solving modes: long-term deliberate methodical vs. short-term spontaneous. Despite behavioral models integrating the multiple activities (e.g. technical and financial issues, emotional responses) arising within and the socio-cultural effects surrounding the long-term creative process in various artistic disciplines, no systematic study exists of short-term improvisatory behavior in response to emotional stimuli within such ecologically valid contexts as film and theatre. In this paper I present and discuss the novel use of one cinematic and one theatrical project that investigate spontaneous creative thinking and emotion perception, particularly as it pertains to in-the-moment expressive translation of emotional scenic variables such as actors' movements and dialogue to musical language. Both projects explore the six universal human emotions (anger, disgust, fear, happiness, sadness, surprise) and were performed and recorded with live improvised music by professional jazz musicians. Combining visual scene analysis with musical feature analysis of the improvised scores, I propose a cognitive feedback model of spontaneous creative emotional innovation that integrates music, spoken language, and emotional expression within the context of live music scoring in both film and theatre. This work also serves as an appeal towards more arts-based cognitive research and interdisciplinary methods in the study of human intelligence.

Keywords: creativity, cognitive psychology, art-based data, musical improvisation, emotion, interdisciplinarity, film, theatre

1. INTRODUCTION

Since the explosion of Big Data from the Internet Age of the 1990s, information is everywhere. Today, the inundation of unstructured data comes in part from all the various social media platforms available that include blogs, Facebook, Instagram, LinkedIn, Twitter, YouTube, and the like. As IBM reported in their 2011 Global Chief Marketing Officer (CMO) Study, "…every day we create 2.5 quintillion bytes of data – so much that 90 percent of the world's data today has been created in the last two years alone."[1] This reveals that our penchant for and necessity of communicating with others via computers is the norm and will only become more integrated in our lives as we interact with increasingly smarter social platforms and technologies. The rise of intelligent technologies is gaining traction at unprecedented speeds: from G.P.S. directions and Siri's recommendations, to the ubiquity of drones in various sectors, robot jockeys for camel racing in the Arab world, and the impending trials of driverless vehicles on public roads in the UK.[2-4] In response to these advancements, futurists and computer science experts have more recently made explicit to the general public both the benefits and dangers of creating intelligent systems that will surpass our own human abilities (i.e. the emergence of artificial *super*intelligence (ASI)).[5-8] And while companies such as Apple make technologies evermore individualized and human, it is important to take a step back and consider the key element that makes us an intelligent species and the one I will focus on in this paper: creativity. Whether devising new tools to enhance survival, understanding the laws of nature through mathematics, or inventing new narratives through improvisational theatre, creative behavior, our capacity to create alternatives to ever-changing situations, has and continues to be an essential part of our human evolutionary, intellectual, and artistic history.[9-17] We are a species who is self-aware, self-improving, and goal-seeking, and to furnish a human-like artificial system is to fundamentally understand how we think and act. More precisely, processing speed and

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memory capacity is not enough until that computer can also match our natural language capabilities, interpret the visual world we daily navigate, experience common sense, and essentially reach our level of creative capacity.[5,18,19] What then can this optimal mode of intellectual functioning tell us about how we think?

As with any complex human cognitive phenomenon, understanding and modeling the creative process remains a line of inquiry ripe for advancement and ingenuity. Given the fundamental nature of creativity, the range and impact of creative behaviors are impossible to predict or determine. Consequently, exploration on the topic has primarily focused on understanding the *how* of creation with the ultimate goal of discovering our own capacities of inventiveness to further improve our ability to innovate. There are particular questions that underlie both theoretical and empirical work on the subject, and they include but are not limited to: How do we define creativity and what are the various types of creative behaviors? How do we accomplish creativity amidst activities that are persistent and long-term vs. spontaneous and short-term? In what ways does artistic creativity differ from non-artistic creativity? How does emotion factor into the creative process? How does creativity arise within a collaborative group setting? How do we best study creativity and what can we learn from new methods of questioning and investigation? What follows is a summary discussion of various empirical approaches, results, and shortcomings to set up the stage for the current novel interdisciplinary study.

1.1 Models of creativity: what behavioral and brain-imaging studies reveal

The breath of literature on creative thinking and its subtopics—achievement, expert knowledge, imagination, insight, intelligence, problem solving, and exceptional accomplishments and/or artistic production post brain trauma as chronicled through case studies—is extensive and rich. There is no shortage of reflection or experimentation, with perspectives ranging from art history, musicology, and philosophy to cognitive science, computer science, and (neuro)psychology.[12,14-17,20-35] The systematic cognitive psychological study of creativity, however, did not receive significant attention until American psychologist J. P. Guilford made it the focus of his now classic presidential address to the American Psychological Association in 1950.[21] This call for investigation came right as the cognitive (and computer) revolution began to respond to the dominant behavioristic approach of scientific psychology and its theories about stimulus-response associations with arguments for the existence of mental representations to fully characterize the complexity of human behavior.[18] Under this *creative cognition approach*, which developed more extensively in the 1990s and the one adopted here, creativity is an accessible and testable behavior amenable to the methods of the empirical cognitive sciences and is defined as a mental phenomenon that engages multiple cognitive processes such as attention, emotion, memory, reasoning, and reflective decision-making judgments to generate unconventional, novel and useful solutions to problems.[36-38] The simultaneous advent and mass availability of brain-imaging techniques in the 1990s precipitated a broad range of experiments, and the effort continues to establish a link between creative (artistic) behavior and particular brain networks.[39-55]

1.1.1 Divergent production

If creativity is characterized by the novelty of a solution to a problem, then one way to study the emergence of creative solutions is to test problem-solving tasks that identify an array of possible solutions. This assumption originates from the claim that creativity is fundamentally measurable in terms of divergent production, or the quantification of varied outcomes, independent of their usefulness, in response to specific stimuli.[21,22] In a study that employed a basic behavioral stimulus-response paradigm, Finke and colleagues asked participants to mentally visualize superimposing a set of letters, numbers, and/or geometric forms in novel ways and to imagine an entirely new image using a set of familiar items. Verbal reports from participants revealed the emergence of new forms otherwise not known, and the invention of familiar items with new parts that may or may not have had functional value but nonetheless were alterable during a subsequent exploratory process that imposed particular functional or categorical criteria on the emergent forms.[56,57] Despite the simplicity of the experimental setup, the study consistently revealed humans' adeptness at not only recreating familiar forms with new sets of items, but inventing entirely new forms without any obvious functional value. This observation of emergence in structure, behavior, and function is confirmatory given the paramount importance of such an intelligent combinatorial capacity necessary for self-improvement and overall evolutionary progress. As an obvious example, look to natural language's infinite combinatorial potential as an indicator of the brain's generative capacity.

In more complex experiments where new shapes are generated from predetermined sets of object parts, results have revealed that the creative thinking process is ultimately a combination of two types of cognitive qualities with one type

more involved than the other depending on the creator's goals (and perhaps even personality traits): spontaneous/unstructured (or chaotic thinking) and intentional/structured (or ordered thinking). In the former type, novel forms rapidly arise unplanned without any explicit conscious deliberation and usually incorporate unexpected associations; the lack of a defined end goal leads to remarkably ingenious innovations. In the latter type, novel forms are generated in a controlled, systematic manner and are influenced by prior knowledge, preexisting categories, and even familiar ideas resulting in outcomes not as novel as those resulting from spontaneous/unstructured thinking.[56] Further understanding the internal exploratory idea development process has led to investigating the interaction between visuo-spatial information in long-term memory vs. short-term working memory and its effects on innovative design making within real-world applicative contexts such as architectural conceptual planning. In a recent study by Bilda and Gero where professional architects designed the conceptual house plan for two different types of clients, the blindfolded group developed design ideas with equal and slightly greater efficiency than the group tasked with traditionally sketching their ideas out with pad and pencil. These findings support the hypothesis that idea generation may be enhanced by imagery alone and does not require explicit visual feedback to be efficient and significantly novel.[58] This hypothesis could in part be explained by functional magnetic resonance imaging (fMRI) evidence that visual imagery draws upon similar neural machinery as visual perception[59] and substantiate the impact of non-direct visually biased sensory input for spontaneous/unstructured creative thinking outcomes.

