

## Neural Mechanisms Underlying Melodic Perception and Memory for Pitch

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The neural correlates of music perception were studied by measuring cerebral blood flow (CBF) changes with positron emission tomography (PET). Twelve volunteers were scanned using the bolus water method under four separate conditions: (1) listening to a sequence of noise bursts, (2) listening to unfamiliar tonal melodies, (3) comparing the pitch of the first two notes of the same set of melodies, and (4) comparing the pitch of the first and last notes of the melodies. The latter two conditions were designed to investigate short-term pitch retention under low or high memory load, respectively. Subtraction of the obtained PET images, superimposed on matched MRI scans, provides anatomical localization of CBF changes associated with specific cognitive functions. Listening to melodies, relative to acoustically matched noise sequences, resulted in CBF increases in the right superior temporal and right occipital cortices. Pitch judgments of the first two notes of each melody, relative to passive listening to the same stimuli, resulted in right frontal-lobe activation. Analysis of the high memory load condition relative to passive listening revealed the participation of a number of cortical and subcortical regions, notably in the right frontal and right temporal lobes, as well as in parietal and insular cortex. Both pitch judgment conditions also revealed CBF decreases within the left primary auditory cortex. We conclude that specialized neural systems in the right superior temporal cortex participate in perceptual analysis of melodies; pitch comparisons are effected via a neural network that includes right prefrontal cortex, but active retention of pitch involves the interaction of right temporal and frontal cortices.

**[Key words:** human auditory processing, music, pitch, auditory working memory, PET, temporal cortex, frontal cortex]

Perceiving a melody, or sequence of pitches, requires relatively complex perceptual analysis, since short-term memory and abstract pattern-matching mechanisms must be involved (Deutsch, 1982; Dowling and Harwood, 1986). It seems likely that such processing would also demand a correspondingly complex set

of neural computations, but at present, the cerebral substrates for melodic processing remain poorly understood. Current knowledge of complex auditory neural processing comes from two principal sources: neuroanatomical and neurophysiological studies of the auditory system of nonhuman vertebrates, and studies of the effects of human brain lesions on auditory tasks. Each of these will be briefly reviewed before introducing the present investigation, which takes advantage of recent advances in PET brain imaging techniques to study the functional cerebral systems involved in melodic perception in the living human brain.

The superior aspect of the temporal lobe has long been known to contain neurons responsive to auditory stimulation in both monkey (Ferrier, 1876; Merzenich and Brugge, 1973) and human (Flechsig, 1896; Celestia, 1976). Several distinct cortical fields may be identified on the basis of the neurophysiological response properties of neurons within those fields (Brugge and Reale, 1985), and also based on their cytoarchitectonic characteristics. A general distinction may be drawn between the primary auditory area—or toniocortex—lying deep within Heschl's gyri in the human brain (Galaburda and Sanides, 1980; Liegeois-Chauvel et al., 1991), and surrounding regions, which may be termed secondary or associative auditory cortex. Some of these cortical fields are arranged tonotopically (Woolsey, 1971; see Brugge and Reale, 1985, for a review), suggesting that they play a role in frequency analysis. However, apart from the primary and immediately surrounding regions, the frequency tuning of individual units can be very broad, and the tonotopic organization can be difficult to discern (Manley and Müller-Preuss, 1978). Some neurons respond best to complex stimuli, such as tones modulated in frequency (Whitfield and Evans, 1965), or patterns of ascending or descending tone sequences (McKenna et al., 1989).

The morphological and physiological distinctions between cortical regions raise important questions regarding the consequences of such an architecture for auditory processing. Can dissociations be identified that would allow functional significance to be assigned to the structural heterogeneity? A possible functional role for human superior temporal neurons in higher-order auditory processes is suggested by the observations of Penfield and Perot (1963) and of Penfield and Jasper (1954). They noted that complex auditory sensations (including voices and music) could be elicited from electrical stimulation of the exposed cortex in this region, but not from Heschl's gyri, which instead usually resulted in more elementary sensations, such as buzzing.

