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Melody processing

Melody has a privileged position in music. It is the fundamental element for most musical cultures. For this reason, it has been the object of extensive studies in music cognition. This chapter presents an overview of the core processes, representations and empirical evidence involved, and explains what kinds of knowledge bases are utilized in these processes.

Melody is at its simplest, physical level merely a series of successive tones. However, perceptually it is a dynamic process, in which the listener actively constructs the gist of the sequence by processing it in terms of 'multiple structural relationships' (Patel, 2003, p. 323). This involves different processes and competencies, similar to speech processing, which can be loosely divided into low and high-level processes. The low-level processes are automatic, unconscious and little affected by specific cultural patterns. High-level processes are affected by conscious attention and long-term memory structures that the listener has acquired through exposure. Moreover, brain-imaging studies with patients suffering from processing deficiencies have indicated that the many of the processes involved are carried out by individual neural components or 'modules' (Peretz and Zatorre, 2005). Here, these are called core processes and are explained from the low-level processes to the more advanced high-level ones.

Core processes: grouping

To isolate a melodic line from polyphonic music, one needs to form a coherent perceptual stream of the melody. This process is known as stream segregation and several principles governing it – as explicated by Al Bregman from the 1970s to the 1990s – relate to timbre, and temporal and frequency proximity of the successive tones. For instance, if the notes of the melody are scrambled across octaves, melody becomes virtually impossible to recognize, since the pitch continuity is broken. Similarly, if two well-known melodies are interleaved with each other within the same register, they are impossible to recognize, but when the other is transposed away, they can be easily recognized, as demonstrated by Jay Dowling in 1973.

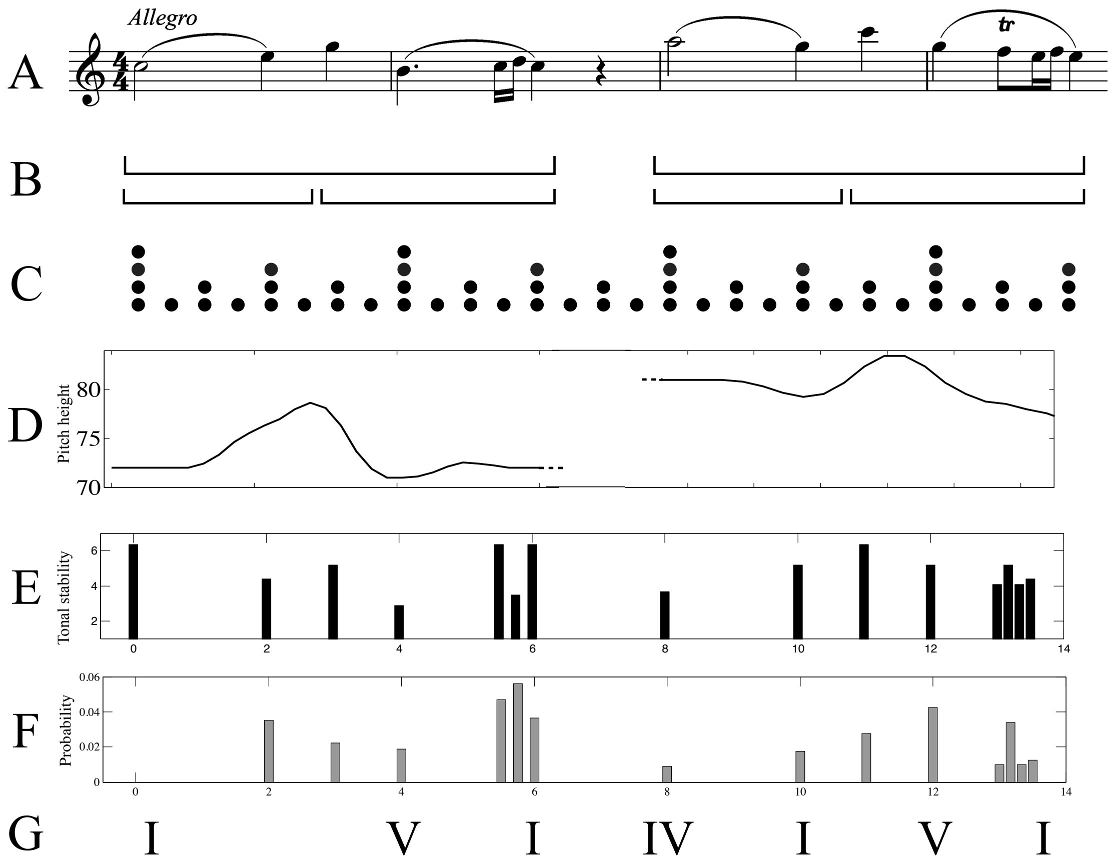

Figure 1. The melody line of the first four bars of W. A. Mozart's Piano Sonata no. 16 in C major K. 545 in score format (A). The following panels demonstrate (B) grouping, (C) metrical structure, (D) contour, (E) tonal hierarchy, (F) probability of pitch transitions, and (G) implied harmony of this melody.