1.1.2 Further insight into prefrontal cortex function

Expanding upon these behavioral observations, psychologist Arne Dietrich has proposed that the two basic types of creative processing modes (deliberate and/or spontaneous) mentioned above can each project computations to cognitive and/or emotional structures and lead to the following four types: deliberate-cognitive (i.e. insight as a result of sustained, focused work), spontaneous-cognitive (i.e. a *Eureka!* moment), deliberate-emotional (i.e. an *Aha!* moment), and/or spontaneous-emotional (i.e. an epiphany). All of these modes interact in any given way during creative thinking and potentially share the same final neural pathway to arrive at an outcome.[38] At the core of insight recognition, evaluation, and expressive realization is the prefrontal cortex (PFC) and its functionally divided aspects: the ventromedial (VMPFC) area which is connected to the limbic system and implicated in emotional and logical evaluation of behavior,[60] and the dorsolateral (DLPFC) area which (a) receives input from the posterior occipital, parietal, and temporal sensory and association cortices, (b) sends output to motor areas for action, and (c) is implicated in key cognitive functions such as working memory,[61] temporal integration,[62] and sustained and focused attention.[63] As a result of this complex network, decision-making relies most importantly on a working memory information buffer in the PFC to hold, rearrange, and restructure relevant knowledge for solving a particular problem.[64] Thus, as a novel thought occurs, its conscious representation in working memory causes it to become a recognizable insight that undergoes further recombination and exploration of self-reflection, evaluation, and reporting until final implementation.[38,64] Of these hypothesized processing modes, one of the better-documented examples has been the investigation of the *Aha!* moment in which blood flow data from fMRI and brainwave electroencephalogram (EEG) data were used to study subjects as they created common two-word compound phrases from single words. This study revealed that the brain prepares for the oncoming breakthrough: the conscious suddenness of insight is preceded by a burst of brain activity whereby the anterior superior temporal gyrus (aSTG), a structure involved in auditory and language processing, in the right hemisphere becomes unusually active one-third of a second before the insight as integration of information occurs.[39] This process has been further dissected with EEG data and observations include (i) a neural correlate of mental impasse, or blank state whereby the problem-solver struggles to find a solution despite extreme focused attention, in parietal-occipital brain areas, (ii) a correlation between the right PFC and conscious restructuring of the problem, and (iii) higher activity in posterior regions within the parieto-occipital area during significant problem understanding and final, sudden retrieval of a solution.[40] Additional studies have shown that this process is also correlated with significant activity in the emotion learning areas of the amygdala,[41] highlighting the positive emotions experienced during identification of a working solution.

While these experiments have focused on relatively common verbal complexities typical in a variety of linguistic contexts, brain studies, like behavioral experiments, have turned towards art professionals and their capacities in an effort to capture the highly skilled brain during controlled simplified moments of artistic creation. This focus lies on the assumption that artists are (a) experts in artistic creativity and can readily adapt to performing in-the-moment generative tasks in an experimental context (unlike novices, who may struggle to innovate because their command of the basic skills, lexicon, and syntactic knowledge necessary for fluency in the artistic domain remains incomplete), and (b) their cognitive processing stages differ significantly enough from non-artists that differences can be observed in their

functional neuroanatomy. Studies of visual artists and non-artists as they sketch novel drawings reveal that there are indeed neural differences such as greater neural activity in PFC regions in the artists' brains than in the non-artists.[42-44] Interestingly, greater cortical thickness in the left lateral orbitofrontal cortex has been significantly linked with higher overall creative achievement.[34] These data, of course, do not explain whether the higher creativity is a product of an increase in gray matter or general greater mass of gray matter in particular brain regions. Other artistic mediums such as story generation,[45] creative brainstorming and writing,[46] improvisational and imagined dance,[47] and choreographed movement imagery,[48] to name a few, have also received attention and have all reported activation in orbitofrontal and dorsolateral prefrontal cortices. Additionally, studies with musicians improvising musical sequences have unsurprisingly observed activation in relevant cortical areas associated with rapid output of auditory-motor sequences, communication, and top-down processing.[49-55] An interesting finding in a jazz study, however, observed both deactivation in the DLPFC and activation in the medial PFC in the task where most improvisational freedom was allowed and musically observed; a mental state the investigators suggest is potential neural evidence of creative flow, or a balance between attenuation of awareness and intense acuity of self-expression.[51] The term *flow* was originally coined by positive psychologist Mihály Csíkszentmihályi in the 1970s to describe an optimal experience that occurs during a highly motivated, intense, enjoyable, and creative (but not necessarily artistic) act by the individual in question[24,25] and, as more recently documented, possible in all members within a collaborative-creating context.[15,66] While the dissociative neural state in the above study remains to be replicated in other musical, artistic, and non-artistic creative acts, it stands as a provocative finding for two reasons: (a) altered states of consciousness–(day)dreaming, drug-induced states, endurance running, hypnosis, and meditation–whereby various similar distortions occur with respect to time perception, adherence to social constraints, and focused attention tend to exhibit a transient decrease in PFC activity[67] and suggest a neurological similarity to creative thinking states, and (b) because the very premise of the Surrealist art movement of the 1920s was founded on the idea that creative invention "…proposes to express, be it verbally, or written, or by whichever method, the actual functioning of thought in the absence of complete control as determined by reason, and exempt from all aesthetic or moral concern"[68] and such a neural result may be modern technology's answer to a century-old proposition.

1.1.3 Dynamic searches and exchanges

Overall, these results provide objective evidence to support the claim that artists (and highly creative individuals) engage in more top-down processing than non-artists. A greater and more advanced knowledge and representation space helps with the unconventional pattern searching and problem restructuring necessary for an optimal solution. Returning to the issue of *how* insight evolves outside of brain states, design computationalist John S. Gero proposed in the mid-nineties a set of hierarchical steps to the process. As new variables and consequent new conceptual schemas are integrated and the current problem space is transformed, a novel design emerges.[29] This presumably entails that the problem space continually alters its shape with every novel idea until the most appropriate design for the intended goal is achieved. Moreover, it appears that an essential component for efficient and original implementation is an internal appraisal by the problem-solver, in comparison to an overt one, as empirically observed in the study with blindfolded architects.[58] While Gero's model can explain how novelty evolves from preexisting forms, it does not explicitly consider integration of the important, and fundamentally inevitable, role ever-changing contexts (cultural, social, and personal) play in the evaluative and consequent implementation processes.[69,70] Explicitly bringing to the forefront both the creator's mind and physical state within their environment and the environment's acceptance of and response to the creator, Glaveanu and colleagues offer an even larger contextual perspective of the creative process within various artistic mediums and affirm that internal cognitive, emotional, and motivational elements of the creator are inseparable from and in constant dynamic feedback with external expectations, interpretations, and reactions from society.[69] As philosopher and psychologist John Dewey remarked in the 1930s, "the external object, the product of art, is the connecting link between artist and audience. Even when the artist works in solitude all three terms are present. The work is there in progress, and the artist has to become vicariously the receiving audience."[71] From this perspective, creativity is hardly a singular experience and brings to the forefront the inevitable inclusion of societal expectations regarding, for example, aesthetic qualities to the creative development process. Under this umbrella of sociocultural psychology, it is imperative to also consider that collaborative, or group, creativity may also reveal much about the process, the individuals involved, and the resulting outcome. Given the real-time exchange of ideas on stage amongst jazz musicians or improvisational theatre actors, for example, Sawyer specifically proposes that group creativity, much like every day conversation, becomes a product of *interactional synchrony* as all relevant parties listen and react to one another and maintain group coherence.[66] In essence, collaboration is necessary for innovation to flourish in a group setting.

