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Unexpected Aspects of Expectancy in Music: A Spreading Activation Explanation

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Abstract

A well agreed discourse in music perception research is that affective response can be generated by music when a tendency in the music is delayed or inhibited. There is a consensus that this tendency is statistically driven, derived from exposure to culturally situated musical idioms. By presenting a neural-network inspired spreading activation model (SAM) this paper argues that the nature of the tendency is worthy of further investigation. SAM organises the music stream perceived by the listener continuously into segments such that a match with an existing 'mental representation' (node) is found, which is then linked to the node for the previously segmented part of the music stream, with the link between these nodes strengthening and consolidating with exposure. The currently activated segment (the music being sounded) will prime the best matching (strongest linked) node available, generating expectancy. Expectancy is defined as the most strongly primed segment, and emerges dynamically through experience with environmental and musical contexts, rather than schematic or prototypical means. Expectancy is the specific exemplar instance that the activated (currently sounding) segment of music and contextual factors prime. This hypothesis of veridical dominance has implications for enduring aspects of music expectancy theory: (1) individual experiences matter in the formation of expectations; (2) expectations are a dynamic process, that change and are updated with experience; (3) context plays a critical role in expectancy; and (4) schema, prototypes and statistical accounts of expectation should be treated as convenient approximations of underlying cognitive processes.

Keywords: music expectancy, spreading activation, associative networks, exemplars, veridical chains

Introduction

When one walks to the shop to buy some milk, they enter the shop, approach the refrigerator, open the door, remove the desired milk, take the milk to the counter, and pay for it. If on a later occasion the same person goes back to the same shop but this time, after following a similar sequence, finds that there is no milk in the refrigerator, after looking again, then checking on different shelves without luck, they

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may feel surprised, or disappointed, or annoyed. This is an affective response that has arisen due to the disruption of expectation. Expectancy, and its violation, is part and parcel of interacting with the environment to achieve goals. Even affective responses to music are thought by several prominent researchers to hinge on the phenomenon. The seminal work on the topic as applied to music was a monograph by Meyer (1956). His influential thesis was that:

> Affect or emotion-felt is aroused when an expectation – a tendency to respond – activated by the musical stimulus situation, is temporarily inhibited or permanently blocked (Meyer, 1956, p. 31).

The thesis claimed that through a process of enculturation, we develop expectations of music's tendency, or 'how music should go':

> the customary or expected progression of sounds can be considered as a norm, which from a stylistic point of view it is; and alteration in the expected progression can be considered as a deviation (Meyer, 1956, p. 32).

The process of enculturation here can be understood as exposure to music of one's culture(s). The process forms mental 'archetypes', against which future musical experiences are compared. An illustrative example is the ending of a piece of unfamiliar Western art music of the 'common practice period' (the period of European high art music compositions from around 1600 to 1900, which includes works by composers such as Vivaldi, Bach, Mozart, Beethoven, Brahms and Tchaikovsky) to a person who is otherwise well versed with these styles of music. She/he knows the piece is coming to an end. Something just sounds (archetypally) like the ending is impending. And then it happens. Or perhaps it almost happens, but is delayed. Or perhaps the music appears to abandon the attempt to end, and moves in a different direction. These are all examples of an expectation, already formed in the mind of the listener, being compared with how the actual, sounded music continues (for a technical and empirical discussion of these possibilities, see Sears et al., 2018). Meyer's thesis holds that when in the latter two cases, temporary and permanent (respectively) blockages of expectation occur, this blockage generates emotional arousal in the listener based on firmly established psychological principles of that time (Koffka, 1935; Landis, 1924; MacCurdy, 1925, among others). Meyer claimed that this experience (here, expectation of the archetype) continues to be generated, even for familiar but non-archetypal pieces (for a discussion on this matter, one to which we shall return, see Jackendoff, 1991; Meyer, 1967).

Meyer inspired, and still does, some of the finest minds in the subdiscipline (e.g., Huron, 2006; Jones, 1981, 1982; Narmour, 1990, 1991; Pearce & Wiggins, 2006; Schmuckler, 1989). An influential example is Huron (2006). For Huron, too, incoming music generates expectations, which if not satisfied will generate emotion: "surprise […] arises from a discrepancy between an actual outcome and a highly practiced schema" (p. 14). The highly practiced schema against which the incoming music is compared is, for Huron, like Meyer, also determined by exposure to culture:

> "Both tonality and meter are sets of enculturated mental structures- schemas that are related to a statistical hierarchy of events. Both are capable of increasing a listener's ability to anticipate and predict future sounds." (Huron, 2006, p. 185).