The connectivity of these regions indicates that both primary and secondary areas receive input from various divisions of the medial geniculate nucleus (Burton and Jones, 1976), suggesting

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# Melodic Perception

**James Caldwell Carlsen**



## **Melodic Perception:**

**Melodic Perception and Analysis** Vida Chenoweth, 1972      **Melodic Perception** Bonita Ford, 1980      *Melodic Perception and Cognition* William Eastman Lake, 1987 study to extant musical theory      **Psychology and Music** W. Jay Dowling, Thomas J. Tighe, 2014-02-24 This book deals with the complex cognitive processes involved in understanding two horizontal aspects of music perception melody and rhythm both separately and together Focusing on the tonal framework for pitch material in melodies the first section provides evidence that mere exposure to music organized in a particular way is sufficient to induce the auditory system to prepare itself to receive further input conforming to the patterns already experienced Its chapters also offer evidence concerning elaborations of those basic schemes that come about through specialized training in music Continuing themes from the first section such as the hypothesis that melodies must be treated as integral wholes and not mere collections of elements the second section discusses the integration of melody and rhythm In these chapters there is an underlying concern for clarifying the relation central to aesthetic questions between physical patterns of sound energy in the world and our psychological experience of them The chapters in the third section provide excellent examples of the new scientific literature that attempts to objectively study early musical abilities Their data establish that infants and young children are far more perceptive and skilled appreciators of music than was thought a decade ago      **Melodic Perception and Analysis** Vida Chendweth, Summer Institute of Linguistics, 1972      **Melodic Perception** James Caldwell Carlsen, 1965      *Melodic Perception* James C. Carlsen,      **The Influence of Expectancy on Melodic Perception** Anna Maria Unyk, James Caldwell Carlsen, 1985      **An Investigation of the Effects of Melodic Perception Instruction on the Pitch Discrimination and Vocal Accuracy of Kindergarten Children** Hilary Everett Apfelstadt, 1983      *The New Handbook of Research on Music Teaching and Learning* Richard Colwell, Carol Richardson, 2002-04-18 Featuring chapters by the world s foremost scholars in music education and cognition this handbook is a convenient collection of current research on music teaching and learning This comprehensive work includes sections on arts advocacy music and medicine teacher education and studio instruction among other subjects making it an essential reference for music education programs The original Handbook of Research on Music Teaching and Learning published in 1992 with the sponsorship of the Music Educators National Conference MENC was hailed as a welcome addition to the literature on music education because it serves to provide definition and unity to a broad and complex field Choice This new companion volume again with the sponsorship of MENC explores the significant changes in music and arts education that have taken place in the last decade Notably several chapters now incorporate insights from other fields to shed light on multi cultural music education gender issues in music education and non musical outcomes of music education Other chapters offer practical information on maintaining musicians health training music teachers and evaluating music education programs Philosophical issues such as musical cognition the philosophy of research theory curriculum and educating

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**PSYCHOLOGICAL FOUNDATIONS OF MUSICAL BEHAVIOR** Rudolf E. Radocy,J. David Boyle,2012-09-01 The fifth edition of Psychological Foundations of Musical Behavior appears at a time of continuing worldwide anxiety and turmoil We have learned a lot about human musical behavior and we have some understanding of how music can meet diverse human needs In this exceptional new edition the authors have elected to continue a one volume coverage of a broad array of topics guided by three criteria The text is comprehensive in its coverage of diverse areas comprising music psychology it is comprehensible to the reader and it is contemporary in its inclusion of information gathered in recent years Chapter organization recognizes the traditional and more contemporary domains with special emphases on psychoacoustics musical preference learning and the psychological foundations of rhythm melody and harmony Following the introductory preview chapter the text examines diverse views of why people have music and considers music s functions for individuals its social values and its importance as a cultural phenomenon Functional music and music as a therapeutic tool is discussed including descriptions and relationships involving psychoacoustical phenomena giving considerable attention to perception judgment measurement and physical and psychophysical events Rhythmic behaviors and what is involved in producing and responding to rhythms are

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