1.2 The interdisciplinary move ahead

The study of (artistic) creativity is undeniably interdisciplinary. We arrive at the crossroads of multiple disciplines and at a moment in history, and in the study of this fundamental human intellectual capacity, where bold methods of investigation are called for if we are to fully and successfully model the complex process of innovation. In essence, we have perhaps circled back to what Renaissance humanists from the fourteenth to sixteenth centuries sought for: eloquence, or a mastery of many disciplines so that lives of wisdom and consequence could be led.[72] I suggest, therefore, to take stock of what we have done and reconsider what we could do in the near future. The studies discussed have used traditional scientific reductionist methods and controlled testing environments for empirical exploration. In other words, pose question x, pick contrasting variables y and z and a control, bring artists into the lab to perform conditions a and b, analyze the observed c behavior to determine if the expected answer can support previous claims regarding question x, and repeat in search of reproducibility and validity. The neuroscience perspective to the *creative cognition approach* similarly needs to be adopted with care.[73] As with other complex psychological categories such as feelings, memories, and the self, thinking is a collection of mental states originating from the brain. Known as the *mind-brain correspondence problem*, psychological categories are not necessarily instantiated in a one-to-one correspondence with brain states and the field of cognitive (neuro)psychology may need to reassess its framework of investigation.[74] Issues aside, the results as they stand have been elucidating. As a side note, the tendency towards experimenting with highly proficient and successful artists when studying creativity does not rule out individuals who are highly proficient and successful in other professions such as business, education, engineering, journalism, law, medicine, etc., that demand enormous amounts of creativity both during immediate and more long-term situations; this has been a flaw from the overall investigators' side of the field, a loss of interdisciplinarity within and between disciplines, and, more broadly, the inevitable immaturity of a field still in its infancy.

An alternative method of investigation that has begun to shine in the spotlight, despite its initiation in the 1950s,[75,76] is known as arts-based behavioral research, or the systematic use of the artistic process in its natural environment as the primary way to explore, experiment with, challenge, and understand perception, emotion, memory, consciousness, and other cognitive functions.[77] It is of course plausible to consider this method entirely applicable to other disciplines. In this domain of inquiry, a question x is posed or a desired effect is established with an openness to in-the-moment change of conceptual direction, variables y and z are chosen for exploration, the artist tests a range of possibilities to see what will emerge or until the desired effect is achieved, and the process is repeated (with alterations), always in search of variations and new effects. A notable example is witnessed in films where Pablo Picasso's creative painting process in his studio was twice the subject of observation: for Belgian filmmaker Paul Haesaerts' *Visit to Picasso* ("Visite à Picasso") in 1950 and French filmmaker Henri-Georges Clouzot's *The Mystery of Picasso* ("Le mystère Picasso") in 1956 in which most of the paintings Picasso created on camera were subsequently destroyed after filming, an action perfectly in-line with the objective of the film (i.e. the creative process, not the resulting product). In both documentaries we witness first-hand concept origin, brushstroke technique, idea transformation during implementation, concept re-inspiration, and aesthetic evaluation and re-evaluation all unfold in real-time; the core elements of a problem space solution-searching model. I make no claims of methodological superiority, simply an open-mindedness to accept Art and Science's individual and collective value as toolboxes of truth searching and a resurgence of arts-based inquiry into the creative process to capture spontaneity in action. Which brings me to the crux of this paper: inspired by artistic methods, but guided by empirical questions, I have created two unique projects within film and theatre at the intersection of Art and Science with the goal of witnessing and revealing how audiovisual sensory information, emotion, language, and the generation of new material all interact in a given live performance moment to produce a coherent artistic object.

2. METHODOLOGY

While the descriptive dynamic action models proposed by Glaveanu and colleagues are widely encompassing of the creative process within art, design, science scriptwriting, and music composition,[69] they focus on a generative creative process of long duration that develops over time, what Sawyer refers to as *product creativity* or long and short-term creative activities that result in single objective, tangible products after many sketches, initial starts, and revisions.[78] An alternative to such creative activities is spontaneous in-the-moment invention as typically witnessed, for example, in jazz concerts and improvisational dance and theatre performances whereby there are no prearranged scores, choreography, or dialogue to perform from and the composition unravels on stage. Jazz and jazz musicians (and dancers, and theatre and

improvisational actors), therefore, are an ideal entity to study for spontaneous creativity because composition and performance are inseparable acts that are always novel moments and experiences because the jazz form *per se* is built "…on the assumption that each individual musician simultaneously and consciously adapts to the whole, supporting the other players, and influencing the overall outcome. In other words…to allow each player to creatively contribute to the whole by levering the creative contributions of the others"[79] in live performance contexts. In cognitive terms, similarly to natural language, these musicians can generate a potentially infinite number of contextually meaningful musical phrases by combining a finite set of notes and rhythms. Moreover, with the inclusion of specific emotional target stimuli as the thematic compositional goal of the musician(s), an ideal platform for real-time emotion perception and translation can be created. As such, film and theatre offer natural environments for music to take on a number of functions: enhance emotional and/or thematic narrative structure, communicate meaning beyond the scene such as characters' internal emotional states, set a scene's mood, provide continuity between scenes and/or events, and offer an overall aesthetic effect to the film-viewing[80] and theatrical experience. To my knowledge, no study of live musical improvisation within cinema and theatre contexts exploring in-the-moment expressive translation of specific scenic variables such as actors' emotional states and dialogue to musical language has been done, either scientifically or artistically. The two novel, interdisciplinary projects discussed below were prepared in order to be screened, performed, and recorded on stage with live improvised music by professional jazz musicians to allow for the merge of improvisational music within two different art forms and to maintain strong ecological validity: a film titled *Moments* and a theatrical play in Spanish with English surtitles titled *Última Partida* ("The Final Draw")[81] that both explore the six universal human emotions (anger, disgust, fear, happiness, sadness, and surprise).[82]

2.1 *Moments*

The inspiration for creating a live performance of improvised music scoring to a new contemporary film came about after watching one of the most famous examples of improvised film scoring in film history, Louis Malle's 1958 debut feature *Elevator to the Gallows* ("Ascenseur pour l'échafaud") with trumpeter Miles Davis at the helm.[83] The interaction between image and sound is breathtaking and multilayered in many scenes throughout the movie, but one particular now iconic 3-minute long scene stands out: the heroine, played by French actress Jeanne Moreau, walks with poise through the dark rainy streets of Paris in search of her lover while Davis' trumpet sings with modal moodiness all her sadness, loneliness, and anger in one single track. In my contemporary reenactment, I wrote, filmed, and directed a 39-minute long film titled *Moments* with minimal spoken dialogue where the six universal emotions are dissected as a woman and man's relationship is tested through a series of events. The purpose of including minimal dialogue, a total of fourteen lines spoken by the woman and 7 by the man, was to provide an almost purely visual yet realistic platform for the musicians to interpret. The film is divided into five chapters with the following headings: Ch. 1: Sadness, Ch. 2: Surprise and Disgust, Ch. 3: Fear, Ch. 4: Happiness, Ch. 5: Anger. Jazz musicians improvised the film's soundtrack live during a public screening in Baltimore, MD.[84] Prior to the public screening I informally screened it to several unbiased viewers to check for the stability of the emotional content within each scene. All viewers agreed that the emotions expressed by the characters were realistic and identifiable.

The trio who improvised the music included piano, tenor saxophone, and bass and all three musicians were familiar with each other but had not yet played together or composed music for film prior to this performance; they had a combined average of eleven years of professional working experience. The musicians and I met several weeks prior to the performance to discuss their role as soundtrack improvisers who would be tasked with creating a soundtrack that "fits" the narrative of the movie and playing continuously from the film's beginning to the closing credits, and watch the film and review the narrative structure of the storyline. Musical ideas and a soundtrack, however, were not developed, charted out, or scored and the musicians left without a copy of the film. I specifically did not make explicit *how* music is used in and for film contexts to avoid constraining musical ideas. The purpose of this arrangement was to familiarize the musicians with the task and layout of the screening and performance venue, and to avoid any musical biases or composed material from being planned and arising during the performance in order to create an entirely novel live audiovisual experience. During the movie's screening the minimal dialogue was muted and included as subtitles and the musicians stood on stage, as in any live concert figuration, each with a small laptop or iPad from which to view the film in real-time. The performance was recorded live. Afterwards, I interviewed a jazz musician with approximately seven years of professional working experience about the technical musical aspects of the improvised compositions. My experimental questions were: what effects do clearly demarcated realistic visual emotional stimuli have on improvised musical content and how will multiple musicians deal with this musical task live on stage?

