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ARTICLE

The behavioral architecture and biological utility of aesthetic reactions

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ABSTRACT

The article presents a behavioral and biological theory as to how aesthetic reactions form. It takes a naturalistic perspective in exploring the likely phylogenetic origins of aesthetic reactions; their functions in the maintenance of human culture; and as indicators of group identity. According to the theory, *aesthetic reactions occur when certain affect-charged cognitions interact with transformative effect*. The term cognition, as used here, refers to verbal, conceptual, abstract, and derived relational behavior in music, poetry, narratives, and the perception of auditory, visual, tactile, sexual and other sensory stimuli, and excludes respondent behavior. Cognitions become affect-charged and come to elicit affect-linked respondents either when they acquire conditioned stimulus (CS) functionalities via previous Pavlovian conditioning episodes, or when such functionalities are genetic. The theory can be tested experimentally by applying it to the laboratory synthesis of aesthetic reactions and then assessing the result's conformity to accepted definitions and instances of aesthetic reactions.

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Introduction

The article offers a behavioral and biological theory of how, and under what conditions, aesthetic reactions form. It also offers ways to test the theory experimentally, made possible by the fact that the theory's components are naturalistic and measurable.[1] The following questions will be discussed:

What are the behavioral components of the reaction often termed "aesthetic?"

Under what conditions do aesthetic reactions occur and how do they come about?

What are the ontogenetic and phylogenetic origins of aesthetic reactions?

What biologically useful functions do aesthetic sensibilities perform?

What functions do aesthetic reactions perform in human societies and cultures?

Elements of the theory were sketched out in three earlier publications to which this one often refers – Mechner (2018a) (*A Behavioral and Biological Analysis of Aesthetics*), which provide numerous examples of aesthetic reactions; a second article published in a special issue of *The Psychological Record*. (Mechner, 2018b), which presents my reply to

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nine commentaries on the first one; and an article published in the *Polish Journal of Aesthetics* (Mechner, 2019). The present article builds on those three and reflects the helpful comments and suggestions I received from many sources over the years.[2]

Part 5 extends the analysis of aesthetics into the interpersonal and socio-cultural domains, and explores the role that aesthetic sensibilities may have played in the evolution of language, inquiry skills, planning, and manipulation of the concept repertoire.

Part 1.0 Features of a behavioral analysis of aesthetics

1.1 The naturalistic approach

The three publications cited above (Mechner, 2018a, 2018b, 2019) conceptualize aesthetics as a natural phenomenon that can be addressed with the methods of behavioral and biological science (Marr & Zilio, 2013). My attraction to the naturalistic approach lies in its tolerance of ignorance. The explorer does not bring a map, just a machete, observation skills, and determination. No hypotheses or theories. These can come later.

I used this approach in examining, over many decades, hundreds of phenomena that many might call aesthetic, in 17 different disciplines including music, poetry, literature, the visual arts, humor, mathematics, science, and the performing arts. Parts 8 and 9 of the 2018a article present analyses of over 200 such "aesthetic" phenomena. I tried to identify shared attributes that might explain why the term aesthetic is often applied to all of them, diverse though they are. I also wanted to understand their behavioral and biological origins and functions. In Mechner (2019), I explored the properties of domains that host aesthetic reactions – of types of spaces (music, narratives, mathematics, visual stimuli, etc.) in which aesthetic reactions can occur.

1.2 The aesthetic reaction

The reaction we call aesthetic appears to fall into a distinctive category, not simply affective,[3] emotional, respondent, operant, or cognitive, but a special blend of these. The core aesthetic reaction does not operate on the environment the way operant behavior does. It is not shaped by its consequences nor does it depend on them. It includes a type of affect that has respondent characteristics and is often entirely covert. Some have characterized it as a type of "chill" (Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011). But that term would be applicable only to the strongest aesthetic reactions. Only rarely do aesthetic reactions reach that level. Most are of such low level as to be virtually imperceptible. Only when the reaction is strong enough does it trigger overt operant behavior like smiles, gasps, or verbal exclamations. Neuroscientists have recently begun to identify some of the loci and pathways of the neurological correlates of such verbal reports as "chills" or "beauty."

Our belief that aesthetic reactions exist at all is supported by their consistency and universality across cultures and eras, much like the universality of pain, pleasure, or thirst, and is based largely on verbal reports regarding private reactions. These reactions are generally described as pleasurable as well as "involuntary," but pleasurable in a distinctive way – generally reinforcing, but not the way eating when hungry or drinking when thirsty is reinforcing.[4] Rather, the reinforcing effect is of a type that is independent of the satisfaction of "drives," as Rolls (2005) also observed.[5] The term aesthetic is also used for certain types of negative reactions like disgust or aversion.

1.3 The locus of beauty: in the beholder or in the object?

The essence of the behavioral and biological conceptualization of aesthetics is that it is *an organism's reaction*. "Beauty" and similar descriptors are not properties of stimuli or of aspects of the external world, though we often speak and act as if they were. They are our perceptions and responses to these, just as our perception of distinct colors is due entirely to the existence, in our retinas, of specialized color receptors that respond differentially to arbitrarily bounded segments of the energy spectrum's frequency range. The colors we perceive exist only in our retinas and nervous systems. The perceptual systems of other species respond to different frequency bands of the spectrum and thus see different "colors" (Mechner, 2019, Section 4.1).

The same principle applies to stimuli that are more complex than the light spectrum, as in the case of optical and other illusions, or contrast effects. Here, the counterpart of the retina is the brain and the behavior repertoire it implements. While illusions may be extreme cases, all of our perceptions are modulated by idiosyncratic learning histories and physiologies. We identify misperceptions only when confronted with objective measurements, with the epistemological implication that objective measurement and the methods of science increase the validity, reliability, and accuracy of our information regarding what is "real." In daily life, we correct for the effects of potentially misleading stimuli automatically, as a result of learning that started at birth, as when we perceive distant objects as being of the same size as near ones even though they project a smaller image on the retina, or as right-side-up when the retinal image is actually upside down, but learning effects can distort our perceptions as to "what is really out there" in similar ways .

The same principle operates in the realms of verbal and interpersonal behavior. For instance, the six-word narrative, "For sale: baby shoes. Never worn," exemplifies the principle that the effects of narratives are generally not defined by the verbal stimulus (in this case, the six words); the story is the *behavior* that those words may evoke when the verbal stimulus interacts with an individual's idiosyncratic learning history and concept repertoire (Palmer, 2018). Depending on those idiosyncrasies, the imputed story may involve the death or physical malformation of a newborn, a miscarriage, or a shoe store with an unbalanced inventory. A similar point was made by Rosenblatt (1938/1995, 1978) regarding the dependence of reactions to literature or poetry on the idiosyncratic history and repertoire of the reader.