This paper interrogates the consensus that expectancy in music is based on a mental comparison made against a cultural norm or statistically based calculations. The approach taken consolidates and extends work on mental modelling of expectancy (Schubert, 2015, 2021; Schubert & Pearce, 2016) by further investigating how music would be mentally organised if the organising principles resembled our recent understanding of the operation of the human brain's architecture. In doing so, this paper will demonstrate some surprising lapses in methods used to investigate the nature and prevalence of different kinds of expectation, and as such argues for alternative hypotheses, and calls for a renewed research focus.

Research on human brain architecture over the last 40 years have come under the headings 'parallel distributed processing', 'neural networks' (Bechtel, 1985; Sun, 2014) and 'grounded cognition' (Barsalou, 2007, 2020). Since the connectionist revolution of the 1980s (McClelland et al., 1986; Sun, 2014) our ability to emulate and understand mental processing, both at the substrate level and in relation to behaviour and cognition, has accelerated. The neural networks refer to the processing of information that is distributed through vast, subsymbolic, interconnected networks that consist of two key building blocks – nodes and links, analogous to the neurons and synapses of the physical neural network in the human brain. The means of communication within the network is through spreading of excitation across parts of the network that are tied to sensory-dependent inputs. The excitation is referred to generically as 'activation' giving rise to the label 'spreading activation'. In music, numerous phenomena have been modelled using such 'spreading activation models'– henceforth SAM (for particularly relevant examples, see Bharucha, 1999; Page, 1994; and a variety of applications reported in Todd & Loy, 1991).

This paper presents the groundwork for the model that builds on these developments, with the intention here of uncovering an alternative, plausible way of interpreting expectancy in music. First 'spreading activation' networks will be introduced. This will be followed by a description of how music would be organised in such networks. Finally, SAM will demonstrate that there are some limitations to the notion that expectancy is driven by culturally learnt, statistically extracted schema.

Rudiments of the Spreading Activation Model (SAM)

Contemporary understanding of cognition posits that real-world stimuli impact the senses, which are then coded in uniquely distributed ways across the mental network in a dynamic, complex, and systematic manner. As a pithy summary, upon perceiving the same stimulus on repeated occasions, more or less the same topological parts of the network ('cell assemblies') as during previous experiences of the stimulus become consolidated (de Vries, 2020). As a result, various perceived objects and events come to be represented with their own, unique characteristic activation patterns (Mannino & Bressler, 2018).

An activated assembly of cells that represent a coherent object, event or context can be thought of as having a unique node that binds the assembly into a mental representation of the object, event or context. From the grounded cognition perspective (Barsalou, 2007; Schilhab, 2017; Wajnerman Paz, 2019), the assemblies that are activated through external stimulation of the senses are both representation and activation. That is, the two concepts (activation and representation) can be regarded as interchangeable. Roy (2014) views this as a localised/globalised duality between the activated assembly (localised) and the single mental representation (the node – globalised), a designation that we adopt here. In the discussion that follows, we will refer to the node as the mental representation of a stimulus that is bounded to a particular assembly of synchronised cells inherently tied to the represented stimulus, event or concept (e.g., representing the activation pattern during the perception of a fish). It should therefore be understood that any such single node is correlated with assembled subnetworks (features of the fish, and relationships among other fish). Perception of other stimuli (e.g., a bird) will each activate a separate assembly of cells that come to be bounded to their own, unique nodes, too.

The perception of a fish will activate cell assemblies that are triggered by the features of the fish (its shape, colour, texture, anatomical characteristics, action and environment). Repeated experience of the same fish will activate the same, or significantly overlapping assemblies. A single node to which these assemblies are bounded flexibly represents the 'fish', providing the perceiver with the experience of the fish as well as knowledge about it (Cameron, 1993; Nikolić, 2015).

