# Commentary on Friedman et al. (2024): A General Preference for Complexity?

ANA CLEMENTE [1]
*Max Plank Institute for Empirical Aesthetics*

ABSTRACT: It is typically assumed in the empirical aesthetics literature that generalizable abstract stimulus attributes like familiarity, fluency, and complexity drive preferences. This *general* nature means that they can, at least in principle, apply to any stimulus regardless of its characteristics and sensory modality. However, most studies in this tradition are restricted to group-level trends and particular stimulus properties. Therefore, they say nothing about amodal or general preferences for particular levels of such abstract attributes independently from their characterization at the individual level. Moreover, the hypothesis of a general, amodal preference for attributes like complexity was not empirically supported and only scarcely tested until we provided empirical evidence against it in our Clemente et al. (2021) study. In their quest for empirical evidence in favor of a preference for complexity across the auditory and visual modalities, Friedman et al. (2024) made two central claims: First, they found it surprising that aesthetic sensitivity for visual and musical complexity did not correlate in our study. Second, they expressed concerns about the comparability of the musical and visual stimuli we used. In this commentary, I show how these claims and the premises on which they rely are debatable and how the results of Friedman et al. (2024) support our conclusion that stimulus information rather than abstract attributes like complexity drive evaluative judgments such as liking.

Submitted 2024 Feb 5; accepted 2024 April 9.
Published 2025 March 3; https://doi.org/10.18061/emr.v19i2.9841

KEYWORDS: *complexity, evaluative judgment, music, sensory valuation, visual*

TRADITIONALLY, research in the field of empirical aesthetics has consistently shown that people overall tend to prefer stimuli that are more frequent (Zajonc, 1968), processed more fluently (Reber et al., 1998), or intermediate in complexity (Berlyne, 1971). Abstract attributes like familiarity, fluency, and complexity can refer to stimuli of potentially any nature, domain, and sensory modality. Variations in the stimulus properties or the perceptual representations defining these attributes are susceptible to influence evaluative judgments. For instance, liking for musical melodies (e.g., Clemente et al., 2022; Pearce, 2018), visual designs (e.g., Corradi et al., 2020; Güçlütürk et al., 2016), haptic textures (e.g., Carbon & Jakesch, 2012; Muth et al., 2019), flavors (e.g., Giacalone et al., 2014; Lévy et al., 2006), odors (e.g., Kermen et al., 2011; Spence & Wang, 2018), and many other stimuli may be affected by how complex they are or how complex they are perceived. This has led to assume the existence of a general preference for complexity (and other abstract attributes) driving evaluative judgments such as liking.

However, this assumption is unfounded because the hypothesis of a general preference for complexity has been disproved (e.g., Rump, 1968) and empirically tested with modern tools when we challenged it (Clemente et al., 2021). This confusion stems from two main issues: First, most studies are restricted to group-level trends and are, thus, unable to support (or contradict) the existence of amodal or general preferences at the individual level. Second, most studies are restricted to particular stimulus properties characterizing particular forms of the abstract attribute in question and are, thus, unable to generalize to any stimulus property and characterization of the abstract attribute.

## TESTING A GENERAL PREFERENCE FOR COMPLEXITY

For an abstract attribute like complexity to generalize across domains and sensory modalities, its impact must be independent of its characterization (definition and operationalization) and domain-specific features like the dynamic or static nature of the stimuli *within* individuals. In other words, asserting that people (*individuals*) show a general preference for complexity entails that they (*each individual*) tend to like or dislike stimulus complexity to a similar extent and direction regardless of how complexity is operationalized—e.g., whether according to its number of elements or its information content—and the nature of the sensory information—e.g., whether dynamic or static, auditory or visual. Otherwise, two compatible scenarios are possible: First, general trends might reflect averaging artifacts and, thus, cannot inform about the underlying evaluative mechanisms (Clemente, 2021). Second, the impact might be limited to particular stimulus properties and not hold across all complexity characterizations—e.g., for stimuli with many but redundant events, taking event density or event entropy to define its complexity would yield opposed results. Therefore, examining the effects at the individual level and manipulating distinct stimulus properties in different sensory modalities are required to properly test the hypothesis of a general, amodal preference for complexity.