1.4 Erroneous imputation of invariance to one's own perceptions

Illusions are not the only instance of humans imputing unwarranted invariance to their own perceptions.[6] All organisms interact with their environments in ways that are often based on, or distorted by, idiosyncratic perceptions or misperceptions. For instance, one may impute the cause of one's anger to the object on which one stubbed one's toe, or to certain actions of another person; or of one's malaise to events in the external world.

But the tendency to seek causes first in the external world and only later (if ever) in one's own behavior, is a pragmatic one: it is a biologically useful heuristic for identifying causes that *truly* reside in the external world, or for generating working hypotheses about such causes. It is far more difficult to analyze the idiosyncratic historic variables that determine one's own reactions.[7] The correlation between our perceptions and objective reality is highest for situations that were most frequently present during our evolution

and lowest in novel situations or rare ones, for which our perceptual abilities have not yet had time to be honed by evolutionary selection.

Perceptual idiosyncrasies are also commonly at play in interpersonal behavior and in such societal issues as prejudices and inter-group conflict. The study of aesthetic reactions may open a new window onto the large domain of perceptual bias phenomena (Jones, 2019), the common failure to recognize their idiosyncratic nature and the consequent unwarranted attribution of invariance to one's perceptions.

The sections below examine ways in which aesthetic reactions are created by the operation of variables that reside mainly in the perceiver's behavior repertoire and perceptual physiology.

Part 2.0 How interactive effects create aesthetic reactions

2.1 Types of interactive effects

In the course of examining hundreds of "aesthetic" phenomena, I noticed that stimuli that elicit aesthetic reactions always involve *an interaction among normally disparate elements* (Mechner, 2018a, Part, p. 1). The effects of such interactions may be novel, even when the interacting elements are familiar. Interactions whose effects are, in that sense, transformative were termed "synergetic" by the German physicist Herman Haken and the American philosopher-engineer Buckminster Fuller. Synergetic effects are different in kind from the individual interacting elements, as in chemical reactions, combustion, photosynthesis, or fertilization.

Here is an example by Pablo Picasso. He takes two cognitions[8] – the handlebars and seat of a bicycle, and repositions them so as to form the head of a bull.

Other kinds of interactions are of the *synergistic* type, where "the total is greater than the sum of its parts," as when one plus one is more than two. When the effect is accelerative, we may call it catalytic. All of these types of interactions may be involved in the formation of aesthetic reactions. When interactions occur concurrently or in close succession, the resulting effects and reactions may in turn interact, often with further compounding and transformative effects.[9]

I have been using the term "synergetic brew" for the interacting cognitions, which may be those listed in footnote 8 as well as aspects of the individual's behavioral history, like recollections and events that prime or potentiate the reaction.[8] As will be explained further in the sections that follow, any of these cognitions can become affect-charged, often as a result of past Pavlovian conditioning events.

A virtue of conceptualizing interactive effects as synergetic, synergistic, catalytic, or compounding is that such interactions can be modeled in the laboratory, where the effects are objectively and quantitatively measurable. Part 4 of the article explains how the present conceptualization offers ways to synthesize aesthetic reactions experimentally and thus study them as laboratory models.

2.2 Compounding effects in the formation of aesthetic reactions

According to the present theory, the aesthetic reaction occurs in response to stimulus *interactions* rather than to isolated stimuli. The component interactions among elements of the brew may themselves involve compounding, synergetic, synergistic, or catalytic interactions, in recursive and iterative fashion.

A reason why this paradigm is plausible is its ubiquity in the natural universe. Processes like "catalysis," "potentiation," "exacerbation," "opponent processors" (Sherrington, 1906) and so forth all involve interactions among disparate elements and are widespread. The same kinds of interactive and relational effects are also seen in many pan-cultural behavior patterns that involve affect, as in the familiar compounding effects that build and augment love, hate, anger, anxiety, or jealousy.[10]

A familiar example of compounding effects is seen in film, where each additional medium (motion, sound, color, acting, music, drama, interactivity, etc.) contributes an additional interactive element to the synergetic brew, and thus augments the potential aesthetic impact (Sections 1.7 and 9.2 of the Mechner, 2018a article). The same compounding effects occur in opera, where the impact is augmented by the combination of drama, music, acting, staging, and lighting. Compounding of reactions also occurs in group or crowd situations as in rallies, religious events, riots, panics, or mob behavior.

The augmenting effects described in the above paragraph all increase the magnitude and character of the affective impact of the elements' interactions. Priming operations often predispose individuals to react to such augmenting effects in particular ways. For instance, a drum roll may create anticipation that amplifies the affective impact of events that follow, such as music or the entrance of a performer; same for the singing of an anthem or the awe-inspiring interior of a cathedral, or stairs leading up to a throne or altar. Thus, priming and potentiating events can often augment or alter the affective impact of subsequent interactions. In the arts, examples of affect-related priming are the

interactions of previously acquired affective associations with certain melodic, harmonic, or rhythmic patterns, or with coloristic or spatial ones. Other instances of such priming are culture-based or based on learning, as when listening to a recording before going to hear the music in a concert hall; all of these instances of priming are interactive processes that can predispose an individual to react to stimuli with augmented affect.

2.3 The process by which aesthetic reactions form

Box 1, Cognitive Behaviors, shows some instances of the complex higher-order conceptual and relational operant behavior discussed in Mechner (2018a), Parts 4–9. Box 4 represents the *compound effects of their interactions* (as when the lyrics of a song interact with elements of the music, or when the subject of a painting interacts with the color scheme or composition).

Boxes 2, 3, and 6 represent the main sources of affect that combine to create the compounded affective components of the aesthetic reactions (Box 5). Box 2 describes how reactions that have a positive affective component may have originated in earlier classical conditioning incidents (for an explanation of how that can happen, see Sections 3.1–3.3 below). Box 3 represents affective respondent reactions of other origins, as elaborated further in Section 3.5, and Box 6 represents the affective reactions that positive reinforcement often generates, in this case the positive reinforcement generated by the cognitive interactions listed in Box 1, also elaborated further in Section 3.5 below. The three sources of affect (Boxes 2, 3, and 6) combine and compound to create the *total affective reaction* (Box 5).

Box 7 represents the final effect of the interactions among the affective and cognitive components of Boxes 4 and 5. The transformative confluence of these creates the aesthetic reaction (Bottom Box). The particular sequence in which the components come together may or may not be important.

2.4 When incremental changes trigger interactions

A common type of interaction is one where a tipping effect occurs when one of the interacting variables reaches a magnitude threshold. The tipping effect can be a change of state or other type of discontinuity. Examples from physics include combustion, freezing/melting, evaporation/condensation, the nuclear chain reaction, and "critical mass." Examples from chemistry include crystallization, explosion, and precipitation in a super-saturated solution.