Further experiences of the fish both activates and dynamically alters the assembled network representing it. A classical architecture for the dynamic organisation of these networks consists of excitation that spreads through parts of the network (cell assemblies), where the excitation not only activates those parts of the network involved in the mental representation, but also reinforces them. Reinforcement refers to strengthening links between cells or nodes, which means easier, more coherent activation on future, similar perceptual or imagined encounters. That is, matching/reactivating existing cell-assemblies through perception or thought creates the internal experience of the perception (Nikolić, 2015; Pecher, 2013, 2018; Petilli et al., 2021). The reverse is also the case: a perception or thought is coherent when it consists of reactivated cell-assemblies that were previously activated as a result of the same or similar earlier perception (Barsalou, Simmons, et al., 2003; Cameron, 1993; Nikolić, 2015).

The network is dynamic, flexible, able to represent entities, events and concepts, and can distinguish particular entities, events or concepts from others, as well as resolving many ambiguities (Barsalou, Niedenthal, et al., 2003; Barsalou, Simmons, et al., 2003). The various activation patterns in the network generally come about through experience, in this case experiences with fish (Talsma, 2015).

Time-Independent Expectancy in SAM

Contextual associations are an important part of what is encoded by the network (Lakens, 2014; Otten et al., 2017; Pezzulo, Barsalou, et al., 2013; Pezzulo, Candidi, et al., 2013; Shamay-Tsoory & Mendelsohn, 2019; Wajnerman-Paz & Rojas-Líbano, 2022). A fish that is always seen in the company of a dolphin will lead to the node representing the dolphin and the node representing the fish developing dynamically strengthening links while the pairing continues to be observed consistently. That is, when different nodes are activated at nearly the same time, link strength between them is developed (Lucas, 2000; Shamay-Tsoory, 2022; Thorwart & Livesey, 2016). In the network the activation of the fish node will 'prime' (or 'pre-activate') the mental representation of the dolphin as a result of activation spreading from the activated fish node to the (as yet unactivated) dolphin node due to the previous encounters. The priming of the dolphin node is more likely than priming of other nodes because the dolphin node is more strongly linked to the fish node, due to the previous experiences. Priming ('pre-activation') thus refers to a small amount of excitation sent to the dolphin node, which itself does not fully activate until the dolphin comes into view along-side the fish. This means that future perceptions of the fish will create the expectation that there will be a dolphin nearby. Contextual factors, such as the environment, and the presence of the fish, contribute to this priming of the dolphin node.

In other words, priming of a node is experienced as expectation (Bharucha & Stoeckig, 1987; Kutas & Federmeier, 2000; Neely, 1991; Thorwart & Livesey, 2016; Waszak et al., 2012), and the subsequent activation of that node (due to the actual perception of the dolphin in this case) is experienced as the satisfaction of expectation, while the absence of the perception of the dolphin is perceived as disrupted expectation. Priming without activation is also the SAM mechanism for disrupted expectation experienced by the milk-seeking protagonist of the opening anecdote. This spreading of activation is fundamental to inter-node communication and for providing cues to the individual. It is foundational to SAM (Anderson, 1983; Collins & Loftus, 1975; Nozari & Pinet, 2020). All environmental factors that can be encoded around the fish, in addition to the dolphin from the example, contribute to contextual associations: the water, algae, presence of other fish and sea-life, and so on. Incidental aspects of the fish (e.g., an unusual marking on one fin) also provide contextual information.

Time-Dependent Expectancy Representation in SAM

The above conceptualisation of SAM described what the literature refers to as semantic, episodic and contextual information (Renoult et al., 2019) where the sequence of information occurrence is not critical (seeing the dolphin creates an expectation of seeing the fish, and seeing the fish creates an expectation of seeing the dolphin – the temporal order of which arrives first is not so important). The mental organisation of events that are sequenced in time adopt similar organisational principles, except that the timing becomes important and is also encoded. Under such circumstances links are formed between the mental representation of one temporal event with the mental representation of another, for example when those two events occur contiguously, that is, one after the other. Such relationships have been identified and exploited in early connectionist simulations (Elman, 1990; Mozer, 1994; Page, 1994).

Here the perception of one temporal event will activate a node that represents that event, and the activated node requires the commensurate amount of time to complete its activation as did the perceived event (Botvinick & Plaut, 2006; Veliz-Cuba et al., 2015). That is, such nodes are analogous to short, meaningful musical units, such as motifs of phrases, or audio-visual units, such as shots or scenes in a movie (Bird, 2020). A perceived event consisting of a shot or short scene from a motion picture, or a motif of a song will come to be represented by the node that codes the multisensory events that took place during the time period of the event in a reasonably faithful manner. Evidence suggests that a mentally reproduced stream of recalled events, such as a song, honour the real-world timing of the enacted event (Halpern, 1988; see also Huyck, 2020, p. 175; Zatorre et al., 1996), and that the string of events stored as a coherent episode span in time from tens of seconds through to minutes (Bird, 2020).