2.2 *Última Partida / The Final Draw*

While the theatrical empirical follow-up to *Moments*, *Última Partida* ("The Final Draw") was thematically inspired by Italian filmmaker Michelangelo Antonioni's 1961 narrative on social deterioration and romantic alienation in *La Notte* ("The Night"). In *Última Partida*, an original one-act dramatic play I wrote, directed, and produced with La Petite Noiseuse Productions, three fictitious characters convene at a cabaret during a single night: a woman, a man, and a pianist. The woman and man's past, present, and future relationship unfolds in six scenes as they discuss love, disaffection, solitude, and death: i. *Oferta para dialogar* ("Offering to talk"), ii. *Esperanza de volver* ("Hoping to get back together"), iii. *Interludio festivo* ("Comic interlude"), iv. *Imposibilidad de volver* ("The impossibility of getting back together"), v. *Dolor de la memoria* ("The pain of memory"), and vi. *El último adiós* ("The final goodbye").[81] The audience is introduced to the jazz pianist through his live improvisations on stage; the character does not have a speaking role. I created this particular role for the pianist to not only push the boundaries of live music within contemporary theatre, but to specifically transform the emotional narrative of both the dialogue and the scene into the language of music, either as explicitly instructed in the script during particular scenes and moments of silence between the characters' dialogue or as the musical background as determined by the pianist. Furthermore, the language and dialogue play with word meanings and rhymes to offer a rich setting for the pianist to improvise (and in stark contrast with *Moments*). This creative improvisational type of presentation necessitates unique music every performance.

The pianist, who also improvised for *Moments*, had an average of 18 years working professionally and while had done some musical theatre containing scored orchestral work before, had not improvised live for a theatrical production of this type. I met with the pianist several weeks prior to rehearsals with the actors to discuss his role, the overall storyline, and the *nuevo tango* ("new tango") style of music I wanted to be implemented as part of the melodic foundation from which to improvise. The pianist then attended the last two weeks of rehearsals to familiarize himself with the dialogue, stage and musical entrance cues explicitly noted in the text, timing between scenes, and particular elements I designated to be incorporated throughout (i.e. the use of *ostinato* or the repetition of a particular phrase or motif). A soundtrack, however, was not charted out or scored. The play was presented to the public eight times in the metropolitan Baltimore, MD and Washington, D.C. areas. All performances were photographed and audio and video recorded live. After the performance I interviewed a jazz musician with approximately seven years of professional working experience about the technical musical aspects of the improvised composition. The presented musical data come from one of the performances. My experimental question was: what effects do clearly established realistic linguistic and visual emotional stimuli have on improvised musical content?

3. DATA AND RESULTS

Using clearly marked emotional segments as regions of interest, I first performed *mise-en-scène* and text analyses of the film and theatrical works and then examined their respective improvised musical scores. A *mise-en-scène* analysis is a method used in film and theatre to identify the key components of a shot or scene (e.g. setting, lighting, costume, staging) in order to explain the meaning of those components and how they connect to the overall narrative themes, and hence affect the audience's interpretation of the work. The purpose of this method is to ultimately hypothesize the narrative intentions of the filmmaker or theatre director. For the particular purpose here, I concentrated on the actions of the actors occurring in each new scene in all five chapters of *Moments* to determine whether there was a correlation between actors' behavior and specific musical variables utilized within the musical content generated. For the theatrical production, I took a slightly different approach of analysis. Although *Última Partida* is thematically divided into six scenes, each scene explores an array of emotions in a far more complex manner than *Moments*. I first analyzed the musical content generated and then reference the original text to assess what the pianist had focused on during his real-time interpretation. This course of action for the film and theatre analyses relies on the fact that music is an effective means for expression and communication, which has persisted for thousands of years and across all known human cultures,[85] and utilizes particular structural elements to reliably do so, be it from the compositional standpoint and/or interpretive performance side of expression.[86-88] Unlike the recent handful of neuroscience studies exploring the brain while pianists improvise simple, one-handed novel melodies on three-octave, non-weighted nonferromagnetic keyboards lying supine within an MRI machine and a mirror to view the keyboard,[49-54] the musicians here were not given any musical (key, mode, pitch range, rhythm, tempo) or physical (mode of delivery) constraints. Moreover, I reject the continuous categorization of emotions as "positive" or "negative"[88] to avoid unnecessary labels and biases.

3.1 *Moments* (film)

Audio 1. Audio samples_Moments. Representative film stills from each emotion category within the film short *Moments* and their respective audio excerpts. http://dx.doi.org/10.1117/12.2083880.1

Table 1. Chapters in *Moments* with their respective synopsis and primary distinguishing musical observations.

Ch. 1 Sadness	**Musical Observations**	**Ch. 2 Surprise**	**Musical Observations**
00:14 Chapter begins 12:38 Scene ends **Synopsis**: Woman works at her desk and shifts through photographs of nameless women. Phone call comes through and she breaks down crying upon hearing bad news.	•Key oscillates: Asus-A minor-Asus-Eflat Major-G minor-D Dorian •Tempo shifts: 58-130-56/58-67 BPM •06:08-11:30: tempo at slowest; sax takes center stage and creates new motif, piano imitates melodically and rhythmically, they alternate; bass follows pulse of woman's breathing; dynamics at steady *mezzo-piano* with slight *crescendo* and *decrescendo*	12:45 Chapter begins 22:54 Scene ends **Synopsis**: Unnamed man makes a phone call requesting "a girl." Woman answers phone, surprised to hear the man's voice. Woman proceeds to grant his request.	•D Phrygian (introduces B flat) •80 BPM •Piano dominates with dissonant A and Bflat together in quarter notes •Piano, sax, and bass all play random alternating inserts with a call and response effect
Ch. 2 Disgust	**Musical Observations**	**Ch. 3 Fear**	**Musical Observations**
12:45 Chapter begins 22:54 Scene ends **Synopsis**: Woman transforms herself in front of a mirror, repeatedly making her face & cleaning it until satisfied. Man is then seen walking and entering a gated area and lead by a faceless woman up a staircase to the roof.	•Tempo steady at 80, then 116 BPM •16:45: piano continues with dissonant A and Bflat notes then changes rhythm, increases tempo, bass follows, piano and sax alternate, intensity increases; circular ascending 4ths sound into high register •C minor blues with walking bass at 122 BPM •Ascending pedal tones, bass descends, sax is dissonant, all *crescendo* to *fortissimo* then *decrescendo* to *mezzo-piano*	23:00 Chapter begins 24:24 Scene ends **Synopsis**: A woman's legs and feet are seen walking on a sidewalk and then into a dark building and up a solitary staircase, her hand sliding up the banister. Woman's terrified face is suddenly seen and assumed being killed.	•60 BPM •Piano in higher register of keyboard with dissonant broken chord pattern in rhythm with woman's steps, *legato* touch •Bass has increased repetitive pulse •Sax moves from lower to higher register •Tension builds w/ piano's broken chord repetition •Sudden *crescendo* by all
Ch. 4 Happiness	**Musical Observations**	**Ch. 5 Anger**	**Musical Observations**
24:39 Chapter begins 35:22 Scene ends **Synopsis**: Woman and man are outside at a plaza with a fountain. They flirt, laugh, and joke around. They eventually blur out behind the fountain's waterfall.	•G Major; starts at 48 BPM (with *rubato*) •Calm piano begins, adds bluesy notes in higher register of keyboard •26:50: sax and bass come in with bass playing rhythm, tempo rises to 114 BPM as couple becomes more playful •33:55: piano starts rolling ascending chords, coda of G Major tune, sax follows	35:28 Chapter begins 37:40 Scene ends **Synopsis**: Woman and man are on balcony. Man confronts woman about her job, she confronts him; nothing is resolved. Man's anger flares up and down. Fade to black, credits roll.	• Loses key center • Out of tempo • Dissonance, varied dynamics; hesitant, mysterious sounding piano-bass-sax trading • Pianist strums piano strings multiple times • Slow *decrescendo* (*forte* to *pianissimo*)

3.2 *Última Partida / The Final Draw* (theatre)

Audio 2. Audio samples_Ultima Partida. Representative photographs from several scenes from the staging of *Última Partida* and their respective audio excerpts. http://dx.doi.org/10.1117/12.2083880.2

Table 2. Significant musical observations with their respective scene, synopsis, and text (translated from the original Spanish).