Biology provides many examples of a small increment in a continuous variable having a sudden effect: the withdrawal reflex being triggered by a heat increment; a pain reaction produced by a pressure increment; an orgasm produced by sustained sexual stimulation; a sneeze produced by a continuing localized tickle; and so forth. Those reactions are mostly hard-wired, but there are myriad instances where learning also plays a role. For instance, when we knock on a door, we normally knock two or three times. The first knock arouses attention, the second one confirms that it's a knock, and the third confirms that someone is knocking. The knocker has learned that the compound effect is transformative, a fact learned by many species. When the dog hears a faint sound, it raises its head and perks up its ears. When it hears a further sound, it may stand up or growl. When it hears still more, it may bark and run to the door.

What these examples have in common is that when a continuous variable reaches a critical value, a final small increment produces a transformative event in some other domain. In the formation of aesthetic reactions, the continuous variable that reaches a critical value can be *the sheer number of the concurrent compounding cognitive and affective interactions.*

Part 3.0 Affect in the formation of aesthetic reactions

3.1 Pavlovian conditioning and affective reactions (box 2 in Figure 1)

As the theory states, for an aesthetic reaction to occur, at least one of the interacting cognitions must be affect-charged. One of the ways cognitions become charged with affect is via Pavlovian conditioning events. The cognitive behaviors that occur throughout life (for examples, see Box 1 in Figure 1 and Mechner, 2018a, Sections 1.3–1.10) randomly coincide, from time to time, with previously unrelated affective events or situations: for instance, loving childhood interactions with a parent or close friend, or a memorable meal. Such random coincidences can result in Pavlovian conditioning events where *the situation's affective aspect performs the function of the unconditioned stimulus* in the respondent conditioning paradigm, and the *cognitive behaviors may acquire the functionality of conditioned stimuli* (CSs), which may subsequently be able to elicit affective respondent reactions on their own. Most people have had the experience of certain food tastes, odors, sounds, or visual stimuli evoking an affective reaction that

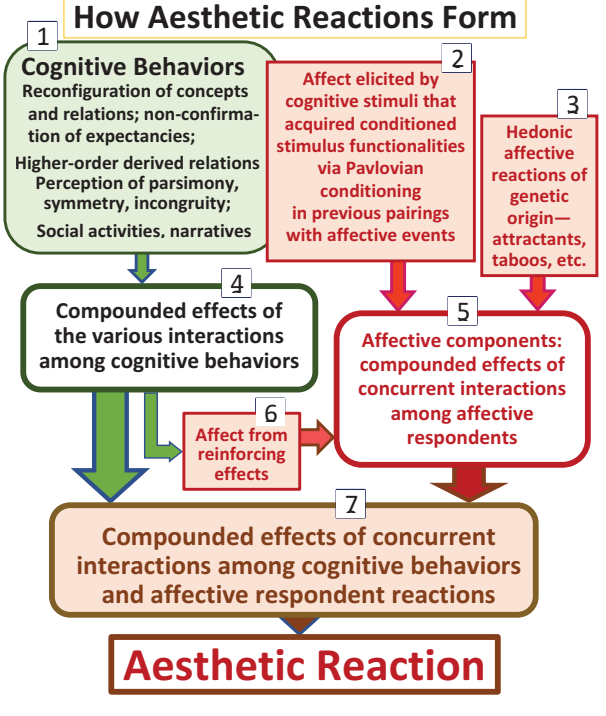

Figure 1. Schematic overview of how interactive effects create the aesthetic reaction, according to the theory.

includes respondents (Mechner, 2018b, Section 7.1; Schlinger, 2018). The concept proposed here is that relatively complex cognitive operants, like a verbal expression, a musical rhythm, or a mathematical expression – stimuli that may previously have been relatively neutral in the sense of producing little affect – can come to function as CSs that elicit affective respondents as a result of earlier Pavlovian conditioning events.

3.2 The role of early respondent conditioning experiences

The affective reactions that cognitive behavioral events may come to induce, often originate in childhood. "Sweet childhood memories" may originally have been elicited by mother's cooking, odors, special outings, sexual experiences, songs that were sung in the childhood home, art works that hung on its walls, and even wallpaper patterns. The spoken sounds an infant hears during critical developmental periods generally have lifelong effects on its verbal behavior. Most people can list stimuli or activities that have persistent personal and idiosyncratic affective significance for them – positive or negative ones and the vast range of flavors in between. This effect also helps explain why individuals have aesthetic sensibilities in some broad areas and not in others, the differences being accounted for by the types of stimuli and contingencies that were present in the particular familial and cultural environments in which they grew up.

3.3 Verbally mediated and derived conceptual relations

Many affective events of learned origin are verbally mediated. The insertion of expletives into utterances is an example. If the utterance has additional affect-inducing attributes, such as a raised voice or affect-evoking content, the compounded affective impact may be increased.

A related example is the addition of rhyme in poetry. When rhyming words occur at the ends of lines in poems, or in an aphorism, they tend to add plausibility to the statement (Mechner, 2018a, Section 8.2, 8.3.3). Other examples of synergetic and compounding effects: a color in isolation usually has no particular impact, but when it appears incongruously within a recognizable shape (e.g., a green cat) or in the context of a black and white image; or as red in a context that suggests blood, affect may be added to the color's impact. Same for a melody whose impact becomes affective when it unexpectedly modulates into a different key or changes timbre. Other instances of affective reactions are created by synergetic interactions among such behaviors as aggression, sex, cooperation for attack or defense, and certain effects in the arts. All of these interactive affective impacts are amplified and often transformative when they occur concurrently. Such effects have been described in such poetic terms as "the soul-stirring synergy of conceptual confluence" (Mellon, 2018), or "a magical metamorphosis of the ordinary" (Gibson, 2011).

3.4 Biological benefits of early impressionability

Conditioning episodes that occur early in life generally tend to be more impactful and have longer lasting effects than later ones (Harlow & Zimmermann, 1958; Hess, 1958; Lorenz, 1935; Schaffer & Emerson, 1964; Schlinger, 2018; Woodruff-Pak, 1988).[11] The biological utility of this phenomenon resides in its function of promoting the adaptation of young organisms to their environment. It also creates a developmental window for the

transmission to them, via early learning, of their parents' knowledge and experience – thereby helping the offspring adapt to current environmental circumstances far more efficiently than merely via the multi-generational evolutionary process of genetic encoding of novel behavioral variants. This biologically useful adaptation may have been a factor in driving the progressive lengthening of neoteny in many vertebrate species. As conditionability increased, so did the post-natal learning period in which to utilize this conditionability.