In a series of studies (Clemente et al., 2021, 2023a), we manipulated the complexity—and other abstract attributes like balance, contour, and symmetry—of Western tonal melodies and static abstract visual designs in an idiomatic way, i.e., adequate and meaningful to each domain. Then, we extracted the aesthetic sensitivities to complexity in each domain, reflecting the individual responsiveness in liking to variations in the stimulus properties manipulated characterizing melodic or visual complexity. The results contradict the hypothesis of a general, amodal preference for complexity—and other abstract attributes like balance and symmetry—because aesthetic sensitivities to melodic and visual complexity were unrelated. The results further suggest inherent divergences not only between the sensory modalities per se but between the stimulus properties considered (e.g., number and variety of elements), all of which contribute to the characterization of complexity in the literature (Nadal et al., 2010). Such differences in stimulus properties are not mere *inadvertent confounds* (cf., Friedman et al., 2024) but essential to investigate (support or contradict) the existence of a general complexity preference.

## INSIGHTS FROM COGNITIVE NEUROPSYCHOLOGY

Our findings align with current knowledge on the neurobiology of sensory valuation—also known as evaluative judgment, hedonic evaluation, and appreciation (Skov, 2019)—which consists of assigning hedonic value (e.g., liking) to a stimulus based on its sensory information combined with personal and contextual factors (Rangel et al., 2008; Schultz et al., 1997). Hedonic values are responses to projections from sensory systems to distributed nuclei in the reward system, modulated by input from the interoceptive and executive systems signaling homeostatic state and contextual information relevant to the valuation event (Berridge & Kringelbach, 2013, 2015; Pessiglione & Lebreton, 2015).

The processing of sensory information in the brain is specific to its nature and thus depends on properties like its sensory modality and temporal structure. For instance, research shows distinct processing of auditory and visual streams (Griffin et al., 2002; Macaluso et al., 2004; Peretz & Coltheart, 2003; Peretz & Zatorre, 2005). Even for similar rhythmic structures, Grahn (2012) showed that beat perception is optimized for the auditory modality and restricted to certain types of stimuli in the visual modality. In the auditory domain, research shows specialization for pitch processing in right auditory networks and a complementary specialization for temporal resolution in left auditory networks (Zatorre, 2022).

In light of these insights, it is unclear how encoding of complexity as a general attribute across the auditory and visual systems might lead to (variations in) liking. Instead, as we have seen with curvature (Clemente et al., 2023b), each specific complexity characterization (definition and operationalization) correlates with different kinds of neural encoding. This suggests that *complexity* is a construct referring to distinct and varied neural events and that conditions imposed by different experimental designs may yield different results because such distinct complexity-encoding events may influence liking in different ways. It follows that an amodal, general preference for complexity in all its manifestations can hardly be implemented at the neural level.

## RELEVANCE OF STIMULUS INFORMATION IN EVALUATIVE JUDGMENTS

The neural specificities noted above are difficult to reconcile with general evaluative mechanisms reliant on abstract attributes, the definition and characterization of which vary widely in the literature. The case of complexity is particularly compelling, as there is a large number of definitions and measures gravitating to two main kinds: feature-based and information-based. A brief comment on some of them illustrates the breadth and variety of complexity characterizations in the remaining of this section.

In melodies and other sound sequences, complexity can vary as a result of the number of tones in a sequence (Mindus, 1968), rhythm and syncopation (Heyduk, 1975), structural change (Mauch & Levy, 2011), variety in pitch, note durations, loudness and timbre (Berlyne & Boudewijns, 1971). The Expectancy-based model (EBM; Eerola & North, 2000; Eerola et al., 2006), or Expectancy-violation model (EV; Eerola, 2016), and the $MUST_K$ (Clemente et al., 2020) are composite measures of weighted structural features that have also been found prominent in the visual modality (Nadal et al., 2010): number (event density) and variety and organization of elements (computed as different forms of entropy in the $MUST_K$). Complexity measures are relatively well defined for static images (e.g., Fernandez-Lozano et al., 2019; Jacobsen & Höfel, 2002; Machado et al., 2015). However, formal measures of dynamic visual complexity are scarce.