When the event is familiar (i.e., a node that it represents exists), the activation of that node constitutes the experience of the event (using the same activation mechanism as for the temporally independent objects and concepts discussed above). While the node is active, it also increasingly primes the node of the event that is most likely to follow, based on previous experience, such as the node representing the next shot or scene of the movie, or the next motivic event or phrase of the song. When the excitation in the active node is complete, the primed node is highly primed but will then become activated if indeed it is the one whose representation is occurring in the environment (Bharucha & Stoeckig, 1987; Bird, 2020; Cariani & Baker, 2022). As in the case with time-independent expectancy, contextual factors will impact on the amount of priming. This includes priming from the event itself (the film, the music, etc.) that has unfolded up to that point in time.

Exposure to Novel Stimuli

When a novel stimulus is experienced, cell assemblies representing the sensory experience of the novel stimulus come into activation, but being novel, they will have little from mental representation of past experiences (semantic, contextual or event-based information) to prime. Repeated experience of the stimulus allows those sensory cell assemblies to become consolidated and linked with other assemblies representing contexts and associations in which the stimulus and perceiver are situated. Eventually, after sufficient exposure or learning, a new representation of the stimulus develops and consolidates into a richer representation within the network (Barsalou, Simmons, et al., 2003; Domijan & Šetić, 2016). Importantly, the network will attempt to recruit existing mental representations to the extent possible. In the case of event coding, this will involve parsing the stimulus into smaller units for processing, to better facilitate matching, and so help make sense of the unfolding stimulus.

Because the cell assemblies come into activation by matching the incoming (in this case) music stream (Becker, 1980; Nikolić, 2015), the stream is flexibly parsed into small, temporally discrete units to facilitate this matching. For example, a new, unfamiliar piece of music that is 10 minutes long will initially have no mental representation it can activate, particularly if there is nothing familiar about the context in which the piece is situated. However, there may be portions of the piece that are familiar or can otherwise be processed fluently (Huron, 2013; Reber et al., 2004), meaning that 'higher level' or 'superordinate' (Fromm et al., 2020; Rendeiro et al., 2014) cell-assemblies can become activated during those musical events. The segmentation can be applied to 'vertical' features, such as timbre or harmony at any given time (as in the pitch to chord activation, and other semantic and contextual nodes - see Bharucha & Stoeckig, 1987), or as short musical episodes, which are in Western music of the common practice period frequently conceived in a time-scale based hierarchy from (shortest to longest, or events to episodes) pitch-rhythm combinations (or motifs), to subphrases, to phrases, to periods, to sections, to movements, to an entire work (Benward & White, 1997; Drabkin, 2001; Jackendoff & Lerdahl, 1983, p. 8; Ratner, 2001; Schubert, 2021). This organisation of incoming stimuli has implications for how expectancy with novel stimuli is developed.

Veridical and Schematic Expectancy in Music Sequences

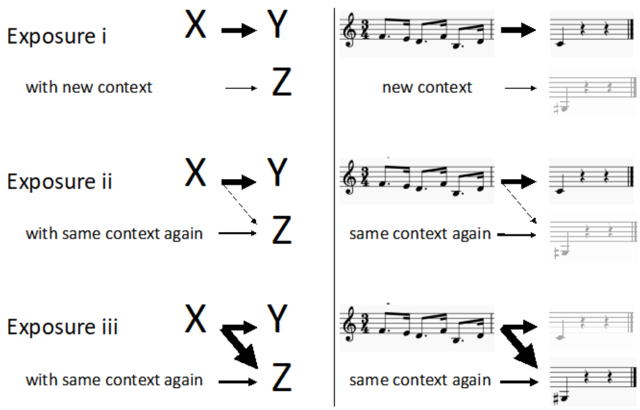
Meyer's (1956) influential work on expectancy left a dilemma that is pertinent to the present discussion: Can re-experiencing a familiar event be unexpected? Consider a simplified representation of Meyer's approach to expectancy. If several pieces of music consist of a musical segment, let's call it X, that is followed contiguously by another segment, which we shall call Y, then over the course of time and exposures, a new piece of music that also utilises the same X segment will, at first listening, create an expectation that segment Y will follow. Afterall, the X segment is mentally represented, and primes the Y segment based on these earlier exposures in a range of contexts. If the X segment of the *new* piece is, however, followed contiguously by a different segment, which we will refer to as Z, rather than Y, a disruption in expectation occurs. This is the classic argument of expectancy disruption outlined by Meyer (see 'exposure i' in Figure 1). As the new piece is heard more and more frequently, does the piece always continue to surprise the listener, as it did during initial listening?