The composition of the particular synergetic brews that are paired with affective stimuli in classical conditioning episodes are generally due to chance factors. The resulting conditioned reactions therefore do not necessarily reflect biological utility (as when the ducklings followed Konrad Lorenz rather than their actual mother – to cite a famous example). However, when the pairings reflect a reliably stable feature of the environment, they are biologically useful (as when the mother is the first thing ducklings normally see upon hatching). Similarly, since parents tend to be familiar with the current environment, what they teach about it to their offspring tends to have valid adaptative utility.

3.5 Other sources of affective contributions

Box 3 in Figure 1 refers to one of the "devices" described in Section 7.4 of Mechner (2018a) under {j} *Emotionalizing Concepts* – one of the many devices that creators of aesthetic effects employ. Such affective effects may be of genetic origin, like all kinds of loud noises, or sudden, unexpected events or sensations, whether pleasant or unpleasant. Other contributors of affect are the reinforcing effects to which Box 6 in Figure 1 refers. Many types of reinforcing events generate affective reactions in addition to their reinforcing effects. Affective effects of reinforcement often entail respondents like pupillary dilation, vascular effects, skin resistance, and undoubtedly also other, less readily observed respondent correlates of affect.

Positive reinforcement effects are often generated by learning episodes, refreshment and maintenance events, parsimony, symmetry, narratives, humor, and the quality dimensions of artifacts or of performances (Mechner, 2018a, Parts 4 and 7, and Section 3.7 below). All of these events owe their reinforcing effects to the evolutionary selection of susceptibility to these reinforcers – a susceptibility that increased the individual's probability of survival and procreation. Most such reinforcers impact the operant repertoire, especially the concept repertoire, by strengthening and shaping portions of it, as explained further in the section below, and by imparting affective impact to parts of it (Box 6 in Figure 1).

3.6 Concept manipulation in the arts

The arts are based on man-made brews of interacting elements designed to elicit aesthetic reactions. The devices that creators of aesthetic effects (musicians, artists, performers, poets, writers, chefs, etc.) use to create such brews generally involve the manipulation of concepts. Sixteen such devices are described and illustrated in Sections 1.10 and 7.4 of Mechner (2018a) and discussed by Killeen (2018). Prominent themes on which these devices are based are class expansion, formation or sharpening of discriminations and generalizations, and the creation of expectations whose confirmation or disconfirmation

has instructional effects.[12] Powerful media for the implementation of these devices are film (Sections 1.7 and 9.2 of the 2018a article), narratives (Hineline, 2005, 2018; Mechner, 2018b, Sections 3.4, 4.3), music, visual arts, humor, performance arts, games, and other disciplines that involve manipulation of concepts and of cognitions.

Just as humans learned to distill and separate the intrinsic reinforcers of eating from the hunger drive, of drinking from thirst, and of sexual behavior from procreation, and repurpose them, so have they also learned to distill and repurpose the intrinsic reinforcers of operant learning from their original functionalities of adaptation and survival. Operant learning for its own sake, repurposed as play, as in games, rarely has significant near-term implications for adaptation or survival, though it often has the beneficial long-term effect of providing practice in important skills, especially the skills of learning, i.e., of learning to learn. All of these distilled reinforcers, even without their original biological functions, can still participate in the ensemble of reinforcing elements that synergetic brews can generate, and thus act in concert, with compounding effect, to elicit aesthetic reactions. One of their "modern" utilities is the subject of Sections 5.3–5.7.

3.7 Reinforcing and aesthetic effects based on quality

The concept of quality applies to how well an artifact is made, the level of craftsmanship it reflects, and thus how well it is suited for its function. For craftsmen, the quality of tools or other implements can have reinforcing and sometimes aesthetic effects (Mechner, 2018b, Section 4.3; Hineline, 2018), and may be described as "beautiful"; the quality of instruments often has such effects for musicians; of conveyances for their users (bicycles, cars, skates); of clothes for their wearers; of weapons for warriors; or of dwellings for their inhabitants. The functionality and utility of tools, conveyances, clothes, or domiciles depends on how well they are crafted. Since the functionality of many of these artifacts have biological utility – even if it is indirect – for survival or procreation, such utility could well be the phylogenetic reason for the quality dimension's aesthetic effect. Like all operant reinforcers, the quality dimension can have both reinforcing and eliciting properties, and hence the power to contribute to aesthetic impact when it applies to certain types of human behavior that have biological utility. Prominent among these are:

- *Interpersonal behavior*, as in acts of love, generosity, communication, collaboration, or protection.
- *Maintenance of a culture's cohesion and continuity* via language, rituals, décor, dress, traditions, customs, art forms, and memes in general.
- *Performances*, as in acting, dance, music, oratory, sports, comedy, or other displays of skill.
- *Narratives* that relate or recall events, orally or via writing or film, or stimulate associations.
- *Prevailing*, as in combat, competitive sports, games, or other types of competition.
- *Provisioning*, as in creating collections and stores of items that may be useful in the future, like food, multiple dwellings, money, or other resources.

The point of this section is that quality dimensions of these six biologically useful activities and probably some others as well, can function as elements of synergetic

brews and contribute to the compounding effects that create aesthetic reactions. For a more detailed analysis of these six activities, see Mechner (2018b Section 4.3). Part 5 below discusses the ontogenetic factors that are at play in the appearance of aesthetic reactions.

Part 4.0 Testing the aesthetics theory

4.1 The theory and how it can be tested

In essence, the theory states that *an aesthetic reaction may occur when appropriately primed, disparate cognitions, at least one of which is affectively charged, interact transformatively*.

It is a type of theory that describes how an observed phenomenon may come about. Examples of biological phenomena described by such theories are photosynthesis, phototropism, conditioning, or memory. One way to test this type of theory is to apply some of its tenets to create an artificial or synthetic exemplar, and then compare that exemplar and its properties to the originally observed phenomenon.

This type of test is available when the theory's component elements and concepts are operationally defined and can therefore be synthesized, simulated, or created. The present theory is testable because it meets these conditions, and the steps of the testing process are operationally feasible. A readily accessible way to test the theory is to create *synthetic laboratory models of aesthetic reactions*, and then assess how well such models conform to the theory's definition of an aesthetic reaction.

4.2 Procedure for synthesizing laboratory models of aesthetic reactions

Step 1. – : Select two cognitions, at least one of which is affect-charged, from the participant's existing repertoire. There are many such cognitions to choose from in every person's repertoire. For example, many people react with affect to certain music passages, songs, voices, facial expressions, stories, or narratives, according to the individual's particular history. For many people, images of cute babies, pets, nudes, and violence are affect-charged, that being why they are so widely used in the visual arts. In addition to such ready-made affect-charged cognitions, enterprising researchers may want to synthesize new affect-charged cognitions in the laboratory. One way to do this is to use Pavlovian conditioning procedures that pair initially neutral cognitions with emotionalizing stimuli in ways that result in the initially neutral stimulus acquiring the functionality of a conditioned stimulus. The main challenge of such an approach is to identify valid emotionalizing and affect-inducing stimuli that are susceptible to laboratory control and have the participant's consent.