The Information Dynamics of Music (IDyOM; Pearce, 2018) is a well-established framework for investigating the impact of information-theoretic properties on the perception and appreciation of music (Clemente et al., 2020; Sauvé & Pearce, 2019). It is a system for constructing multiple-viewpoint, variable-order Markov models for predictive modeling of probabilistic structure in symbolic, sequential auditory domains like music. IDyOM acquires knowledge about a domain through statistical learning and generates conditional probability distributions representing the estimated likelihood of each event in a sequence, given the preceding context and incremental training on the current stimulus. From the conditional probability estimates for each event, IDyOM computes Shannon entropy, which reflects the prospective predictive uncertainty of the probabilistic prediction given the context, and information content, which reflects the contextual unpredictability of the actual event. IDyOM's architecture is flexible enough to enable the computation of information-theoretic measures of any sequence of discrete events.

In Clemente et al. (2024), we used IDyOM to quantify auditory complexity and, for the first time, dynamic visual complexity, providing comparable and generalisable measures of dynamic auditory and visual complexity. Interestingly, we found additive (rather than interactive) contributions of rhythmic auditory and visual complexity to liking for audiovisual stimuli and visual capture in the perception of dynamic stimuli (Spence & Soto-Faraco, 2010). These findings indirectly contradict the hypothesis of a general, amodal complexity preference using a complexity characterization across sensory modalities, highlighting the implications for evaluative judgments of distinct processing of auditory and visual streams.

## EVIDENCE FOR A GENERAL PREFERENCE FOR COMPLEXITY?

That the definition and operationalization of complexity and any other abstract attribute are relevant to the evaluation of a stimulus is not new (e.g., Nadal et al., 2010). However, and despite notable direct evidence against general factors in appreciation (e.g., Rump, 1968, regarding complexity; and Leder et al., 2019, regarding symmetry), implicit and explicit claims of universal complexity or symmetry preference are still pervasive in the literature and conform to a tradition of thought still prevailing in empirical aesthetics.

Aligned with this tradition, Friedman and colleagues (2024) sought evidence for a cross-modal correspondence. Their timely approach presents important advantages over other research on cross-modal correspondences in evaluative judgments: they factored in variability due to participants and stimuli, and they considered evaluative judgments at the individual level—i.e., in terms of individual aesthetic sensitivities. Crucially, they did not test for a general complexity preference. Instead, they purposely focused on stimulus properties susceptible to yield similar evaluative judgments using particular auditory and visual stimuli: First, they compared our MUST melodies to their visual equivalent. Second, they used a visual entropy assessment aimed to parallel our MUST entropy measures but disregarded the fact that they contributed only partially to our $MUST_K$ composite measure, thus enhancing the potentially amodal quality of the stimuli. With this setting, they found that people showed preference for particular stimuli varying in dynamic complexity across the auditory and visual modalities and for specific characterizations of static images and melodies. However, these relationships explained a limited proportion of the variance, which suggests that the contribution of other factors to liking was more prominent, and one can argue that very special stimuli and measures are required to find a significant association between aesthetic sensitivities to melodic and visual complexity. These limitations prevent their results from characterizing the role of complexity as a general, amodal attribute across its multiple definitions and operationalizations.

Friedman and colleagues' (2024) study does not seem to provide any compelling evidence that liking is determined by an amodal or cross-modal complexity module. Instead, their results concur with associations between preferences for other stimulus features across sensory modalities in the literature, such as simplicity/harmoniousness versus complexity/inharmoniousness of musical melodies/chords and combinations of colors (Palmer & Griscom, 2013; Song et al., 2022). These findings support cross-modal correspondences in evaluative judgments *only* between *particular* auditory and visual features. Their claim for "renewed evidence for cross-modal correspondence in evaluative responses to musical sounds and visual images" (Friedman et al., 2024, p. 1) is bound to the specific stimulus properties considered. Their research neither necessarily nor sufficiently supports a general, amodal preference for any abstract attribute such as complexity. Quite the opposite. Taken together, these studies (Clemente et al., 2021, 2023a; Friedman et al., 2024; Palmer & Griscom, 2013; Song et al., 2022) contribute evidence for the influence of the definition and operationalization of abstract attributes such as complexity on the evaluative judgment of a stimulus.

