Memory and Music

Issues and Music and Sciences

Dr. David John Baker
HU Berlin, Winter 2020

Outline

I. Memory forms the foundation of a large portion of our musical experiences
II. Study of memory can be grouped based on duration of time
III. Memory is theorized to form the basis of our meaning, emotion, and expectations in music
IV. Studying memory and expectation draw heavily on the brain-as-computer metaphor

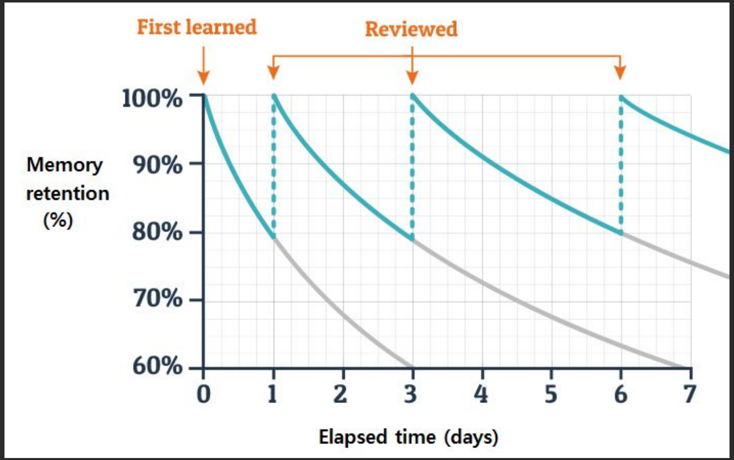
Discussion Question

What is one thing from today’s readings that you found interesting, boring, exciting, or new?

Memory

History of Memory

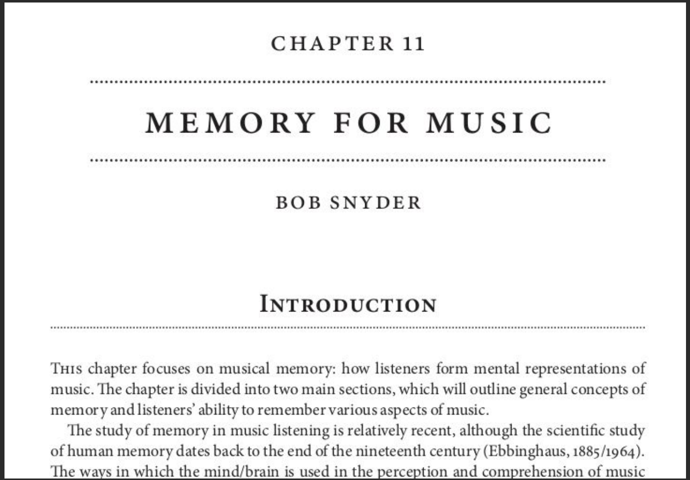
- Memory refers to how information is stored (in brain, in body)
- Memory is one of the oldest topics of study in field of psychology
- Ebbinghaus, 1885's forgetting curves (pictured right)
- Musical memory more recent in comparison
- One of the larger sub-domains of music psychology and neuroscience



https://www.researchgate.net/publication/324816198_The_effect_of_flipped_learning_on_academic_performance_as_an_innovative_method_for_overcoming_ebbinghaus%27_forgetting_curve/figures?lo=1&utm_source=google&utm_medium=organic

Memory as f(time): definitions abound

- Long Term Memory
  - Autobiographical
  - Schematic, Veridical
- Short Term Memory
  - Echoic Memory
  - Short Term Memory
  - Working Memory



CHAPTER 11

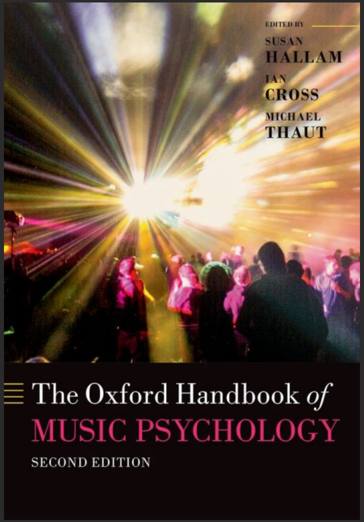
MEMORY FOR MUSIC

BOB SNYDER

INTRODUCTION

THIS chapter focuses on musical memory: how listeners form mental representations of music. The chapter is divided into two main sections, which will outline general concepts of memory and listeners' ability to remember various aspects of music.