Bharucha (1987) proposed a dual expectancy approach to address this question. Meyer and his intellectual progeny refers to a schematic kind of expectation, that is generated through exposure to culture, through awareness of cultural norms, through sensitivity to cultural and stylistic idioms, the extraction of statistical regularities (each of these characterisations are treated as similes here). This reflects the expectation that X will be followed by Y, which Bharucha referred to as schematic expectancy.

The second system proposed by Bharucha was veridical expectancy. This is the expectation that Z, rather than the more commonly expected Y, should follow for this particular piece. The expectation of the Z segment after hearing an X segment of music is peculiar to that single piece of music. He argued that the two systems (schematic and veridical) operate in parallel, and to different degrees, hence responding to Meyer's conundrum, because even though the listener has access to veridical expectations for familiar music, the schematic process is never far away. As Bharucha put it, when schematic expectations are disrupted in familiar music it "is familiar in a sense and surprising in another" (Bharucha, 1994, p. 216).

Figure 1

Changing Link Strength with Exposures to a Contiguous Temporal Segment XZ



Note. Changing link strength with exposures to the contiguous temporal segments XZ when the contiguous segments XY have previously been learned (schematic expectation). Link strength changes when a usual (schematic) temporally contiguous pairing of XY is expected, but XZ is experienced (Exposure i) for a novel stimulus. Contextual information is also incorporated, and includes information peculiar to the novel piece prior to arriving at segment X. Upon repeated exposures of X with this new context (Exposure ii, iii etc.), Z comes to be expected according to SAM principles, making the veridical expectancy dominate over schematic. Exposure numbers are not literal or based on empirical evidence. They are shown for illustrative purposes. It remains for further research to determine if and what the sufficient number of exposures is to reach the state shown in Exposure iii. The XY example in the right column is taken from the "Adagio" of *Quodlibet for Small Orchestra* by Peter Schickel (PDQ Bach) (the 'Y' continuation) and the slow movement from *Symphony no. 5 in C minor, Op. 67* by Ludwig van Beethoven, (the 'Z' continuation). The notation has been transposed up and from Ab major to C major, which should provide less context for triggering the veridical expectation of Z, but knowledge of the intended piece would provide context.

SAM Characterisation of Veridical Expectancy

Veridical expectancy means that a specific cell assembly/node is primed that is unique to the exemplar (the specific stimulus) being experienced. Schematic expectancy means that there is a typical cell assembly/node that is primed or several related assembly/nodes are primed (see Pecher, 2013). In the present system, the most typical cell assembly cannot be a statistical average, because the network architecture is not a statistical model (although it could be estimated through statistical means). Instead, it primes all potential matches, with best matches being more primed. Best matching here refers to the strongest link. Links are strengthened by previous activation occurrences (i.e., previous experience) of those links. The eventual 'winner' (Newman, 2003) will also be determined by additional factors, such as contextual cues, which can be the environment around which the piece occurs, information available about the piece (e.g., access to information about the identity of the piece, through a verbal introduction to the piece, program notes etc., see Chmiel et al., 2022), and from within the piece, such as timbral, pitch, metric and other cues that are peculiar to the piece undergoing audition (see Figure 1).

Therefore, after repeated exposure to the non-idiomatic stimulus containing the XZ temporal stream, link strength from X to Z will become so strong that Z will be most primed (Figure 1, 'exposure iii') and thus expected. The amount of priming of Y will not increase when this piece is sounded because of the absence of reinforcement, and the various contextual cues that accompany this piece provide additional reinforcement of the newly evolving and consolidating priming of Z, rather than Y, during the activation of X. That is, the veridical will dominate once the new piece becomes sufficiently encoded (familiar). What does the literature have to say about this?