Another low-level process that allows us to make sense of tone sequences is grouping of phrases and motives, separated by boundaries. Such boundaries are formed by rests, longer durations, melodic leaps or relation of the tones to the key (Panel B of Figure 1). Grouping is often marked by other stylistic devices, based on harmonic or melodic conventions. Listeners expect certain regularities at grouping boundaries, and regular grouping structures facilitate processing melodies, evident in empirical studies using recall and recognition tasks.

Grouping structures at a higher level creates musical forms (ABA, AABB), which is also a device that influences melody processing. When the appropriate and familiar form is recognized, the repetition of the musical material facilitates the processing of subsequent melodic materials.

Core processes: pulse and meter

Part of the process of parsing a coherent melody together perceptually is to relate the individual tones to an underlying pulse. This refers to a perceptual phenomenon that is inferred from the events in the melody. The listener sets up an isochronous sequence of pulses to track the passage of time within the musical material. Pulse trains are hierarchically organised into different meters by grouping repeated beats at different time scales (one for 4/4 meter is shown in Panel C of Figure 1). The basic period of this pulse train, often called the *tactus level*, is around 60 to 150 beats per minute. Latching onto the meter allows the listener to allocate attention selectively and synchronize perception with the production of music. The result of this for perception of melody is that the events occurring at the dominant hierarchical locations are perceptually more salient.

Core processes: melodic contour

The global shape of the melody is called *melodic contour* (Panel D of Figure 1). Although there are alternative ways to represent contour, it is known to be robust and central for the processing of melodies. For instance, violations of the contour disrupt melody recognition more dramatically than mere pitch violations. Contour is also one of the key aspects of how infants and small children recognize music. Subsequently it is not a surprise that melodic contour is little affected by musical expertise and changes in contours are detectable even when attention is not devoted to the music listening task. However, the importance of contour decreases when the musical material becomes more familiar; in familiar melodies, it is the intervallic contents that have larger impact on recognition. The neural areas involved in processing melodic contour are located at least in the right superior temporal gyrus, although other areas may also be involved. These areas are at least partly shared by contour processing in speech.

The computational models of melodic contours often represent them in an abstracted fashion; in other words, by carrying out a form of *reduction* of the melodic surface by eliminating ornaments, and the precise pitches and intervals (the topic of the next process).

Core processes: reduction

Studies on melody recall have suggested that listeners carry out a form of melodic reduction, since most recall errors occur in places that are not hierarchically important. Fred Lerdahl and Ray Jackendoff (1983) outlined the reductional principles in tonal music by proposing segmentation, metrical, time-span and prolongational reduction. The first two principles approximate the processes described above under the headings of grouping and meter, and the latter two are concerned with tonal structures of the music, which utilize the syntactical structures of pitch combinations and harmonic structures (both described later). An abundance of empirical work has, in the main, confirmed the principles of this theory, particularly at the level of phrasing, if not over larger time spans.

Core processes: statistical regularities and relative matching

Listeners adapt to regularities in their environment without any conscious awareness. This process – called statistical learning – is important for processing melodic expectations. Listeners quickly pick up the transitional probabilities of the adjacent tones, which will affect processing of melodies in a fundamental fashion, since the listeners will more easily detect patterns heard before and will notice violations of these patterns. The patterns are typically construed as intervals rather than pitches, since our concept of melody is relative rather than absolute. That is, we can recognize melodies in different octaves and also observe the relationships between the two patterns to be similar, even if they are transposed. The emphasis on relative rather than absolute frequencies seems to be unique to humans, since other primates and birds do rely mostly on absolute pitch information. It has been assumed to relate to speech, since speech in most language utilizes relative emphasis of the words rather than relying on specific pitches.

Panel F of Figure 1 demonstrates the probabilities of pitch transitions in terms of the transition probabilities in a large sample of classical music themes. This highlights how the typical combinations – C-D, B-C, C-G – are distinct from the more rare combinations that feature larger intervals. More sophisticated application of the probabilistic perspective to account for listeners' expectations usually involves information-theoretic evaluation of the amount of information provided by the statistical distributions of chains of events. Whilst the sensitivity to event frequencies was demonstrated with pitch-based processing, the same process also holds true for durations, although this has accumulated less research to date.