- **Scene 1 & Synopsis**: Man offers to recuperate relationship with woman; woman does not. Man repeatedly tries in vain.
- **Text**: Woman: *...Did you notice? That constant rhythm that comes and goes with every hour took some time to disappear from consciousness. And slowly, s-l-o-w-l-y, I let it go*. Man: *Woman, you know you can count on me. And not just a couple of times…*
- **Musical Observations**: Cabaret theme introduced. Variations upon theme created with the same sequence of chords, reoccurring ii-V-I motion. *Rubato* tempo creates colored tones within sweeping arpeggios. Shifts between minor and major tonalities. Flourishes incorporated (e.g. trills.). Overall *mezzo-forte*.

- **Scene 1 & Synopsis**: The couple seduces one another with lustful language.
- **Text**: Man: *...Curves left ... and right ... so sweetly soft ... that I loose myself. I can't help but roll my tongue with so many words!* Woman: *Haha... I can't help but laugh at your oh so masculine perspective!*
- **Musical Observations**: Blues tune introduced. *Andante* tempo. Major tonality.

- **Scene 1 & Synopsis**: Woman reminds man of her skepticism.
- **Text**: Woman: *...Do you not hear yourself? Oh so ready to talk. Look at yourself initiating new methods, imagining moves, asking questions, giving praises. But you haven't taken a good hard look at the past, or far beyond in the future.*
- **Musical Observations**: Tango-theme inserted, followed by a cycle of minor dominant chords and a sweet cascade in right hand.

- **Scene 2 & Synopsis**: The couple begins a flirtatious dance.
- **Text**: Man: *...Let's talk. And I'm not giving up on us. Let's make a deal.* Woman: *All right. ...*
- **Musical Observations**: A sensual, romantic tango enters with a chromatic half step encircling of a C leading into F minor.

- **Scene 2 & Synopsis**: The couple returns to the happiness of the past and consider what could be in the present.
- **Text**: Man: *...like wild deer we search for something under these sweet golden trees at our reach.* Woman: *And with uninhibited laughs we desire everything under these mature red trees at our reach.*
- **Musical Observations**: A return to all of the above but without the tango tune. Higher register on the keyboard, tender touch, *rubato* tempo. Eventually descends into lower register with a *decrescendo* and resolves in a minor chord.

- **Scene 2 & Synopsis**: Silence. Man knows his efforts are in vain and decides to take a bolder, more aggressive move. Woman waits anxiously to know what he thinks about her proposal for the future.
- **Musical Observations**: Tempo and dynamics increase. More rhythmically driven. Heavy bassline emphasizing chord tones with more minor tonality. From *mezzo-forte* to *forte*.

- **Scene 2 & Synopsis**: The couple discusses why their relationship failed.
- **Text**: Woman: *We can't have a conversation like this.* Man: *You said it a long time ago. Since day one our love was like a statue made out of glass: translucent because we could clearly see our emotions but never their reasons. Fragile, each of us with our way of being…*
- **Musical Observations**: More nebulous floating quality via higher register, dissonance, whole-tone scale patterns, parallel chords.

- **Scene 3 & Synopsis**: The couple take turns throwing call and response flirtatious poetic stanzas at each other.
- **Text**: Woman: *... I only wanted to see you once! I say. The field will sprout anew! You say. I will kill myself before I see those green tomatoes!* Man: *You and your ambiguities. Here you go: B is equal to V, which is equal to W. They say that a B is a V, that a V is a B, that W doesn't even exist. ...*
- **Musical Observations**: 6/8 time signature introduced; triplets create rolling effect. *Ostinato* in right hand, melody in left hand dips back and forth between lower and higher registers to create a call and response effect. Dissonance slowly increases.

- **Scene 4 & Synopsis**: The couple digs deeper into their clashing personality traits.
- **Text**: Man: *...So you can understand yourself better. You also have demons to extricate. I don't have another response. Trust me. I'm telling you that I'm willing to change if you're willing to accept me.* Woman: *Is that what you say to your students? Trust me. No. Not even with a thousand words said with delicacy...*
- **Musical Observations**: Augmented chords are introduced, creating ambiguous major and minor tonality. Semitone dissonant clusters persist with a higher diminished chromatic line played above the right hand within *rubato* tempo, creating a jarring, anguished feel. Overall *mezzo-piano*.

- **Scene 4 & Synopsis**: Woman's monologue. She dissects her role in society, her vocation, and ultimately her role towards herself.
- **Text**: Woman: *...I've gone from bitterness to curiosity, from joy to monotony and finally... to the p-o-s-s-e-s-s-i-o-n of myself. I look at myself with open eyes and with certainty: look, this is me, here and now. And more beautiful than ever. ...*
- **Musical Observations**: Intimate texture created via single quarter notes, lighter touch of the keys, higher register, nuanced range of subtle *pianissimo* to *mezzo-piano* dynamics.

- **Scene 5 & Synopsis**: The couple knows and accepts there is no remedy for the end that already arrived between them.
- **Text**: Man: *You demand too much.* Woman: *So now I'm the one demanding too much! ... You asked me for a final story and I'm giving you what I've learned after all this time.*
- **Musical Observations**: Pianist picks up Ástor Piazzolla's composition *Adiós Nonino* as the underlying melodic structure with an increasingly heavy touch, louder dynamics, and sweeping arpeggios before recoiling back.

- **Scene 6 & Synopsis**: The man has left and the woman remains crying, alone in the cabaret. A stark contrast to her final epilogue.
- **Musical Observations**: Single notes turn into heavy accented chords, lower notes, a descending bass line, all with a progressive *crescendo* and inserts of sweeping arpeggios before *decrescendo* to end on a minor chord.

Combining the data from both projects, several observations can be made. First observation: visual emotional content has a bijective effect on improvised music. For example, a happy scene elicits the creation of happy music, a fearful scene fearful music, a seductive scene seductive music, a tense-filled scene tense music, and so on. Second observation: musical variables such as mode (major or minor), tempo (fast or slow in beats per minute (BPM)), rhythm, pitch range (high or low), and dynamics (loud or soft) are all used in a variety of combinations to create enhanced emotional contexts to the visual and spoken narrative via mimicry of the physiological characteristics of each emotion. In *Moments*, for example, we see the following as described in Table 1. In Ch. 1: Sadness where the female character receives bad news and begins crying the tempo falls to *larghetto*, dynamics are at *mezzo-piano*, and the bass, in particular, mimics the pulse of the woman's slow, heavy breathing. In Ch. 4: Happiness where the scene follows the two characters during their pleasant and relaxed time together outside, the music starts off in a major key, at a *lento* tempo, with a bluesy feel, and at about an octave above middle C. As the characters become more playful, the music increases in tempo to an *allegro moderato*. In Ch. 5: Anger, the scene shows the same two characters in a far more estranged way. Their backs are to the camera, a large empty space sits between them, and their subsequent actions are unpredictable. Here, the music is atonal, tempo is erratic, dissonances arise, and dynamics are uneven. In *Última Partida*, we see similar effects as described in