The study of memory in music listening is relatively recent, although the scientific study of human memory dates back to the end of the nineteenth century (Ebbinghaus, 1885/1964). The ways in which the mind/brain is used in the perception and comprehension of music



Long Term Memory

- Long Term Memory → LTM
- Episodic Memory
  - Autobiographical Memory
  - Dynamic, changes with every attempt to access it
  - “Darling they are playing our song!!”
- Semantic Memory
  - Conceptual Knowledge
  - Categorical, fact based knowledge
- Very robust to forgetting, even against degenerative diseases

Episodic Memory

Music evokes vivid autobiographical memories

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Music is strongly intertwined with memories—for example, hearing a song from the past can transport you back in time, triggering the sights, sounds, and feelings of a specific event. This association between music and vivid autobiographical memory is intuitively apparent, but the idea that music is intimately tied with memories, seemingly more so than other potent memory cues (e.g., familiar faces), has not been empirically tested. Here, we compared memories evoked by music to those evoked by famous faces, predicting that music-evoked autobiographical memories (MEAMs) would be more vivid. Participants listened to 30 songs, viewed 30 faces, and reported on memories that were evoked. Memories were transcribed and coded for vividness as in Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. [2002. Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging*, *17*, 677–689]. In support of our hypothesis, MEAMs were more vivid than autobiographical memories evoked by faces. MEAMs contained a greater proportion of internal details and a greater number of perceptual details, while face-evoked memories contained a greater number of external details. Additionally, we identified sex differences in memory vividness: for both stimulus categories, women retrieved more vivid memories than men. The results show that music not only effectively evokes autobiographical memories, but that these memories are more vivid than those evoked by famous faces.

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Autobiographical Significance of Meaningful Musical Experiences: Reflections on Youth and Identity

Landon S. L. Peck, Patrick Grealey

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Altmetric 17

Abstract

Meaningful musical experiences during youth can leave a lasting impression on an individual by shaping their identity and place in the world. This study examines such experiences in relation to autobiography and self-identity. An online questionnaire ($N = 50$) was distributed to establish how individuals understood musical experiences from their youth as important to their past and present self-identities. Following the online study, 10 questionnaire participants were selected to be interviewed to further examine the meanings created within their nominated experiences, and how these meanings had been autobiographically contextualised against the backdrop of the memory of these experiences. Questionnaire data was analysed using Thematic Analysis to establish shared autobiographical- and identity-related concepts. Interpretative Phenomenological Analysis served as the methodological framework for analysing the participant interviews to support a more individualised interpretation of each participant's experience. Data from the online

Semantic Memory

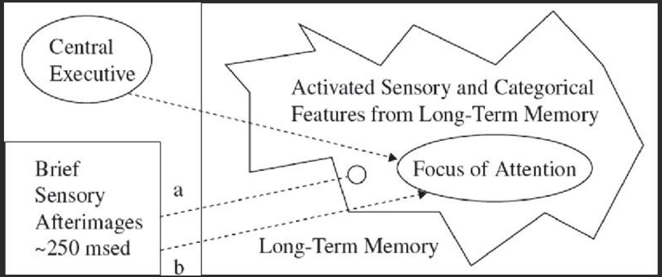
- Refers to the “facts”, not related to your individual experience
  - How many strings does a cello have?
  - What is the time signature of The Trout quartet?
  - What is the melody for the national anthem?
  - More abstract, what kind of musical event would you think happen next?
  - Basis for expectation

Short Term Memory

- Varied time scale of 4 -- 30 seconds
- Defined by having a capacity limit
  - How much information can you remember before you start to forget
  - Different than LTM which is not constrained
  - Increased with practice
  - Associative
- Increase store of STM with chunking (Miller, 1956)
  - Related items grouped together
  - 123456 vs B!E2XDX
- Will change depending on theoretical framework

Working Memory

- One of most studied topics in cognitive psychology
- Memory that requires BOTH the storage and active manipulation of information
- Competing models/Theories
  - Atkinson-Shiffrin (original)
  - Cowan Embedded Process Model
  - Baddeley and Hitch Multicomponent Model



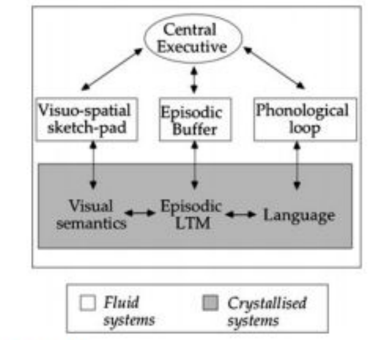
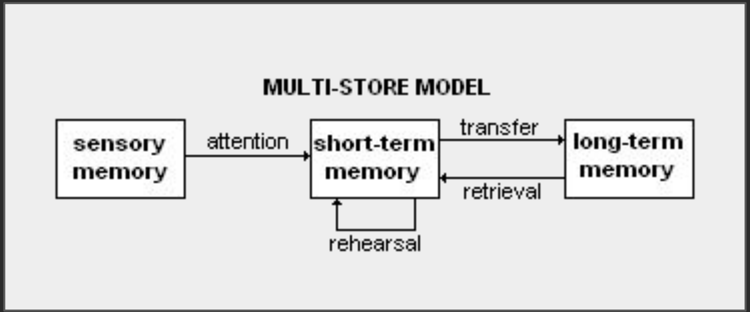