Evidence that Veridical Expectancy Overrides Schematic Expectancy

The empirical literature is inconclusive as to whether veridical expectancy of a non-idiomatic piece of music dominates schematic expectancy after a sufficient number of exposures, even though a narrative can be traced suggesting the likelihood of its eventual dominance, and some limited evidence does exist. Van Den Bosch et al. (2013) exposed participants to unfamiliar music, which after later repeated listenings was deemed more pleasurable, and generated greater physiological arousal, leading the authors to conclude that "mere exposure may increase emotional arousal by increasing the listener's veridical and dynamic expectations" (p. 7). But it was not clear whether the unfamiliar music had elements that lent themselves to schematic expectancy, which may itself have contributed to the outcomes.

A study by Thompson et al. (2000) had similar limitations in terms of applying results to the question that concerns us here. In that study participants were incidentally exposed to tonal-sequences in order to generate familiarity without deliberate awareness. 30 sequences were presented, with three exposures to each.

Participants were distracted from deliberately memorising the music by being asked to count the number of pitches in the sequences during audition. This part of the study was the exposure phase. Since the exposure phase exposed participants to novel sequences, the mental representations could arguably be thought of as consisting of veridical expectations in each case. Later on, in the test phase of the study, the participants were exposed to the sequences, but on some occasions the sequences had the final note altered from the one presented during the exposure phase. Participants were asked to rate how expected the final note was in each case. When the final note was the same as that presented in the exposure phase, expectancy was rated higher than when the modified stimuli were rated. Thus, even with just three exposures, there is evidence that veridical expectancy is already developing. The study therefore supports the principle that expectancy is generated through veridically driven exposure to specific stimuli. However, it was not the aim of either of these studies to explicitly test whether one (veridical or schematic) expectancy dominates over the other. The stimuli employed did not depend on source stimuli resemblance with idiomatic patterns.

Schmuckler (1989) investigated how various mid-excerpt endings (with the original or a substituted pitch) were rated. The excerpt was from a *Lied* by Robert Schumman ("Du Ring an meinem" from *A Woman's Love and Life*). On some occasions the participant would hear the piece with the originally composed 'true continuation' truncating note. At other times it would be another note selected from one of the remaining 11 chromatic notes, resembling a probe tone paradigm (Krumhansl & Kessler, 1982). For each stimulus, participants rated the final note of the truncated excerpt from very poorly through to very well, along a scale of 1 to 7 respectively, at each hearing of the excerpt from the beginning up until that point. Stimuli were generated with a range of mid-excerpt ending points selected, taking into consideration when the true continuation of the original composition subverted the archetypal structure, opening the design up to the possibility that the artificially intruding tone may offer a more archetypal solution to the listener in some cases.

Of particular interest here is that a group of participants rating the various stimuli were familiar with the *Lied* prior to the experiment, while another group only started to become familiar with the piece during the study. While the overall results were fairly similar between these groups, analysis of the rated fit scores given to originally composed tone compared to the artificially substituted ones revealed an interesting difference. Those who were familiar with the piece prior to the study gave overall higher fit ratings for the originally composed versions (M = 4.25) than those who were not familiar with the piece prior to the study (M = 3.12), suggesting greater expectancy for well-established but non-idiomatic occurrences (i.e., veridical expectancy). The non-familiar (prior to the experiment) participants did have some exposure to the stimulus by listening to the various different endings as the experiment progressed. And so, again, the study was not designed to facilitate conclusions about veridical expectations.

It is worth noting that level of familiarity with music is likely to be correlated with musical training (Ollen, 2006; Zhang & Schubert, 2019), meaning that studies investigating expectancy should produce differential results if the participant has musical expertise or not, simply because the more expert musicians have been afforded greater chance of having specific familiarity with pieces containing non-idiomatic patterns as a result of exposure to a wider range and amount of music. However, such extensive musical experiences will also mean that those people will have had opportunity to develop sufficient exemplars that are archetypal, biasing overall response to unfamiliar stimuli toward an archetypical listening strategy (e.g., Bergeson, 1999; Pearce & Wiggins, 2006; Schellenberg, 1996), potentially concealing the tendency to respond with veridical expectancy.