Table 2. In scene 1 near the beginning of the play when the cabaret setting is introduced and the two characters begin a back and forth yes-and-no game of proposals by the man and rejections by the woman, the music shifts between minor and major tonalities and the tempo liberally speeds up and slows down ever so slightly (*rubato*) to mimic their push and pull. Then as the couple begins to close in on and seduce each other through their words, a bluesy melody slips in, the tonality is more major, and the tempo stays at a steady *andante*. In scene 4 when the woman delivers an intimate, passionate monologue about self, the piano enters softly and tenderly with single notes. Then as the couple begins to clash, dissonant semitone clusters persist to jarring effect. Third observation: salient non-emotional scenographic elements within the narrative are also simultaneously musically translated. For example, in Ch. 2: Surprise and Disgust in *Moments*, the two characters are shown ascending a long narrow seemingly infinite staircase to the rooftop. An overall effect of continuous circular movement is created as the piano ascends up the keyboard with heavy chords and repeating bass notes (pedal tones), the bass descends, and the saxophone repeats his same dissonant melody with slight variations through various keys. In Ch. 3: Fear where a woman's hand unrelentingly slides up the banister, the pianist mimics with a continuous *legato* touch. Within Ch. 4: Happiness, water falling in a fountain is present within the visual frame and the improvised music mimics its glistening sound effects with rolling ascending chords. In *Última Partida*, we also witness a similar effect. Most significantly, in scene 2 where the couple begins to dance flirtatiously, the music enters with a tango. As scene 2 moves forward and they discuss why their relationship failed, the man mentions a "statue of glass" and its fall. The music enters with parallel chords (a sequence of chords containing intervals that do not change as the chord moves up or down), then moves to an even higher register on the keyboard to shattering effect, and then continues with the dissonant parallel chords as the couple's views begin to clash. In scene 3 when the couple throws flirtatious poetic stanzas back and forth, the pianist reflects the repetitiveness of their actions with the continuous repetition of a short melodic phrase (*ostinato*) in their right hand and the alternating call and response with a flowing left hand below and above the right hand. Fourth observation: in the case of *Moments* where a trio improvised the score, the musicians simultaneously engaged in interactive communication between each other that included various common musical exchanges exemplified within jazz such as melodic and rhythmic imitation and motivic development[15,79] as significantly observed in all the chapters, and with each instrument taking the melodic or rhythmic lead at various points.

4. DISCUSSION AND CONCLUSIONS

These film and theatre projects are interesting and crucially relevant to today because of the merge of the underlying elements within and between multimedia works, and the consequences for the study of artistic creativity. The first element to consider is the visual stimulus. Within a visual image there are several variables among which narrative, scene elements like lighting and lens focusing, and physiological changes expressed by the actors all interact to represent an emotion and elicit a mood. In a case where language is involved, words add another layer of emotional and contextual meaning. Although in the context of distinguishing between perceived and represented reality through various artistic mediums, art historian Ernst Gombrich makes the point of comparing various photographs and paintings of the same image but with different lighting exposure levels to (a) explore our responses to such variances,[89] and (b) highlight the importance of scenographic information on our overall emotional and conceptual understanding of a visual narrative. For example, an image of a landscape printed with a narrower range of grays than one containing a wider range and stronger contrasts looks drastically different: rainy and foggy vs. bright and sunny. Aside from exposure levels within black and white, color too has been shown cross-culturally to have specific affective associations.[90] With respect to the present study, there are several elements to point out: (i) In *Moments*, which was shot in black and white HD video, except for the fear and happiness chapters that took advantage of *chiaroscuro* and high contrast sunny lighting to enhance the level of suspense and pleasantness within each scene, respectively, all other chapters did not have any special lighting effects and were shot either under natural or natural light-resembling studio lighting conditions within a medium range of grays. (ii) In *Última Partida*, colored lighting was used to denote place and time. Scenes one and two took place in the present moment in a cabaret with red hues, scene three took place at an undefined time either outdoors or in a dream with white light, scenes four and five begun in the present and moved into an evening in the past and back to the present with red, purple, blue, and red hues, respectively, and scene six took place in the present moment in the cabaret with red hues. Again, these projects were prepared with the intention of utilizing primarily physiological and linguistic cues as the sources for musical interpretation, but not ignoring lighting entirely to maintain contextual and narrative realism.

The second element is the audial stimulus. The use of improvised music, let alone pre-scored music, at least for film, is not novel. The history of music in and for film is almost as long as film history itself. From masking the noise of the

projector to serving as a tool for enhancing the emotional and narrative meaning of scenes, piano, organ, instrumental, and orchestral music both improvised and taken from classical repertoire were indispensable for silent films since 1895 up into the 1930s. By 1932 volumes of music books were published with musical suggestions for particular scenes known as "cue sheets."[80,91] The 1940s to 1960s were a golden age for original scored orchestral music, Bernard Herrmann (e.g. 1958: *Vertigo*) and Ennio Morricone (e.g. 1966: *The Good, the Bad, and the Ugly*) as notable examples. It was in the 1950s and beyond, however, when new film techniques and styles changed dramatically that all types of jazz like hard bop, free, modal, and Afro-Cuban took off in experimental and improvisatory directions landing such historic collaborations as those between Shafi Hadi in John Cassavete's *Shadows* (1959), Martial Solal and Jean-Luc Godard in *Breathless* ("À bout de souffle," 1960), Freddie Redd's Quartet with Jackie McLean in Shirley Clarke's 1961 *The Connection*, Michelangelo Antonioni's 1966 *Blow-Up* with Herbie Hancock, and the more traditional orchestral film-scoring style by Lalo Schifrin that innovatively infused a wealth of jazz rhythms for Peter Yates' action thriller *Bullitt* (1968), to name just a few. I mention these titles not only to offer past revolutionary examples within both cinematic and musical worlds, but, in conjunction with the novel work and analyses presented here, to bring to the forefront the empirical value of improvisatory music in response to visual information as a means of understanding how visual, music, language, and emotion perception all interact during the creation of an ephemeral and powerful aesthetic moment. Like in *Moments* and *Última Partida*, these musical scores take on the primary role of creating thematic congruence between sound and image (as in an ascending motion in tandem with an ascending melodic sequence[80]). The result is a focused, enhanced, and elicited set of emotions and particular key narrative details as determined by the improviser (if not the director) via the combination of specific musical elements. Moreover, given the real-time nature of the entire process, the improviser (several or soloist) is presumably in a constant feedback loop between new ideas emerging as a result of unraveling narratives on screen, on stage, and/or instrumentally, and selected ideas already in the midst of development without the opportunity to rewind into the past and revise the composition. Combining visual stimuli and audial information in real-time thus reveals a fascinating yet complex map of cognitive processing to piece apart. I propose, therefore, in Figure 1 a general cognitive feedback model of spontaneous creative emotional innovation that integrates the ever-changing music, spoken language, and emotional expression inevitable within live music scoring in film and theatre. Although not addressed here, but implied in the model and a question for further investigation, the actors on stage are hypothetically affected not just by their textual interpretation, but the emerging music as well.

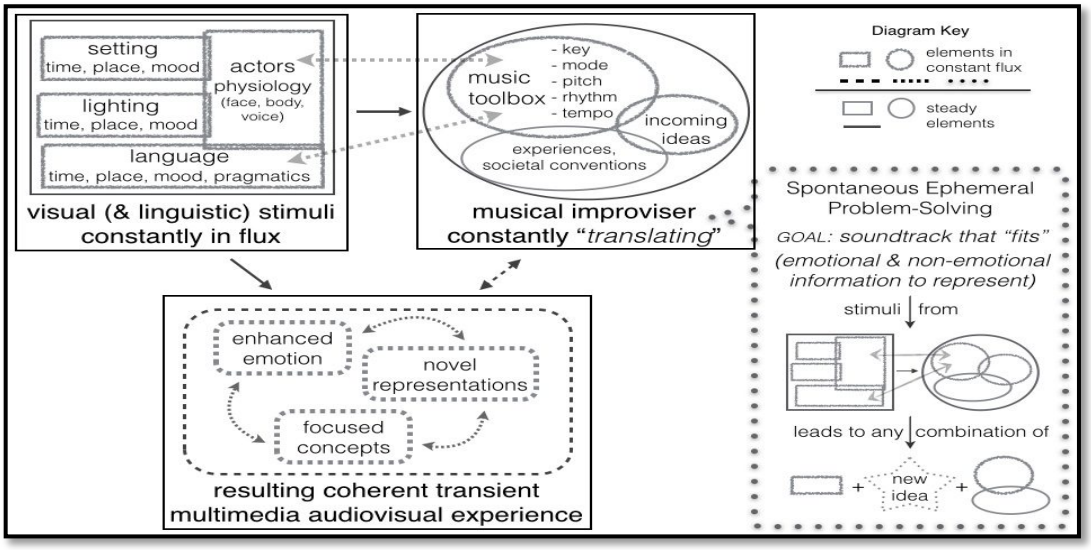

Figure 1. Cognitive model of live spontaneous creative musical composition and perception during film and theatre performances.