Core processes: syntactic processing

Melody processing is syntactic, since it builds an hierarchical system on a small set of basic units (pitches, chords, durations), in some ways similarly to language. However, whereas music has no equivalents to nouns and verbs, and direct meanings in language, there are hierarchical and syntactical relationships created by scales, pitch-classes and chords.

The intervals within the scale as well as the pitches within a key are both highly hierarchically organized. Interval structures in Western music are organized by series of semitone differences (2 2 1 2 2 1). Scale structures themselves are used in an implicit manner by listeners in most recognition and memory tasks. Individual pitches in the scale are not equal. In more precise terms, pitch-classes vary in their functional importance and the sense of closure they are able convey. This hierarchical organization of the tones has been the object of numerous psychological, musicological and neuroscience studies. Using a probe-tone paradigm, Carol Krumhansl revealed how the pitch-classes differ in their tonal stability, summarized in one of the most influential monographs of the field (1990). In a key of C, F# is unresolved and unstable, whereas C is not. The stability of each pitch-class forms a hierarchical set, which differentiates the tonic and dominant (these stable elements are also known as cognitive reference points), the diatonic pitches and the non-diatonic pitches, which are the least stable. This profile, drawn from listening experiments, is also echoed by the frequency of pitch-classes in music. For this reason, listeners are assumed to have learned these through exposure. These so-called key profiles have been widely used in constructing key-finding models for tonal music. However, alternative explanations posit that local rare intervals are more important in revealing the key than the frequency-based rationale. Both explanations for key-finding have been supported over the years.

Panel E in Figure 1 shows the key profile values of the individual tones within the context of C major, underlining the beginning and the ending of the phrases.
Errors that violate the local key context in melody are immediately noticeable, and such violations are actually used as identifiers of congenital amusia – a severe case of tone-deafness. Brain studies have shown the processing of tonal hierarchies to be

asymmetrical distributed across hemispheres, and the area particularly involved in the process is the superior temporal gyrus. However, the neural populations processing syntactic violations created by tonal violations have been found to be closely overlapping with the areas involved with processing syntax in language (Patel, 2010). Although monophonic melody does not have harmony as such, it is common that the notes themselves convey a sense of *implied harmony*. The implied harmony of a melody also guides the processing of the melody. In the first bar of the example, C E G gives a strong sense of the underlying tonic chord (I) in a key of C (see Panel G). Implied chords, particularly the alternating functions of the chords (tonic, subdominant, dominant) give rise to a sense of tension and resolution in melody, which often coincides with the grouping structures of melodies, but typically contrasting sequential patterns are constructed with implied harmonies.

Implicit knowledge and long-term memory

Explicit musical training is not necessary for acquisition of most syntax-like relationships in music (scale, chord and key relationships, as well as contour and marking the pulse of the sequences). Studies of infants and of differences between those who lack expertise show that most of these processes are operational very early in development (Trehub, 2001), though this form of knowledge is assumed to be acquired through exposure. However, such knowledge is not under conscious control and, for this reason, it is called implicit knowledge.

Neuroimaging studies of implicit knowledge related to melodies suggest that many aspects of melodies are processed automatically and pre-attentively in the auditory cortex. The low-level processes involved in the extraction of pitches and their order sequencing are known to take place in core cortical areas. When the melodic contour is under the focus of attention, it is the right superior temporal gyrus that is essential, and the patterns of pitches are processed in Heschl's gyrus, the anterior planum temporale.

Listeners retain in their long-term memory a large number of melodies, melodic patterns and stylistic conventions called *schemata* that are accessible with little effort. Melodies accessible to conscious processing (i.e. that are recognized and can be named) are called *explicit memories* whereas the other forms of memories are *implicit*. When a listener recognizes a melody, the explicit memory of the tune will strongly guide the processing and may override some of the core processes involved in melody processing.

Summary

Processing melody addresses a series of fundamental issues in music cognition that span syntactical, reductional, sequential and hierarchical processing. We currently do not have adequate grasp of all the sub-processes involved; in particular, the interactions between the processes have been little studied to date. There are also other factors, such as expression, complexity, intonation, symmetry and timbre, which may all contribute to processing of melodies and need exhaustive study in the future. Nevertheless, studying melody processing provides a fascinating look at the array of complex overlapping structural relationships that listeners are able to harness to appreciate even the simplest of melodies.

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See Also: Contour; Grouping; Generative Theory of Tonal Music (GTTM); Harmony; Meter; Pitch and pitch perception; Scale; Similarity; Statistical learning; stream segregation; Structure; Tactus and Pulse

Further readings

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