The above studies, and several other (e.g., Schellenberg, 1996; Schmuckler & Boltz, 1994) used synthesised timbres to create the music stimuli that were more commonly known through acoustic instrument performances. The synthesis procedure was required in part to manage technological limitations while allowing control over the stimuli. Such methods may inadvertently remove some contextual information that could be helpful for identifying cues toward pieces exhibiting non-idiomatic patterns. Consider the excerpt in Figure 1 which has been transposed from the original key and register, and presented without identification of the instrument. Knowledge that the excerpt is taken from a piece played in a different key (Ab major) in a lower register, and by celli would, according to the SAM prediction, be easier to assess from a veridical perspective.

Huron (2006) illustrated how disruption of veridical expectation could be achieved by satisfying schematic expectation with amusing results. He referred to Peter Schickele's "Adagio" from *Quodlibet for Small Orchestra* (a sample of which is shown in Figure 1), in which a parody of a well-known celli soli (a group of cellos playing a melody) by Beethoven (also see Figure 1) consisted of replacing a harmonically unexpected pattern (from a schematic expectancy point of view) with one that is more idiomatic. In an earlier study, Huron (2004) examined audience responses to the live concert recording of Schickele's treatment of the Beethoven, reporting the strongest laughter on the recording occurring at the point where the schematic alternative was inserted in place of Beethoven's better known non-idiomatic version. The study was not designed to determine whether the laughter reflected surprise arising from disruption of expectation that leads to the laughter, versus the laughter reflecting the amusement of a better (more expected) alternative solution to the famous excerpt. But by Huron's own account, the laughter response could be a result of surprise, which is the essence of disrupted expectation.

A study examining brain response to schematic versus veridical expectancy (Pagès-Portabella et al., 2021) could not make strong conclusions about either kind of expectancy, but still suggested that:

> veridical observations about any acoustical irregularity that appears often enough could prevail over the learned rules of hierarchical expectations, as if the irregularity becomes the new rule. Even music with quartertones sounds

> unpleasant at first, but after some repetitions, listeners tend to like it more as a result of the 'mere exposure' effect (p. 13).

The authors suggested that these results were not produced possibly because of the nature of the stimuli used, where stimuli intended to generate veridical expectations consisted of some very strongly dissonant intrusions.

A common limitation emerging from this literature that is relevant here is that the number of exposures has been insufficient or poorly controlled. The presence of intrinsic schematic patterns, and the number of exposures are methodological issue that must be controlled to properly test the SAM prediction (other studies that may fail to support the dominance of veridical expectancy potentially for these very reasons also include Baddeley & Larsen, 2003; Guo & Koelsch, 2016; Tillmann & Bigand, 2010).

Discussion and Conclusion

Expectancy in music is commonly thought of as being driven by culturally situated, statistically calculated, prototypical (or schema based) norms. The present research applied a spreading activation model (SAM) to arrive at a different conclusion, which has implications for theory of expectancy, and for how musical expectancy needs to be investigated empirically.

The central argument was that, contrary to conventional assumptions of expectancy, the tendency for an unfolding piece of music is not a schema, prototype or some kind of statistically determined outcome, but a specific instance of an exemplar, previously experienced by the individual. If the exemplar is non-idiomatic, it must be experienced with sufficient frequency until the sequences of music that form its constituents become reinforced to the point of having the non-idiomatic portions become (veridically) expected. This is because dynamically adjusted link strength between musical sequences, and consequent priming on future exposures, contributes to expectancy, and not some fairly static, statistical averaging process.

Statistical explanations do not easily account for the dynamic and interactive impact of listening upon mental organisation. In SAM, every time an exposure occurs, whether to a familiar or a novel piece of music, the network is excited accordingly, and the excitations that did or did not take place lead to further revision of the extant link strengths and (therefore) priming. Expectation will not stabilise for a piece of music containing non-idiomatic aspects, at least not until the veridical expectancy is thoroughly consolidated. At that point, veridical expectation will dominate.

As far as adding to the debate of schematic and veridical expectancy, SAM assays greater specificity by predicting that a novel, non-idiomatic piece of music may initially be driven by what appears to be schematic expectancy. However, those early occasions will consist of best-available fit solutions, against which mismatches will generate disruption of expectancy. But as the novel piece becomes increasingly familiar, the dynamic weighting adjustments will eventually lead to a dominance of veridical expectancy. Contextual factors about the non-idiomatic piece and the environment in which it is heard also bear upon the establishment of veridical expectation, because these factors can provide additional cues unique to the non-idiomatic piece that, as mental representations themselves, provide additional priming of the non-idiomatic segments of the music.