## CONCLUSION

It is unlikely that Friedman and colleagues have reconciled our research (Clemente et al., 2021) "with theories that posit modality-general individual differences in preference for information differing in complexity (e.g., Cacioppo & Petty, 1982), with theories of aesthetic preference that are based on domain-general cognitive mechanisms of prediction and processing fluency (e.g., Brielmann & Dayan, 2022), and with other recent empirical studies that appear to show quite robust cross-modal commonalities in preferences for complexity (e.g., Palmer & Griscom, 2013; Song et al., 2022)" (Friedman et al., 2024, p. 8). On the contrary, the results of Friedman and colleagues (2024) support our *provocative* conclusion that "evaluative judgments of visual designs and melodies are not based on abstract representations of balance, symmetry, and complexity, but on visual- and auditory-specific instantiations of such attributes" (Clemente et al., 2021, p. 9), with those instantiations reflecting specific characterizations (definitions and operationalizations) of such attributes.

## ACKNOWLEDGEMENTS

I am grateful to Dr. Martin Skov for his insightful comments and suggestions to the draft of this commentary. This article was copyedited by Eve Merlini and layout edited by Jonathan Tang.

## NOTES

[1] Correspondence can be addressed to Dr. Ana Clemente, Max Plank Institute for Empirical Aesthetics, Grüneburgweg 14, 60322 Frankfurt am Main, Germany, ana.clemente@mpg.de.

## REFERENCES

Berlyne, D. E. (1971). *Aesthetics and psychobiology*. Appleton-Century-Crofts.

Berlyne, D. E., & Boudewijns, W. J. (1971). Hedonic effects of uniformity in variety. *Canadian Journal of Psychology/Revue Canadienne de Psychologie, 25*(3), 195–206. https://doi.org/10.1037/h0082381

Berridge, K. C., & Kringelbach, M. L. (2013). Neuroscience of affect: Brain mechanisms of pleasure and displeasure. *Current Opinion in Neurobiology, 23*(3), 294–303. https://doi.org/10.1016/j.conb.2013.01.017

Berridge, K. C., & Kringelbach, M. L. (2015). Pleasure systems in the brain. *Neuron, 86*(3), 646–664. https://doi.org/10.1016/j.neuron.2015.02.018

Carbon, C. C., & Jakesch, M. (2012). A model for haptic aesthetic processing and its implications for design. *Proceedings of the IEEE*, *101*(9), 2123–2133. https://doi.org/10.1109/JPROC.2012.2219831

Clemente, A. (2022). Aesthetic sensitivity: Origin and development. In *The Routledge International Handbook of Neuroaesthetics* (pp. 240–253). Routledge. https://doi.org/10.4324/9781003008675-13

Clemente, A., Board, F., Pearce, M. T., & Orgs, G. (2024). Dynamic complexity in audiovisual aesthetics. *Psychology of Aesthetics, Creativity, and the Arts.* Advance online publication. https://doi.org/10.1037/aca0000685

Clemente, A., Friberg, A., & Holzapfel, A. (2023a). Relations between perceived affect and liking for melodies and visual designs. *Emotion, 23*(6), 1584–1605. https://doi.org/10.1037/emo0001141

Clemente, A., Penacchio, O., Vila-Vidal, M., Pepperell, R., & Ruta, N. (2023b). Explaining the *curvature effect*: Perceptual and hedonic evaluations of visual contour. *Psychology of Aesthetics, Creativity, and the Arts.* Advance online publication. https://doi.org/10.1037/aca0000561

Clemente, A., Pearce, M. T., Skov, M., & Nadal, M. (2021). Evaluative judgment across domains: Liking balance, contour, symmetry and complexity in melodies and visual designs. *Brain and Cognition*, *151*, 105729. https://doi.org/10.1016/j.bandc.2021.105729

Clemente, A., Vila-Vidal, M., Pearce, M. T., Aguiló, G., Corradi, G., & Nadal, M. (2020). A set of 200 musical stimuli varying in balance, contour, symmetry, and complexity: Behavioral and computational assessments. *Behavior Research Methods, 52*(4), 1491–1509. https://doi.org/10.3758/s13428-019-01329-8