Figure 3

The model following the introduction of a fourth component, the episodic buffer, a system for integrating information from a range of sources into a multidimensional code (Baddeley 2000).



A

$$1 + (2 + 1) = 0$$

TRUE OR FALSE

Q

$$3 * (1 + 1) = 6$$

TRUE OR FALSE

J

$$1 + 2 = 4$$

TRUE OR FALSE

A	E	B
T	F	R
J	Z	C

Select In Order Remembered!

Working because…

→ Had to retain (letters)

→ Actively manipulate (math problems)

→ Theoretical framework linked to how it's measured!!!

Check for understanding

Creating a test that incorporates aspects of your theoretical framework attempts to ensure your test is _______ in measuring your construct of interest.

A) Validly
B) Reliability
C) Consistently
D) Accurately

Echoic Memory

→ example... ready?

Try to remember as much of the next slide as possible!!

A	X	R	Q
D	E	Z	F
S	L	P	B

Echoic Memory

- Formed as brief sensory image
- Engages with unconscious storage
  - Sensation of realizing someone called your name a few seconds ago, then registers in conscious memory
- Recorded within millisecond range
- Relationship between echoic memory and short term memory not always very clear (Synder, 2014)

A	X	R	Q
D	E	Z	F
S	L	P	B

Statistical Learning

Why does memory matter?

- Not all information is always readily available
- Often can hum a tune, but not remember name
- Both conscious and subconscious activity
- Brain is always tracking incoming information
- Memory is theorized to be basis for musical memory
- Evidence from linguistics, also music

Statistical Learning

- Brain is always tracking patterns in auditory scene
- Auditory scene → fancy way of saying what you are hearing now
- Statistical learning theory proposes your brain unconsciously tracks patterns of ALL sounds

→ How is it then that you are able to break up the constant sound that is me reading this sentence into small little chunks known as words?

→ Why is it that listening to a language you don't speak, it sounds like you can't tell where one word starts and another ends?

Hungry Hippo

Example: HUN * GRY * HIP * PO

HUNGRY HIPPO

HUN → GRY

→ ER

→ TER

→DRED

→ GOVER

GRY → ?HIP?

HIP → PO

HIP → STER

HIP → PIE

LOW transitional probability between GRY and HIP

HIGH transitional probabilty between HIP and PO

Transitional Probabilities

- Get large collection of natural language to represent what we hear
- Large collection of text referred to as a corpus (corpora for plural)
- Can break down every sentence into smaller syllables
- Calculate how frequently certain words or syllables follow each other
- Same technology (ish) used in auto-complete features on phone and text!

With Tones

4.1.2. *Materials*

Tone sequences were constructed out of eleven pure tones of the same octave (starting at middle C within a chromatic set) and the same length (0.33 s), using the sine wave generator in SoundEdit 16. The tones were combined into groups of three to form six tone words (Language One: ADB, DFE, GG#A, FCF#, D#ED, CC#D). While some tones appeared in only one word, others occurred in multiple words. For example, D occurred in four different words, while G# occurred in only one word. The statistical structure of these words exactly mirrors that of the words used by Saffran et al. (1996a). The tone words were not constructed in accordance with the rules of standard musical composition, and did not resemble any paradigmatic melodic fragments (e.g., major and minor triads, or familiar three-tone sequences like the NBC television network's chimes).