Step 2. – : Bring about synergetic interactions between the cognitions. The cognitions can be combined and brought together visually (by visual positioning), by using the motion picture medium, or by other methods; in narratives; in poetry; musically; and so forth. A relatively new way of creating synergetic interactions is to use software that morphs one face into another. For instance, faces of certain prominent individuals are affect-charged for many people, and can be morphed into any other face or symbol with the use of morphing software.

Cognitions often interact transformatively when the combination is unexpected, surprising, antithetical, incongruous, or when it increases coherence in some other way. For instance, Picasso positioned the bicycle parts to look like a bull (Section 2.1). In general, artists, poets, and composers try to create such transformative interactions with the aim of producing aesthetic effects.

Accompanying musical effects can enhance most transformative impacts, which is why music is widely used in film.

4.3 Assessment: is the resulting reaction an aesthetic one?

The reaction would be assessed the same way it is assessed outside the laboratory – the assessment would use the same criteria as those currently used to identify the existence of an aesthetic reaction. Do the participants describe their reaction as aesthetic? As reinforcing? Does the fMRI recording resemble those of other presumed aesthetic reactions? If enough of the answers are positive, here is a small sample of the independent variables whose effects can then be studied experimentally:

- Number of repetitions of the stimulus presentation,
- Time between repetitions
- Amount and type of priming (see Mechner 2018a), Section
- Various types of potentiation (see Mechner 2018a), Section
- Number of simultaneously interacting cognitions
- Sensory modality of the cognitions (visual, auditory, verbal, etc.)
- Method used to bring about interactions among the cognitions

For example, the method would provide a way to investigate experimentally the well-known but as-yet largely unexplained phenomenon that an aesthetic reaction to a given stimulus often does not extinguish or habituate as a function of multiple, even thousands of exposures. The proposed experimental methodology offers many ways to increase our understanding of aesthetic reactions and their role in human culture.

Part 5.0 The biological utility of aesthetic sensibilities

5.1 Do they confer a biological benefit?

Since the reinforcing functionalities of aesthetic stimuli are so consistently linked to their biological utility, one might ask whether the general human susceptibility to reacting aesthetically confers a biological benefit or evolutionary selection advantage upon individuals (or groups) that possessed that susceptibility. Might the exalted place that philosophers have traditionally assigned to aesthetic sensibilities be a deserved one, perhaps one based on a type of biological utility? The foregoing analysis and theory of aesthetics suggests that the answer may be yes, and that in fact, aesthetic sensibility, like language, may have been a significant milestone in the evolution of modern humans and of their various cultures. Note that this conjecture and similar ones are not part of the present theory, and not readily testable, just tantalizing speculative explorations.

5.2 Their function as markers of group identity

The pervasive role of aesthetic reactions in human civilization is due in part to their function as glue that bonds members of social groups. The strength of that glue is due to the authenticity of aesthetic reactions, which is mainly due to the reactions' affective component. Smiles, tears, or gasps tend to be authentic. It is this authenticity that makes aesthetic reactions so valid as behavioral traces of long-term immersion in a group's culture and memes, and therefore as credible indicators of group identity. The group membership bonds created by this glue have significant biological utility, as group cohesion is an important determiner of group survival.

The assessment of each other's group identity is a pervasive aspect of human social behavior. For instance, new friends, neighbors, or acquaintances soon compare their aesthetic tastes. While the most widely used indicators of group identity are physical appearance and spoken language, aesthetic reactions often supplements these. Observing someone having an aesthetic reaction to a certain type of music, laughing at a certain type of joke, or dressing in certain way, supplements the information that other indicators may convey. For instance, an aesthetic reaction to a piece of classical music or to a billiard shot suggest a history of immersion in a certain sub-culture. This may also be why lovers and teenagers often seek shared aesthetic experiences, bond over jokes, and why rallies and religious events promote bonding by means of orations, symbols, and music that may generate aesthetic reactions.

5.3 Biological mechanisms for the maintenance of behavior

Behaviors on which the organism's life depends, like breathing, eating, and drinking, or on which survival of the species depends, like reproduction, must occur reliably – their maintenance and continuity must be assured. Accordingly, the behaviors that maintain vital functions have evolved to be either reflexive or intrinsically reinforcing. Intrinsic reinforcers therefore become linked to the behavior they maintain, like savory tastes to eating certain foods or sexual sensation to sexual activity.

But since not all behavior is as essential as breathing, eating, drinking, and reproduction, *the degree* to which behaviors evolved to be intrinsically reinforcing would be related to their biological importance. Behavior whose biological utility is intermediate – often very useful but only sometimes required for survival – are learning, exploration, and discovery. The biological utility of these operant behaviors is based on how they help the organism adapt to its environment or modify it, and have thus evolved to be intrinsically reinforcing, though not to the same degree as eating, drinking and sex. These behaviors therefore need extraneous sources of reinforcement for adequate maintenance. The present theory suggests a conjecture as to how this may happen – that aesthetic reactions may participate in the performance of that maintenance function. Sections 5.4–5.8 seek to explain how aesthetic reactions, which are observed to be reinforcing, are able to maintain certain biologically valuable human behavior that has not yet had enough evolutionary time to acquire the intrinsically reinforcing properties needed for reliable performance of the maintenance function.

5.4 Why are aesthetic reactions reinforcing?

The observation that aesthetic reactions are reinforcing is inherent in the term's semantics – it forms part of our reason for applying the term aesthetic to a reaction. We seek out and revisit stimuli to which we react aesthetically (e.g., that we consider beautiful, interesting, delicious, moving, etc.), whether music, verbal utterances, narratives, art, foods, performances, or concepts. But what is the behavioral mechanism that accounts for their reinforcing property?

This article and previous ones (Mechner, 2018a, 2018b, 2019) have pointed out that ability to adapt to the environment and to modify it (i.e., operant learning) enhances the probability of survival and procreation, an ability that confers an evolutionary selection advantage upon individuals for whom operant learning was reinforcing. This may be how operant learning evolved to be reinforcing, as evidenced by the intrinsically reinforcing power of exploration, satisfaction of curiosity, and play – common forms of operant learning in many species.

One is therefore tempted to invoke the same dynamic to account for the observed fact that aesthetic reactions have reinforcing properties. Do they have anything in common with operant learning? After all, aesthetic reactions don't operate on the environment or on adaptation to it the way operant learning does.

