The Cognitive Bases of Music Performance

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Overview

- Memory and planning
- Timing in performance
- Feedback in performance
- Musical deficits: The case of “bad” singing
Memory and Planning

- Errors and “what’s on your mind?”
  - Freud’s best contribution!
  - Lashley (1951): Errors suggest hierarchical, not serial, organization

Chaining vs. Hierarchy

Memory and planning

- Serial ordering errors
  - Target vs. intruder

- Target/intruder relationships
  - Distance
  - Direction
    - Anticipation
    - Perseveration
    - Exchange

Examples

“But barkling water is bad for you” (intended: sparkling)
Vousden et al., 2000

Performed

Interlinked
Memory and Planning

- Errors constrained by structure
  - Remain within a melodic line (Plamer & van De Sande, 1993; Palmer, 1996)
  - Stay within a musical phrase (P&vDs, 1995)

- Directional characteristics of planning
  - Anticipations = thinking ahead
  - More anticipations = fewer errors (e.g., Drake & Palmer, 2000; Dell et al., 1997)
  - Faster tempo = fewer anticipations (Drake & Palmer, 2000; but not Palmer & Pfordresher, 2003)

Planning and structure

Errors move toward boundaries (but do not cross…)

Palmer & van de Sande, 1995
Anticipations are GOOD
(Drake & Palmer, 2000)

In speech
(Dell, Burger, & Svec, 1997)

Memory and Planning
  - Planning and distance
    - Greater distance for adults
    - Greater distance for slower tempi
  - The range model (Palmer & Pfordresher, 2003; Pfordresher et al., 2006). Distance results from
    - Serial proximity: \( S_x = d(x/y) \)
    - Metrical similarity: \( M_x(i) = \text{sim}(m_i, m_{i-j}) = 1 - \frac{|m_i - m_{i-j}|}{m_i + m_{i+j}} = 1 - \frac{\Delta m}{2m} \)
The range model

Event Activation

Level 2
Level 1

Serial = “tapering off” from current
Metrical = “up/down” pattern

Timing

- Maintaining regularity: Two sources of variability (Wing & Kristofferson, 1973):
  - Expressive timing
    - Present even in “deadpan” performances (Palmer, 1989)
    - Associated with structure (Todd, 1985)
    - Association with movement? (Sundberg & Verillo, 1999)
  - Relational invariance? (e.g., Repp, 1998)

Problems:
- Ornaments (Desain & Honig, 1994)
- “Swing ratios”
The Wing & Kristofferson model

"Clock" variability

Palmer, 1989

"Metronomic" performance?

Palmer, 1989
Music and Structure
(Todd, 1985)

Music and Motion
(Friberg & Sundberg, 1999)

\[ v(x) = [1 + (v_{\text{end}} - 1)x]^{1/q}. \]
Relational invariance and generalized motor programs

Rhythm at fast tempo (IOIs):
|----500-----|--250--|--250--|

Rhythm at slower tempo (IOIs):
|-------800---------|----400----|----400----|

Predicting IOIs is easy:
\[ \text{IOI}_i = \beta \cdot x_i \]
where \( \beta = \text{tempo} \) (base IOI)
and \( x_i \) is the ratio for each IOI

\( \beta \cdot [1 \quad .5 \quad .5] \), where \( \beta = 500 \) or 800

Tempo like a “switch” that turns up or down the IOIs

Perceptual feedback

- Focus mostly on auditory
  - Altered auditory feedback
- What is necessary?
  - Presence of feedback?
    - Facilitates memory, but not necessary
    - Absence doesn’t disrupt piano (Repp, 1999)
      - Though more important for singing
  - Timing of feedback? IMPORTANT
    - Disruption varies with delay amount
    - Probably function of rhythm
**Normal Feedback**

**Actions**
(key press)

**Feedback**

**Time**

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**Asynchronous Feedback (e.g., DAF)**

**Actions**
(key press)

**Feedback**

**Time**

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**Altered Feedback Contents**

**Actions**
(key press)

**Feedback**

**Time**

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**Feedback and memory**

*Finney & Palmer (2003)*

**Example**

**Stimulus:**

**Results:**
Disruption from feedback absence?

Piano: Repp, 1999
Voice: Mürbe et al., 2003

Delayed auditory feedback

Absolute time: Gates et al. (1974)
Relative time: Pfordresher & Benitez (2007)
Perceptual feedback

- Feedback contents? More complex
  - Random pitch sequences: no disruption (Finney, 1997)
  - Serial shifts do disrupt (Pfordresher, 2005)
    - Even when shift is a "variation" (Pfordresher, in press)
- What is the role of feedback?
  - NOT “feedback”!!!
  - Rather, perception and action share a common “plan” (Pfordresher, 2006)
A framework for auditory feedback (Pfordresher, 2006)

Musical deficits: “Bad” singing

- Nature of the deficit
  - Mistuned notes
    - May be influenced by vocal range
  - Compress pitch intervals
  - NOT: contour errors
  - Sing faster than they should (Dalla Bella et al., 2007)
**Bad singing and mistuning**

(Bad singers)

Vocal range

Pfordresher & Brown (2007)
See also Welch (1979)

**Bad singing and pitch intervals**

Pfordresher & Brown (2007)

Slope = .88

Slope = .69

NOTE: Both are good fits
“Bad” singing

- What causes bad singing? Still a question…
  - Tone deafness (literally)?
    - Congenital Amusia (Peretz et al., 2002)
    - BUT: evidence that bad singers are good listeners (Bradshaw & McHenry, 200; Dalla Bella et al., 2007; Pfordresher & Brown, 2007)
  - Motor control? Not likely either…

- How prevalent is bad singing?
  - Probably ~10% of population
  - Twice as prevalent as true “tone deafness”

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Congenital amusia and singing

*Perception*

*Production*

*Hyde & Peretz, 2004*

*Ayotte, Peretz, & Hyde, 2004*