Previous arguments favouring the dominance of veridical expectancy by espousing a SAM-like approach have been proposed in the past (Schubert, 2015; Schubert & Pearce, 2016), but provided little in the way of specific implications for methodology. The present research makes explicit and novel predictions about the contribution of veridical organisation of mental processing and, consequently, expectancy, as well as drawing attention to methodological approaches that are needed to test the predictions. There have been several important developments in research on musical expectation, particularly in recent years, where implicit (e.g., evoked brain potential) in addition to explicit (e.g., self-reported ratings of expectancy) responses to a range of stimuli have been investigated. But empirical research has, to the author's knowledge, failed to directly and systematically investigate the predictions of SAM.

To summarise, further empirical research should take into consideration the following six points:

- **Level of familiarity**: Consideration of the varied levels of familiarity each individual has with a particular stimulus and the style of the stimulus (which can be thought of as Musical context, see below).
- **Exposure frequency and period**: For novel, non-archetypal stimuli, quite extensive exposure periods might be required, possibly spanning several experimental sessions distributed in a way that simulate typical listening habits (see Ecological plausibility).
- **Stimulus treatment**: Create non-idiomatic intrusions for novel stimuli that are varied in degree, rather than just present or absent. Highly unusual modification may have a different affect upon expectancy than less unusual modification.
- **Environmental context**: For novel stimuli, a stable environment, particularly if affording some contrast to the environment in which other stimuli are presented, should also facilitate development of veridical expectancy for those novel stimuli. This could be physical setting/location, the timing at which the piece is sounded, information (e.g., program notes) about the piece, etc., so called 'framing' (Chmiel & Schubert, 2020).
- **Musical context**: Consideration other than adjusting the targeted intrusion in a treated stimulus, but factors about the music itself leading up to the intrusion that may provide addition cues regarding veridical expectation (e.g., timbre, register, key, style/genre, and the use of a single, 'canonical' recording), that are in some way unique, and different to other stimuli.

- **Ecological plausibility**: Use naturalistic listening situations that might be expected in typical listener settings. That is, effects of laboratory-based low-, massed- (many, frequent) or over- (a long period of massed) exposure (Martindale, 2007) should be taken into account.

The significance of veridical expectancy is reflected by contemporary views of mental organisation, and reconsideration of the well-established view that the schematic dominates is worth contemplating. Schematic expectancy can be thought of as a specific (veridical) instance that happens to occur across several exemplars, where each instance shares considerable overlap in the cell-assemblies that are bound to a node. Effectively, no single prototype becomes primed, but each of the many exemplars are related to some artificial prototype/schema (Nosofsky et al., 2022). Debates continue as to whether mental processing involves activation of a family of related exemplars or a single prototypical abstraction that represents the exemplars (Barsalou, 2019; Borghi & Barsalou, 2021; Nosofsky et al., 2022; Pecher, 2013).

Because the argument proposed here is driven by models of mental operation and not driven by music theory, it promises to be less biased by traditional Western music theory dogma and less limited by avoiding ambiguous definitions of cultural norms (Fishbein & Ajzen, 1975). It also promises to be more universally applicable than extant expectancy related theories (Gjerdingen, 1990). Furthermore, the implicit assumption of a dichotomy between (a dominating) schematic and (lesser sibling) veridical expectancy is questioned. Rather, all relationships experienced in a domain begin as veridical. As further related experiences develop within the same domain, new veridical relationships form. As the new links form, the network will try to optimise the organisation of the relationship by sharing parts of the network where certain feature combinations (cell assemblies) are already encoded. Development of experiences within a domain are fundamentally veridical, and will eventually, with sufficient experience, give the impression of being schematic because of shared encoding. The SAM conceptualisation tells us to think of schematic expectancy as one side of an expectancy spectrum, rather than one side of a dichotomy. All expectancies are veridical. From the SAM perspective, they are just instances, with similar options, betraying a fundamentally veridical mode of mental processing.

To summarize, the Spreading Activation Model laid out here has implications for enduring aspects of musical expectancy theory: (1) individual experiences matter in the formation of expectations; (2) expectations are a dynamic process, that change and are updated with experience; (3) contextual factors of the music that lead up to the non-idiomatic events contribute to shaping (priming) expectancy; and (4) schema, prototypes and statistical explanations of expectation should be treated as convenient approximations of underlying cognitive processes.

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