What they do have in common with operant learning is modification of the concept repertoire – the manipulation and elaboration of discriminations, generalizations, and relations,[13] which always occurs in operant learning. Since this type of involvement of the concept repertoire is also always present in aesthetic reactions (see the 16 "devices" described in Section 7.4 of Mechner (2018a)), one is tempted to conjecture that concept manipulation (which usually results in some learning) is one of the explanations for the reinforcing effects of aesthetic reactions. Another component of the explanation for the reinforcing quality of aesthetic reactions is their affective component, described in Section 5.6 below.

5.5 Modern cognitive competencies (MCCs)

We know that versatile operant behavior repertoires, including certain complex cognitive competencies, made their evolutionary appearance relatively recently. Paleontologists say that among the most recent (modern) ones are linguistic-verbal competencies and abstract conceptual competencies that enable generalized problem-solving abilities, inquiry skills, and planning skills. The term language is generally applied to the linguistic-verbal competencies, but we are extending our "cognition" concept to include music (as a special language for the communication of affect Levitin, (2006)), and mathematics (as a language for the communication of abstract concepts). Let's call all of these "Modern Cognitive Competencies," MCCs for short. The great power that these competencies bestowed on humankind does not require special comment.

MCCs are fragile: not all members of the human species learn them, and they are not self-maintaining, perhaps due to their relative phylogenetic recency. Their reinforcers and biological benefits are generally too delayed or uncertain to perform the required maintenance functions. Familiar examples of MCCs that have uncertain or long-delayed benefits are planning, inquiry, and the learning of music, mathematics, or second languages. Unlike behaviors that are intrinsically reinforcing or reflex-like, MCCs, being neither, need extrinsic reinforcers that are immediate and yet non-genetic and non-intrinsic. In order

to become and remain part of the human repertoire of competencies, MCCs need extrinsic support for their maintenance lest they deteriorate or extinguish.

While some MCCs are maintained by immediately intrinsic reinforcing consequences during normal use, (e.g., the reinforcing effects of ordinary oral conversation and communication, or those that certain music, poetry, or visual art can have), these reinforcers are still not as intrinsic as those of eating, drinking, or sex. They have not been around long enough, phylogenetically speaking, to have evolved genetically encoded reinforcement mechanisms. Reinforcement bridges are therefore required. That's where aesthetic reactions enter the scene.

5.6 How aesthetic reactions maintain MCCs

Most modern humans grow up or spend significant formative time in environments replete with MCCs. Since most human environments are also replete with affect-eliciting events, MCCs and affective events will often coincide fortuitously. These coincidences would therefore often result in Pavlovian conditioning events that impart conditioned CS functionalities to the impacted MCC elements, turning them into carriers of affective reactions (as when an initially neutral graphic symbol like a flag or emblem, or a melodic phrase, acquires affect-evoking functionality via Pavlovian pairing with independent affect-evoking stimuli). Those MCCs would then perform the dual function of the CS that contributes the affective respondent (Boxes 1, 2 and 6 in Figure 1), while retaining their original function of evoking, say, surprise or performing other concept manipulations (Boxes 1 and 4 in Figure 1). The combined and compounded effect of *the resulting aesthetic reaction generates part of the reinforcing effect that contributes to the MCCs' maintenance*. For instance, and for a certain person, the compounding interaction may occur among a certain verbal expression (e.g., perhaps one that her beloved Grandma often used) and its occurrence in a gripping movie scene, at a time when she also happened to be homesick.

Note that the schedule on which MCCs acquire CS functionalities is normally intermittent, in accordance with the intermittency and randomness with which a given MCC's occurrence coincides with an affective occurrence. This source of intermittency would contribute to the resistance to extinction of the MCC's resulting CS functionalities.

5.7 Maintenance by self-sustaining feedback

As was stated in the above section 5.6, elements of MCCs can come to elicit affective reactions (act as CSs) as a result of having previously been paired, occasionally, coincidentally, and fortuitously, with "emotional situations," i.e., stimuli that elicit affective respondents. An MCC element with this type of history effectively functions as a carrier of positive affect. For instance, it may elicit affective reactions to a melody that a close friend used to whistle. But for an aesthetic reaction to occur, such a carrier of positive affect *must then interact with another cognitive element* of the MCC in a transformative way, as described earlier.

By thus producing an aesthetic reaction, which, like all aesthetic reactions, is reinforcing, an MCC can be self-reinforcing. Such self-reinforcing properties promote maintenance of MCCs in the behavior repertoire – a feedback cycle (the reinforcing output feeding back to the input) that can make MCCs self-sustaining and self-maintaining over time.

5.8 Instances of MCC maintenance

Let's examine two of the MCCs listed in Section 4.3 above – verbal behavior and inquiry behavior – and consider how aesthetic reactions may contribute to their maintenance.

Verbal behavior and the development of verbal competency starts in infancy. During the formative years and beyond, such elements of verbal behavior as words, phrases, and verbally stated concepts have ample opportunity to be fortuitously paired with affect-producing stimuli and contexts. In such pairings, verbal stimuli can acquire affect-eliciting properties and thus come to function as CSs. When the positive affect elicited by these CSs then combines with the cognitive effects of poetry, literature, narratives, music, visual stimuli, humor, or oratory, the interactive effects can be of the sort termed aesthetic. This aesthetic reaction would then reinforce the verbal MCC that generated it. The ensuing feedback cycle would thus help maintain the verbal MCC.

Inquiry behavior, whether it takes the form of asking, testing, searching, or exploring, often produces reinforcing stimuli (answers, revelations, observations) that maintains the inquiry behavior. But inquiry behavior may also provoke affect via CS functionalities that it acquired via earlier fortuitous Pavlovian conditioning episodes. The interactive effect of the inquiry behavior's cognitive and affective components (resulting in aesthetic reactions) can be sufficient for long-term maintenance of the inquiry behavior.

Aesthetic reactions have the same long-term maintenance effects on other MCCs, like planning, problem solving, and the manipulation of abstract concepts. We know that mathematicians and scientists often find their work enthralling. It is also worth noting that similar mechanisms operate in the long-term maintenance of cognitive behavior that we would ordinarily not describe as aesthetic. People pay money to see or read tragic or disturbing works (Shakespeare, Aeschylus, certain operas horror movies, and thrillers). These works evidently have reinforcing effects, presumably for the same reasons as the more common aesthetic reactions. Aversions, loves, hates, and even phobias share properties with aesthetic reactions, but that topic falls outside the scope of the present article.