The six tone words were concatenated together in random order, with no silent junctures between words, to create six different blocks containing 18 words each. A particular tone word was never produced twice in a row. The six blocks were in turn concatenated together to produce a seven minute continuous stream of tones. The tone sequence was tape-recorded directly from the sound output jack of a Quadra 650 computer. As in the linguistic materials used by Saffran et al. (1996b), there were no acoustic markers of word boundaries. An orthographic representation of the tone stream is analogous to the following: DFEFCF#CC#DD#EDGG#A. The only

consistent cue to the beginnings and ends of the tone words were the transitional probabilities between tones. Transitional probabilities between tones within words averaged 0.64 (range 0.25–1.00). In contrast, transitional probabilities between tones spanning word boundaries averaged 0.14 (range 0.05–0.60).[2]

The second tone language was constructed in precisely the same manner as the first. The same eleven tones were used, but combined differently to form six new words (Language Two: AC#E, F#G#E, GCD#, C#BA, C#FD, G#BA). The statistical structure of Language Two was very similar to Language One. Transitional probabilities between the tones within words averaged 0.71 (range 0.33–1.00), with lower average probabilities across word boundaries (mean = 0.18; range 0.07–0.53).[3]

ELSEVIER

Cognition 70 (1999) 27–52

COGNITION

Statistical learning of tone sequences by human infants and adults

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Abstract

Previous research suggests that language learners can detect and use the statistical properties of syllable sequences to discover words in continuous speech (e.g. Aslin, R.N., Saffran, J.R., Newport, E.L., 1998. Computation of conditional probability statistics by 8-month-old infants. Psychological Science 9, 321–324; Saffran, J.R., Aslin, R.N., Newport, E.L., 1996. Statistical learning by 8-month-old infants. Science 274, 1926–1928; Saffran, J., R., Newport, E.L., Aslin, R.N., (1996). Word segmentation: the role of distributional cues. Journal of Memory and Language 35, 606–621; Saffran, J.R., Newport, E.L., Aslin, R.N., Tunick, R.A.,

Table 4.1

Transitional probabilities for pitch successions arising from the melodic figures shown in figure 4.2.

Antecedent state	Consequent state										
	c	c#	d	d#	e	f	f#	g	g#	a	b
c	0	0.056	0	0	0	0.056	0.056	0	0	0	0
c#	0	0	0.056	0	0	0	0	0	0	0	0
d	0.011	0	0.022	0.011	0	0.078	0	0.022	0	0.022	0.056
d#	0	0	0	0	0.056	0	0	0	0	0	0
e	0.011	0	0.011	0.011	0	0.011	0	0.011	0	0.011	0
f	0.056	0	0	0	0.056	0	0	0	0	0	0
f#	0.011	0	0.011	0.011	0	0	0	0.011	0	0.011	0
g	0	0	0	0	0	0	0	0	0.056	0	0
g#	0	0	0	0	0	0	0	0	0	0.056	0
a	0.011	0	0.067	0.011	0	0.011	0	0	0	0.011	0
b	0.011	0	0.011	0.011	0	0.011	0	0.011	0	0	0

Figure 4.2

Sample of six melodic figures used by Saffran et al. (1999). See also figure 4.3.

Figure 4.3

Excerpt of a sample tone sequence used in the exposure phase of Saffran et al. (1999). Sequences lasted for seven minutes and were constructed by randomly stringing together the three-note figures shown in figure 4.2. Tone sequences were constrained so that no single figure was repeated twice in succession.

Figure 4.4

Sample test stimuli used by Saffran et al. (1999). Listeners heard two three-note sequences and were asked to identify which sequence was more familiar.

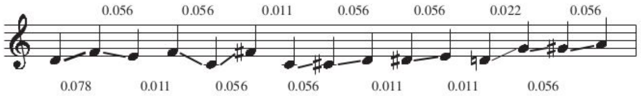

Figure 4.5

Sample exposure stimuli showing the long-term statistical probabilities of pitch-to-pitch transitions. Thick lines indicate high probability. Thin lines indicate medium probability. Absence of line indicates low probability.

With Weird Tones

Acquiring new musical grammars – A statistical learning approach

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ABSTRACT

In the present study we examine the ability of humans to acquire knowledge of new music. We designed two artificial musical grammars based on a microtonal harmonic system, and created melodies as legal exemplars of each grammar. In three experiments each participant was exposed to melodies from one grammar. Tests were conducted to assess learning, including forced-choice recognition and generalization, pre- and post-exposure probe tone ratings, and subjective preference ratings. In Experiment 1, five melodies were presented for 25 minutes. Participants correctly recognized and preferred melodies they had heard, but failed to generalize their knowledge to new exemplars of the same grammar. In Experiment 2, 15 melodies were presented for 25 minutes. Participants showed some tendency to recognize new melodies in their given grammar, and also showed an increased sensitivity to the statistics of the musical grammar following exposure. In Experiment 3, after exposing participants to 400 melodies for 30 minutes, forced-choice tests showed significant recognition as well as generalization, as well as sensitivity to the relative frequencies of tones in the new musical system. Results suggest that larger sets of exemplar melodies promote the extraction of harmonic regularities underlying the melodies, whereas smaller sets lead to better recognition and are more likely to influence subjective preference.