Moments and *Última Partida*, unlike past and present film and theatrical music, remain as unique artistic objects in constant fluctuation: their musical soundtracks change with every live presentation; and every composition is one more datum to the combinatorial options available for scenic translation into musical language. The ecological realism of the paradigm, moreover, allows for a richness of musical interpretations. As a result, this cognitive model offers a glimpse into the spontaneous improvisatory mind in action, and encourages the creation of contemporary multimedia works that both challenge the audiovisual experience and help us solve this complex problem-solving process that is creativity.

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REFERENCES

[1] IBM, "IBM Study: digital era transforming CMO's agenda, revealing gap in readiness," IBM News Room, 11 Oct 2011, <http://www-03.ibm.com/press/us/en/pressrelease/35633.wss> (2011).
[2] Nonami, K., "Prospect and recent research & development for civil use autonomous unmanned aircraft as UAV and MAV," J. System Des. Dyn., 1(2), 120-128 (2007).
[3] Ironmonger, J., "UK to allow driverless cars on public roads in January," BBC News Technology, 30 July 2014, <http://www.bbc.com/news/technology-28551069> (2014).
[4] Borden, S., "Tough day at the track? Blame the robot: camel racing blends centuries-old traditions and modern technology," The New York Times, 26 December 2014, <http://www.nytimes.com/2014/12/28/sports/camel-racing-in-the-united-arab-emirates-is-a-blend-of-centuries-old-traditions-and-modern-technology.html?_r=0> (2014).
[5] Marcus, G., "Why we should think about the threat of artificial intelligence," The New Yorker, 24 October 2013, <http://www.newyorker.com/tech/elements/why-we-should-think-about-the-threat-of-artificial-intelligence> (2013).
[6] Barrat, J., [Our Final Invention: Artificial Intelligence as the End of the Human Era], Thomas Dunne Books: St. Martin's Press, New York, (2013).
[7] Bilton, N., "Artificial Intelligence as a threat," The New York Times, 5 November 2014, <http://www.nytimes.com/2014/11/06/fashion/artificial-intelligence-as-a-threat.html?_r=0> (2014).
[8] Andersen, K., "Enthusiasts and skeptics debate artificial intelligence," Vanity Fair, 26 November 2014, <http://www.vanityfair.com/culture/2014/11/artificial-intelligence-singularity-theory> (2014).
[9] Dissanayake, E., "A hypothesis of the evolution of art from play," Leonardo, 7, 211-217 (1974).
[10] Dissanayake, E., "The artification hypothesis and its relevance to cognitive science, evolutionary aesthetics, and neuroaesthetics," Cogn. Semiotics, 5, 148-173 (2009).
[11] Dissanayake, E., "In the beginning, evolution created religion and the arts," Evol. Rev.: Art, Science, Culture, 2, 64-81 (2011).
[12] Bunge, M., [Intuition and Science], Prentice-Hall, Inc., Englewood Cliffs, New Jersey (1962).
[13] Davidson, I., and Noble, W., [Tools, Language and Cognition in Human Evolution], Cambridge University Press, Cambridge, 125-155 (1993).
[14] Gardner, H., [Creating Minds: An Anatomy of Creativity Seen Through the Lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Gandhi], Basic Books, New York (1993).
[15] Berliner, P.F., [Thinking in Jazz: The Infinite Art of Improvisation], The University of Chicago Press, Chicago and London (1994).
[16] Calvin, W., and Bickerton, D., [Lingua Ex Machina: Reconciling Darwin and Chomsky with the Human Brain], MIT Press, Cambridge, Massachusetts (2000).
[17] Simonton, D.K., "Cognitive, personal, developmental, and social aspects," Am. Psychol., 55(1), 151-158 (2000).
[18] Marcus, G., "How *does* the mind work? Insights from biology," Top. Cogn. Sci., 1(1), 145-172 (2009).
[19] McClelland, J.L., "Emergence in cognitive science," Top. Cogn. Sci., 2(4), 751-770 (2010).
[20] Bergson, H., [Matière et Mémoire: Essai Sur la Relation du Corps à L'Esprit], Skira, Genève (1946).
[21] Guilford, J.P., "Creativity," Am. Psychol., 5, 444-454 (1950).
[22] Guilford, J.P., "The structure of intellect," Psychol. Bull., 53(4), 267-293 (1956).
[23] Guilford, J.P., "Creative abilities in the arts," Psychol. Rev., 64(2), 110-118 (1957).
[24] Csíkszentmiháyli, M., [Beyond Boredom and Anxiety: Experiencing Flow and in Work and Play], Jossey-Bass, San Francisco, CA (1975).
[25] Csíkszentmiháyli, M. and Csíkszentmiháyli, I.S. (Eds.), [Optimal Experience: Psychological Studies of Flow in Consciousness], Cambridge University Press, Cambridge (1988).
[26] Bastick, T., [Intuition: How We Think and Act], John Wiley and Sons, Inc., Chichester, England (1982).

[27] Richardson, C.P., "Creativity research in music education: a review," Bull. Counc. Res. Music Educ., 74, 1-21 (1983).
[28] Finke, R.A., "Imagery, creativity, and emergent structure," Conscious. Cogn., 5(3), 381-393 (1996).
[29] Gero, J.S., "Creativity, emergence and evolution in design," Knowledge-Based Systems, 9(7), 435-448 (1996).
[30] Pressing, J., [Generative Processes in Music: The Psychology of Performance, Improvisation, and Composition], Clarendon Press, Oxford (1988).
[31] Chatterjee, A., "The neuropsychology of visual artistic production," Neuropsychologia, 42(11), 1568-1583 (2004).
[32] Miller, B.L. and Hou, C.E., "Portraits of Artists: Emergence of Visual Creativity in Dementia," Arch Neurol., 61(6), 842-844 (2004).
[33] Collins, D., "A synthesis process model of creative thinking in music composition," Psychol. Music, 33(2), 193-216 (2005).
[34] Jung, R.E., Segall, J.M., Bockholt, H., Flores, R.A., Smith, S.M., Chavez, R.S. and Haier, R.J., "Neuroanatomy of creativity," Hum. Brain Mapp., 31(3) 398-409 (2010).
[35] Ness, R., [Genius Unmasked], Oxford University Press, New York, New York (2013).
[36] Smith, S.M., Ward, T.B. and Finke, R.A. (Eds.), [The Creative Cognition Approach], The MIT Press, Cambridge, Massachusetts (1995).
[37] Boden, M.A., "Creativity and artificial intelligence," Artif. Intell., 103(1), 347-356 (1998).
[38] Dietrich, A., "The cognitive neuroscience of creativity," Psychon. Bull. Rev., 11(6), 1011-1026 (2004).
[39] Jung-Beeman, M., Bowden, E.M., Haberman, J., Frymiare, J.L., Arambel-Liu, S., Greenblatt, R., Reber, P.J. and Kounios, J., "Neural activity when people solve verbal problems with insight," PLoS biology, 2(4), e97 (2004).
[40] Sandkühler, S. and Bhattacharya, J., "Deconstructing insight: EEG correlates of insightful problem solving," PLoS one, 3(1), e1459 (2008).
[41] Ludmer, R., Dudai, Y. and Rubin, N., "Uncovering camouflage: amygdala activation predicts long-term memory of induced perceptual insight," Neuron, 69(5), 1002-1014 (2011).
[42] Solso, R.L., "Brain activities in a skilled versus a novice artist: an fMRI study," Leonardo, 34(1), 31-34 (2001).
[43] Bhattacharya, J. and Petsche, H., "Drawing on mind's canvas: differences in cortical integration patterns between artists and non-artists," Hum. Brain Mapp., 26(1), 1-14 (2005).
[44] Amedi, A., Merabet, L.B., Camprodon, J., Bermpohl, F., Fox, S., Ronen, I., Kim, D.-S. and Pascual-Leone, A., "Neural and behavioral correlates of drawing in an early blind painter: a case study," Brain Res., 1242, 252-262 (2008).
[45] Howard-Jones P.A., Blakemore S.J., Samuel E.A., Summers I.R. and Claxton, G., "Semantic divergence and creative story generation: an fMRI investigation," Cogn. Brain Res., 25(1), 240-250 (2005).
[46] Shah, C., Erhard, K., Ortheil, H.J., Kaza, E., Kessler, C. and Lotze, M., "Neural correlates of creative writing: an fMRI study," Hum. Brain Mapp., 34(5), 1088-1101 (2013).
[47] Fink, A., Graif, B. and Neubauer, A.C., "Brain correlates underlying creative thinking: EEG alpha activity in professional vs. novice dancers," NeuroImage, 46(3), 854-862 (2009).
[48] May, J., Calvo-Merino, B., Delahunta, S., McGregor, W., Cusack, R., Owen, A., Veldsman, M., Ramponi, C. and Barnard, P., "Points in mental space: an interdisciplinary study of imagery in movement creation," Dance Res., 29(2), 402-430 (2011).
[49] Bengtsson, S.L., Csíkszentmiháyli, M. and Ullén, F., "Cortical regions involved in the generation of musical structures during improvisation in pianists," J. Cogn. Neurosci., 19(5), 830-842 (2007).
[50] Berkowitz, A.L. and Ansari, D., "Generation of novel motor sequences: the neural correlates of musical improvisation," NeuroImage, 41(2), 535-543 (2008).
[51] Limb, C.J. and Braun, A.R., "Neural substrates of spontaneous music performance: an fMRI study of jazz improvisation," PLoS one, 3(2), e1679 (2008).
[52] de Manzano, Ö. and Ullén, F., "Goal-independent mechanisms for free response generation: creative and pseudo-random share neural substrates," NeuroImage, 59(1), 772-780 (2012).
[53] Lopez-Gonzalez, M. and Limb, C.J., "Musical Creativity in the Brain," Cerebrum: the Dana Forum on Brain Science, 2012 (2012).
[54] Donnay, G.F., Rankin, S.K., Lopez-Gonzalez, M., Jiradejvong, P. and Limb, C.J., "Neural substrates of interactive musical improvisation: an fMRI study of 'trading fours' in jazz," PLoS one, 9(2), e88665 (2014).
[55] Liu, S., Chow, H.M., Xu, Y., Erkkinen, M.G., Swett, K.E., Eagle, M.W., Rizik-Baer, D.A., and Braun, A.R., "Neural correlates of lyrical improvisation: an fMRI study of freestyle rap," Sci. Rep., 2 (2012).
[56] Finke, R.A., Pinker, S. and Farah, M.J., "Reinterpreting visual patterns in mental imagery," Cogn. Sci., 13(1), 51-78 (1989).