5.9 Aesthetic reactions in other species

This topic has relevance to our analysis of the behavioral and phylogenetic origins of human aesthetic sensibilities, as similar mechanisms may have been at play in their evolution. Reactions of other species that resemble the human reactions we term aesthetic have been described extensively. Bird songs, colorful plumages, dances, and the various mating ritual antics of certain species are generally explained in terms of their mate-attraction functionalities, going back to Darwin. These behaviors are of great interest in the context of suggesting hypotheses and conjectures regarding the evolutionary origins of human aesthetic sensibilities and their biological utilities.

In a discussion of some of that literature (Mechner, 2019, Sections 4.2–4.6), I suggested that the selection dynamics in these rituals are often reciprocal: it is not only the female assessing the male's fitness and suitability as a mating partner, based on the quality and competence of his performance, but also the male assessing the female's competency; her discernment of subtle stimulus properties of the male's performance (a type of "theory of mind" competency), as such discernment can play a future role in raising a family. It is plausible that a mother's ability to assess the behavioral potentialities and capabilities of

others – friend, foe, or offspring – confers significant biological benefits. Human artists, too, are often reinforced by the degree to which their work evokes a reaction. Here, too, the assessment is reciprocal, as artists tend to be attracted to audience members who exhibit the discernment and discriminative competency required to appreciate their work.

Summary

The article presents a naturalistic and testable theory regarding the behavioral and biological processes involved in the formation of aesthetic reactions. It also explores the ontogenetic and phylogenetic origins of aesthetic reactions and their functions in human culture.

One of the theory's tenets is that the aesthetic reaction can be evoked by interactions among cognitions that have certain characteristics. I used the term "cognitions" for the broad and fuzzy category of behavior that *excludes* respondent behavior, and includes concepts, relations, verbal, abstract, and derived relational behavior; responses to narratives; to auditory stimuli including voices and music; to tactile, sexual, and other sensory stimuli like odors, sensations, and visual stimuli; to recollections of all kinds; and so forth.

The essence of the theory is that aesthetic reactions, when they occur, are evoked by certain kinds of *interactions* among such cognitions rather than by their mere occurrence. To evoke an aesthetic reaction, *at least one of the interacting cognitions must be affect-charged* (must have an "emotional" component, as one might say colloquially). A cognition that is initially affectively neutral can become charged with affect via respondent conditioning events that occur from time to time in the normal course of life, that is, when cognitive events coincide, randomly and fortuitously, with unrelated affective events or situations. When such coincident pairings occur, the cognition may acquire conditioned stimulus (CS) functionalities. The unconditioned stimulus (US) in such conditioning events may be an affect-laden event of various possible origins.

In such instances, an aesthetic reaction will occur when the cognitions have been adequately primed, when the interactions have been adequately potentiated, and when the multiple interactive effects among the cognitions have compounded sufficiently to reach the required magnitude. The compounding effects may be multiplicative, catalytic (accelerative), synergistic (1 + 1 = 3), or synergetic (transformative). Such amplification can occur not only among cognitions but also, recursively, among the interactions themselves, along intensive as well as qualitatively transformative dimensions.

The article proposes a methodology for testing the theory. Being rooted in operationally defined concepts, the theory's tenets can be used to synthesize laboratory models of aesthetic reactions. The result can then be assessed against proposed definitions, descriptions, and accepted instances of such reactions. This approach permits the experimental exploration of a vast range of variables that relate to our understanding of aesthetic reactions.

Aesthetic reactions are worthy of such study because of the many vital roles they play in human civilization. For instance, they are part of the glue that accounts for the cohesion of human social groups. In the interactions of members of social groups, the inherent authenticity of aesthetic reactions contributes to their validity as markers of group identity, alongside the many other aspects of individuals' verbal and other social behavior. The article also discusses the roles of aesthetic reactions in the selection of mates for procreation.

Another possible functionality of aesthetic reactions may be the maintenance of modern (phylogenetically recent) cognitive competencies (MCCs) like verbal and linguistic behavior, abstract concept manipulation, music, mathematics, and the skills of learning, inquiry, and planning. These MCCs, having emerged more recently in our phylogenetic history, are not as firmly or universally embedded in human behavior repertoires as, say, eating or drinking, and thus depend on extrinsic reinforcement for their maintenance.

Here is how aesthetic reactions can reinforce MCCs:

Aesthetic reactions generally have reinforcing effects (as the article explains). Reinforcement of MCCs thus occurs when cognitive behaviors that comprise MCCs interact transformatively to generate aesthetic reactions. These reinforcing effects refresh and maintain their MCC carriers, which might otherwise extinguish due to the long delays of their natural reinforcers. That is how aesthetic reactions may have enabled the emergence and continued maintenance of MCCs, and thereby of human cultures.

Notes

1. *A personal note*: Some EJOBA readers may recognize the roots of this work as traceable to Europe as well as the USA. Its European roots lie in the environment of my childhood – pre-WW2 Vienna where music, poetry, art, and philosophy, including the logical empiricism of the Vienna Circle, flourished. Its American roots go back to the behavioral orientation of Keller's and Schoenfeld's Columbia University Department of Psychology where I spent the years 1951 to 1960. There, I was exposed to B.F. Skinner's (1938) advocacy of the empirical/naturalistic approach when exploring uncharted territory – an approach that avoids preconceptions and defers hypotheses. That seemed to me like the right one for studying aesthetics (Mechner, 2018a, Section 1.15). For a brief review of recent literature on the topic of aesthetics, see Mechner (2018a), Appendix B; and 2019, Section 2.6.
2. Acknowledgements: I owe much of my understanding of this topic to my former Columbia University professors Fred S. Keller, Ernest Nagel, W. N. Schoenfeld, and Lofti Zadeh; to my former Columbia Psychology Department colleagues Donald A. Cook and Robert Berryman; to M. Jackson Marr for his substantive contributions as Guest Editor of my previous articles on the topic; and to the nine commentators in the TPR special issue. The present article is loosely based on a talk I gave at the January 2018 conference honoring Murray Sidman in Sarasota, Florida.
3. For present purposes, the term *affect* is more useful than *emotion*. The concept of emotion carries too many undesired connotations, and is categorized in too many culture-dependent ways. The reasons I prefer to bypass the term "emotion" are set forth in Mechner (2018b, Part, p. 2); Barrett (2017), and Berlyne (1971). I am using the terms "affect" and "affective" in the narrow sense of a reaction that can be conditioned and measured, at least in principle, like respondents in general.
4. For more detail regarding the nature of the aesthetic reaction, see Mechner (2018a, Sections 1.3–1.4).
5. To understand the biological functions of these drive-independent reinforcing effects, it is necessary to consider both their ontogenetic origins in the individuals' conditioning histories (Part 3, below) as well as the phylogenetic history of the effects.
6. This may be the type of phenomenon to which Hineline referred when he suggested that aesthetics involves instances of "complex invariance" (Hineline, 2018).
7. A similar dynamic is operative when the phenomenon to be explained is the behavior of another person, as when we try to explain talent, creativity, or other exceptionalities. The natural tendency is to seek the explanation in the person's remarkable behavior rather than in one's own perceptions and history regarding that behavior.