Eerola, T. (2016). Expectancy-violation and information-theoretic models of melodic complexity. *Empirical Musicology Review, 11*(1), 2–17. https://doi.org/10.18061/emr.v11i1.4836

Eerola, T., Himberg, T., Toiviainen, P., & Louhivuori, J. (2006). Perceived complexity of Western and African folk melodies by Western and African listeners. *Psychology of Music, 34*(3), 337–371. https://doi.org/10.1177/0305735606064842

Eerola, T., & North, A. C. (2000). Expectancy-based model of melodic complexity. In *Proceedings of the Sixth International Conference on Music Perception and Cognition*. Keele, Staffordshire, UK: Department of Psychology. CD-ROM.

Fernandez-Lozano, C., Carballal, A., Machado, P., Santos, A., & Romero, J. (2019). Visual complexity modelling based on image features fusion of multiple kernels. *PeerJ, 7:e7075*. https://doi.org/10.7717/peerj.7075

Friedman, R. S., Song, S. E., & Cox, G. (2024). Reexamining the association between aesthetic sensitivity to musical and visual complexity. *Empirical Musicology Review, 19*(2), 77-87. https://doi.org/10.18061/emr.v19i2.9705

Giacalone, D., Duerlund, M., Bøegh-Petersen, J., Bredie, W. L., & Frøst, M. B. (2014). Stimulus collative properties and consumers' flavor preferences. *Appetite*, *77*, 20–30. https://doi.org/10.1016/j.appet.2014.02.007

Grahn, J. A. (2012). See what I hear? Beat perception in auditory and visual rhythms. *Experimental brain research*, *220*, 51–61. https://doi.org/10.1007/s00221-012-3114-8

Griffin, I. C., Miniussi, C., & Nobre, A. C. (2002). Multiple mechanisms of selective attention: differential modulation of stimulus processing by attention to space or time. *Neuropsychologia, 40*(13), 2325–2340. https://doi.org/10.1016/S0028-3932(02)00087-8

Güçlütürk, Y., Jacobs, R. H., & Lier, R. V. (2016). Liking versus complexity: Decomposing the inverted U-curve. *Frontiers in human neuroscience*, *10*, 112. https://doi.org/10.3389/fnhum.2016.00112

Güçlütürk, Y., Güçlü, U., van Gerven, M., & van Lier, R. (2018). Representations of naturalistic stimulus complexity in early and associative visual and auditory cortices. *Scientific Reports*, *8*(1), 3439. https://doi.org/10.1038/s41598-018-21636-y

Heyduk, R. G. (1975). Rated preference for musical compositions as it relates to complexity and exposure frequency. *Perception & Psychophysics, 17*(1), 84–90. https://doi.org/10.3758/BF03204003

Jacobsen, T., & Höfel, L. E. A. (2002). Aesthetic judgments of novel graphic patterns: Analyses of individual judgments. *Perceptual and Motor Skills, 95*(3), 755–766. https://doi.org/10.2466/pms.2002.95.3.755

Kermen, F., Chakirian, A., Sezille, C., Joussain, P., Le Goff, G., Ziessel, A., ... & Bensafi, M. (2011). Molecular complexity determines the number of olfactory notes and the pleasantness of smells. *Scientific reports*, *1*, 206.

Leder, H., Tinio, P. P., Brieber, D., Kröner, T., Jacobsen, T., & Rosenberg, R. (2019). Symmetry is not a universal law of beauty. *Empirical Studies of the Arts*, *37*(1), 104–114. https://doi.org/10.1177/0276237418777941

Lévy, C. M., MacRae, A., & Köster, E. P. (2006). Perceived stimulus complexity and food preference development. *Acta psychologica*, *123*(3), 394–413. https://doi.org/10.1016/j.actpsy.2006.06.006

Macaluso, E., George, N., Dolan, R., Spence, C., & Driver, J. (2004). Spatial and temporal factors during processing of audiovisual speech: A PET study. *Neuroimage, 21*(2), 725–732. https://doi.org/10.1016/j.neuroimage.2003.09.049

Machado, P., Romero, J., Nadal, M., Santos, A., Correia, J., & Carballal, A. (2015). Computerized measures of visual complexity. *Acta Psychologica, 160*, 43–57. https://doi.org/10.1016/j.actpsy.2015.06.005

Mauch, M., & Levy, M. (2011). Structural change on multiple time scales as a correlate of musical complexity. In 12th International Society for Music Information Retrieval Conference (ISMIR 2011) (pp. 489–494). https://ismir2011.ismir.net/papers/PS4-3.pdf

Mindus, L. A. (1968). *The Role of Redundancy and Complexity in the Perception of Tonal Patterns* (Doctoral dissertation, Clark University).