Keywords

music cognition, statistical learning, artificial grammar, melody, harmony, preference

INTRODUCTION

Music we encounter every day is composed of sequentially and simultaneously presented pitches. While sequential pitches give rise to melody, simultaneous pitches give rise to harmony. Together, melody and harmony are viewed as the horizontal and vertical organizational dimensions in music.

Various studies in the field of music perception and cognition have shown that humans have reliable but implicit knowledge of both melody and harmony. Melodies that end with unexpected or incorrect notes elicit electrophysiological responses (Besson & Faïta, 1995) as well as decreased goodness-of-fit ratings (Krumhansl, 1990). In the vertical dimension, when perceiving chord progressions that violate the principles of traditional Western harmony, e.g. when a chord progression resolves to a chord other than the tonic, the listener's musical expectation is violated, and such an expectation violation can be observed empirically using reaction time (Bharucha & Stoeckig, 1986) as well as electrophysiological (Koelsch et al, 2000) methodologies. These results have led researchers to ask about the source of knowledge in harmony. Some aspects of harmonic knowledge may result from the neurobiological properties of the auditory system (e.g. Tramo et al, 2001). It is also possible that certain features of harmony might be learned via exposure within one's culture. In particular, the perception of stability, as well as tension and resolution in response to chord progressions, might be partially learned via exposure to the relative frequencies and probabilities of sounds in the environment.

The Psychological Representation of Musical Intervals in a Twelve-Tone Context

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PREVIOUS STUDIES OF TWELVE-TONE MUSIC suggest that participants can learn a twelve-tone row and identify it in a forced-choice test (Bigand, D'Adamo, & Poulin, 2003; Krumhansl, Sandell, & Sergeant, 1987). However, these findings invite speculation about the extent to which participants were attuning to intervals to complete the task. The present study builds upon these previous experiments by specifically investigating whether participants implicitly attune to repetitive

Väisälä, 1999, 2002; Wintle, 1982), 5) that serial music by composers such as Stravinsky is somewhat like neo-classical music in its avoidance of elements that clarify the structure (Straus, 2001), and finally 6) that the music is based on incomplete symmetries (Perle, 1991). However, not all of these analytical approaches would claim to model the listener's experience.

Only in more recent times has the perception of non-tonal music been investigated experimentally. This research has tested the listener's ability to perceive the similarity of atonal chords (Bruner, 1984; Kuusi, 2003; Millar, 1984; Samplaski, 2000, 2004), to identify and

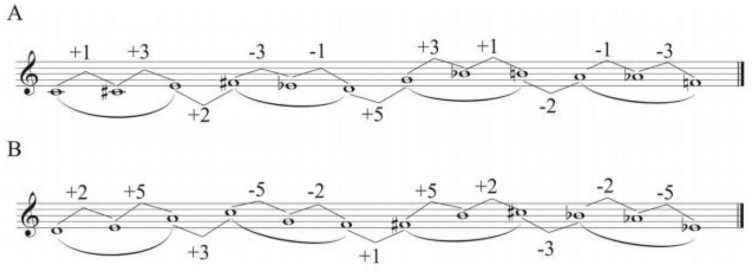

FIGURE 1. (A) The row used as source material for Familiarization Phase 1 (heard in Experiment 1), showing the pitch intervals between adjacent notes. (B) The row used as source material for Familiarization Phase 2 (heard in Experiment 2).

Brain as Computer

Calculating Probability

- Statistical Learning assumes that we have a working store of all the patterns that we have ever heard
- Follows that there are ways to empirically test this

→ Discussion Question: How could we find a way to get a rough approximation of transitional probabilities in music like the language example?

Counting Notes

- Memory assumed to from basis of expectation
- Need a way to also represent music and melodies like words!
- Collect giant collection of melodies
- Use computers to count patterns the same way!
- Result in computational model of auditory cognition!

Pearce 2018 and IDyOM

C (bars 23–24)

Position	1	2	3	4	5	6	7	8
Pitch	G_5	F_5	A_4	B_4	C_5	E_5	D_5	C_5
Probability	0.509	0.234	0.003	0.053	0.691	0.234	0.314	0.360
IC	0.98	2.10	8.34	4.25	0.53	2.09	1.67	1.47

Brain as Computer?

Discussion Question: If you can train a computer to perform like a human would in musical tasks, does it help to think about the brain as a computer?

Terms to Review

Statistical Learning

Transitional Probability

Long Term Memory

Short Term Memory

Echoic Memory

Working Memory

Autobiographical Memory

Check for Understanding