8. The term "cognition" is rarely used by behavior analysts, mainly because of its frequent misuse as explanatory fictions. But here it is used to refer collectively to the set of overt and covert operant behaviors, including conceptual, verbal, musical, or abstract. All are behavioral repertoire elements that *do not* consist of respondent behavior or emotion. Examples of such "cognitions" would be concepts, relations, melodies, rhythms, voices, shapes, pictures, narratives, symbols, metaphors, flavors, textures, recalled events, etc. A "cognition" would then be an element or subset of that set. Used in this way, the term is a descriptive category name only, not an explanatory construct.
9. Priming factors in the individual's history would include prior exposures to the work or to similar works; potentiating factors would include ambience, the mood or physiological state of the audience, or social factors like the presence of others who are also having an aesthetic reaction (Mechner, 2018a, Part, p. 6), as well as various behavioral contingencies (Layng, 2017; Mechner, 2011).
10. In their commentaries on Mechner (2018a), Palmer (2018) and Hineline (2018) both implied, correctly, that not all transformative interactions are sufficient to reach the threshold of an aesthetic effect. The present version of the theory responds to these comments with the observation that the incremental actions of compounding of interactive effects, including of affective ones, are needed to take the total effect past the threshold of the aesthetic range and into it.
11. Other variables are also at play, of course, such as the intensity of the event's emotional impact.
12. The main devices involve: non-realization of an expectation (for an analysis of the "expectation" construct, see Mechner, 2018b, Part, p. 6); combining concepts to form new ones; reclassification; distortion or exaggeration; distillation or summarization; provoking induction; linking distantly related concepts; recognition; mirroring of emotions; use of concepts that are emotionalizing; repetition; symmetry; parsimony; and use of incongruity or contradiction to create humor.
13. For more detailed discussions of concept formation and the concept repertoire in humans, see Part 2 of Mechner (2018a); Fields and Arntzen (2018); and Hayes, Barnes-Holmes, and Roche (2001).

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References

Barrett, L. F. (2017). *How emotions are made*. New York: Houghton Mifflin Harcourt.
Berlyne, D. E. (1971). *Aesthetics and psychobiology*. New York: Appleton-Century-Crofts.
Fields, L., & Arntzen, E. (2018). Meaningful stimuli and the enhancement of equivalence class formation. *Perspectives on Behavior Science*, *41*, 69–93.
Gibson, E. (2011, April 16). A magical metamorphosis of the ordinary. *The Wall Street Journal*. Retrieved from https://www.wsj.com/articles/SB10001424052748703551304576261042931202326
Harlow, H. F., & Zimmermann, R. R. (1958). The development of affective responsiveness in infant monkeys. *Proceedings of the American Philosophical Society*, *102*, 501–509.
Hayes, S. C., Barnes-Holmes, D., & Roche, B. (Eds.). (2001). *Relational frame theory: A post-Skinnerian account of human language and cognition*. New York: Plenum Press.
Hess, E. H. (1958). Imprinting in animals. *Scientific American*, *198*(3), 81–90.

Hineline, P. N. (2005). The aesthetics of behavioral arrangements. *The Behavior Analyst*, *28*, 15–28.
Hineline, P. N. (2018). Challenge of the ineffable: Concerning Mechner's 'A behavioral and biological analysis of aesthetics'. *The Psychological Record*, *68*, 323–324.
Jones, L. D. (2019). *Topographic bias and variability within non-criterial components of the operant class* (unpublished doctoral dissertation). Oslo Metropolitan University, Oslo, Norway.
Killeen, P. R. (2018). A ludic appreciation of Mechner's aesthetics. *Psychological Record*, *68*, 325–330.
Layng, T. V. J. (2017). Private emotions as contingency descriptors: Emotions, emotional behavior, and their evolution. *European Journal of Behavior Analysis*, *18*(2), 168–179.
Levitin, D. J. (2006). *This is your brain on music*. New York: Penguin.
Lorenz, K. (1935). Der Kumpan in der Umwelt des Vogels: Der Artgenosse als auslösendes Moment sozialer Verhaltensweisen. *Journal Für Ornithologie*, *83*, 137–215, 289–413.
Marr, M. J., & Zilio, D. (2013). No island entire of itself: Reductionism and behavior analysis. *European Journal of Behavior Analysis*, *14*(2), 241–257.
Mechner, F. (2011). Why behavior analysis needs a formal symbolic language for codifying behavioral contingencies. *European Journal of Behavior Analysis*, *12*, 93–104.
Mechner, F. (2018a). A behavioral and biological analysis of aesthetics: Implications for research and applications. *Psychological Record*, *672*. doi:10.1007/s40732-017-0228-1
Mechner, F. (2018b). Mechner's reply to the commentaries on his article, 'A behavioral and biological analysis of aesthetics'. *Psychological Record*, *68*, 385–404.
Mechner, F. (2019). A naturalistic and behavioral theory of aesthetics. *The Polish Journal of Aesthetics*, *52*, 73–93.
Mellon, R. C. (2018). A technology of aesthetic appreciation: Tweaking the reinforcing potency of synergetic events. *Psychological Record*, *68*, 343–346.
Palmer, D. C. (2018). A behavioral interpretation of aesthetics. *The Psychological Record*, *68*, 347–352.
Rolls, E. T. (2005). *Emotion explained*. Oxford: Oxford University Press.
Rosenblatt, L. M. (1938/1995). *Literature as exploration*. New York: The Modern Language Association of America.
Rosenblatt, L. M. (1978). *The reader, the text, the poem: The transaction theory of the literary work*. Carbondale, IL: Southern Illinois University Press.
Salimpoor, V. N., Benovoy, M., Larcher, K., Dagher, A., & Zatorre, R. J. (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. *Nature Neuroscience*, *14*, 257–262.
Schaffer, H. R., & Emerson, P. E. (1964). The development of social attachments in infancy. *Monographs of the Society for Research in Child Development*, *29*, 1–77.
Schlinger, H. D. (2018). A functional analysis of "aesthetic": A commentary on Mechner. *Psychological Record*, *68*, 353–358.
Sherrington, C. S. (1906). *The integrative action of the nervous system*. New Haven, CT: Yale University Press.
Skinner, B. F. (1938). *The behavior of organisms: An experimental analysis*. Oxford, England: Appleton-Century.
Woodruff-Pak, D. S. (1988). Aging and classical conditioning: Parallel studies in rabbits and humans. *Neurobiology of Aging*, *9*, 511–522.