[57] Finke, R.A., "Imagery, creativity, and emergent structure," Conscious. Cogn., 5(3), 381-393 (1996).
[58] Bilda, Z. and Gero, J.S., "Idea development can occur using imagery only," Proc. DCC'08, 303-320 (2008).
[59] Ganis, G., Thompson, W.L. and Kosslyn, S.M., "Brain areas underlying visual mental imagery and visual perception: an fMRI study," Cogn. Brain Res., 20(2), 226-241 (2004).
[60] Damasio, A.R., [Descartes' Error: Emotion, Reason, and the Human Brain], Putnam, New York (1994).
[61] Baddeley, A., "Exploring the central executive," Q. J. Exp. Psychol.: Section A, 49(1), 5-28 (1996).
[62] Fuster, J.M., "Temporal processing," Ann. N. Y. Acad. Sci., 769(1), 173-181 (1995).
[63] Posner, M., "Attention: the mechanism of consciousness," Proc. Natl. Acad. Sci., 91(16), 7398-7403 (1994).
[64] Damasio, A.R., [The Origins of Creativity], Oxford University Press, Oxford, 59-68 (2001).
[65] Campbell, D.T., "Blind variation and selective retention in creative thought as in other knowledge processes," Psychol. Rev., 67(6), 380-400 (1960).
[66] Sawyer, R.K., [Group Creativity: Music, Theater, Collaboration], Lawrence Erblaum Associates, Publishers, Mahwah, New Jersey and London, England (2003).
[67] Dietrich, A., "Functional neuroanatomy of altered states of consciousness: the transient hypofrontality hypothesis," Conscious. Cogn., 12(2), 231-256 (2003).
[68] Breton, A., [Manifeste du Surréalisme], Éditions du Sagittaire, Paris, France (1924).
[69] Glaveanu, V., Lubart, T., Bonnardel, N., Botella, M., de Biaisi, P.-M., Desainte-Catherine, M., Georgsdottir, A., Guillou, K., Kurtag, G., Mouchiroud, C., Storme, M., Wojtczuk, A. and Zenasni, F., "Creativity as action: findings from five creative domains," Front. Psychol., 4 (2013).
[70] Mumford, M.D., Mobley, M.I., Reiter-Palmon, R., Uhlman, C.E. and Doares, L.M., "Process analytic models of creative capacities," Creativity Res. J., 4(2), 91-122 (1991).
[71] Dewey, J., [Art as Experience], Minton, Balch and Company, New York, 106 (1934).
[72] Gray, H.H., "Renaissance humanism: the pursuit of eloquence," J. Hist. of Ideas, 24(4), 497-514 (1963).
[73] Abraham, A., "The promises and perils of the neuroscience of creativity," Front. Hum. Neurosci., 7 (2013)
[74] Barrett, L.F., "The future of psychology: connecting mind to brain," Perspect. Psychol. Sci., 4(4), 326-339 (2009).
[75] Arnheim, R., [Art and Visual Perception: A Psychology of the Creative Eye], University of California Press, Berkeley, CA (1954).
[76] Langer, S.K., [Philosophy in a New Key: A Study in the Symbolism of Reason, Right, and Art], Harvard University Press, Cambridge, Massachusetts and London, England (1957).
[77] McNiff, S., [Handbook of the Arts in Qualitative Research: Perspectives, Methodologies, Examples, and Issues], Sage, London, England, 29-40 (2008).
[78] Sawyer, R.K., "Improvisation and the creative process: Dewey, Collingwood, and the aesthetics of spontaneity," J. Aesthet. Art Critic., 58(2), 149-161 (2000).
[79] Bastien, D.T. and Hostager, T.J., "Cooperation as communicative accomplishment: a symbolic interaction analysis of an improvised jazz concert," Communication Studies, 43(2), 92-104 (1992).
[80] Cohen, A.J., [Language, Music, and the Brain: A Mysterious Relationship], The MIT Press, Cambridge, Massachusetts and London, England, 173-202 (2013).
[81] López-González, M., [Última Partida / The Final Draw], La Petite Noiseuse Productions, Publisher, Baltimore, MD, 1st Bilingual Edition, Library of Congress, ISBN 978-0-578-14352-1 (2014).
[82] Ekman, P., "Are there basic emotions?," Psychol. Rev., 99(3), 550-553 (1992).
[83] Carr, I., [Miles Davis: The Definitive Biography], Da Capo Press, Boston, Massachusetts (2006).
[84] López-González, M., "Jazz meets film revisited," The Baltimore Jazz Alliance Newsletter, 10(8), 4-5 (2013).
[85] Cross, I. and Morley, I., [*Communicative Musicality*], Oxford University Press, Oxford, 61-82 (2009).
[86] Gabrielsson, A. and Juslin, P.N., "Emotional expression in music performance: between the performer's intention and the listener's experience," Psychol. Music, 24(1), 68-91 (1996).
[87] Gabrielsson, A. and Lindström, E., [Music and Emotion: Theory and Research (Series in Affective Science)], Oxford University Press, New York, New York, 223-248 (2001).
[88] McPherson, M.J., Lopez-Gonzalez, M., Rankin, S.K., & Limb, C.J., "The role of emotion in musical improvisation: an analysis of structural features," PloS one, *9*(8), e105144 (2014).
[89] Gombrich, E.H., [Art and Illusion: A Study in the Psychology of Pictorial Representation], Princeton University Press, Princeton, New Jersey, 33-62 (1960).
[90] Adams, F.M. and Osgood, C.E., "A cross-cultural study of the affective meanings of color," J. Cross-Cultural Psychol., 4(2), 135-156 (1973).
[91] Rosar, W.H., "Film music–what's in a name," J. Film Music, 1(1), 1-18 (2002).