Muth, C., Ebert, S., Marković, S., & Carbon, C. C. (2019). "Aha" ptics: Enjoying an aesthetic aha during haptic exploration. *Perception*, *48*(1), 3–25. https://doi.org/10.1177/0301006618818014

Nadal, M., Munar, E., Marty, G., & Cela-Conde, C. J. (2010). Visual complexity and beauty appreciation: Explaining the divergence of results. *Empirical Studies of the Arts*, *28*, 173–191. https://doi.org/10.2190/EM.28.2.d

Palmer, S. E., & Griscom, W. S. (2013). Accounting for taste: Individual differences in preference for harmony. *Psychonomic Bulletin & Review*, *20*, 453–461. https://doi.org/10.3758/s13423-012-0355-2

Pearce, M. T. (2018). Statistical learning and probabilistic prediction in music cognition: Mechanisms of stylistic enculturation. *Annals of the New York Academy of Sciences*, *1423*(1), 378–395. https://doi.org/10.1111/nyas.13654

Peretz, I., & Coltheart, M. (2003). Modularity of music processing. *Nature Neuroscience, 6*(7), 688–691. https://doi.org/10.1038/nn1083

Peretz, I., & Zatorre, R. J. (2005). Brain organization for music processing. *Annual Review of Psychology, 56*(1), 89–114. https://doi.org/10.1146/annurev.psych.56.091103.070225

Pessiglione, M., & Lebreton, M. (2015). From the reward circuit to the valuation system: How the brain motivates behavior. *Handbook of Biobehavioral Approaches to Self-Regulation*, 157–173. https://doi.org/10.1007/978-1-4939-1236-0_11

Rangel, A., Camerer, C., & Montague, P. R. (2008). A framework for studying the neurobiology of value-based decision making. *Nature Reviews Neuroscience, 9*(7), 545–556. https://doi.org/10.1038/nrn2357

Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of perceptual fluency on affective judgments. *Psychological Science, 9*(1), 45–48. https://doi.org/10.1111/1467-9280.00008

Rump, E. E. (1968). Is there a general factor of preference for complexity? *Perception & Psychophysics, 3*, 346–348. https://doi.org/10.3758/BF03212482

Sauvé, S. A., & Pearce, M. T. (2019). Information-theoretic modeling of perceived musical complexity. *Music Perception: An Interdisciplinary Journal, 37*(2), 165–178. https://doi.org/10.1525/mp.2019.37.2.165

Schultz, W., Dayan, P., & Montague, P. R. (1997). A neural substrate of prediction and reward. *Science, 275*(5306), 1593–1599. https://doi.org/10.1126/science.275.5306.1593

Skov, M. (2019). The neurobiology of sensory valuation. *The Oxford handbook of empirical aesthetics*, 1–40. https://doi.org/10.1093/oxfordhb/9780198824350.013.7

Song, S. E., Kowalewski, D. A., & Friedman, R. S. (2022). Preference for harmony: A link between aesthetic responses to combinations of colors and musical tones. *Psychomusicology: Music, Mind, and Brain, 32*, 33–45. https://doi.org/10.1037/pmu0000290

Spence, C., & Soto-Faraco, S. (2010). Auditory perception: Interactions with vision. *The Oxford handbook of auditory science: Hearing, 3*, 271–296. https://doi.org/10.1093/oxfordhb/9780199233557.013.0012

Spence, C., & Wang, Q. J. (2018). On the meaning (s) of perceived complexity in the chemical senses. *Chemical Senses*, *43*(7), 451-461. https://doi.org/10.1093/chemse/bjy047

Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology*, *9*, 1–27. https://doi.org/10.1037/h0025848