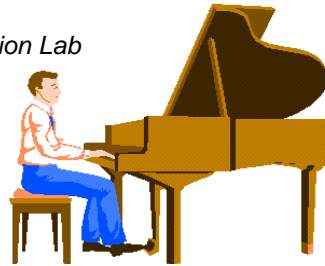# The Cognitive Bases of Music Performance

Peter Q. Pfordresher

Department of Psychology
Auditory Perception and Action Lab

Overview

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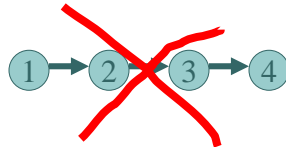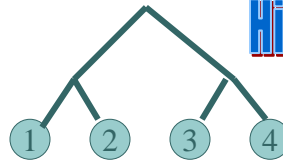- Musical deficits: The case of "bad" singing

Memory and Planning

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

Chaining

1 → 2 3 → 4

Hierarchy

1 2 3 4

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

Intended

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
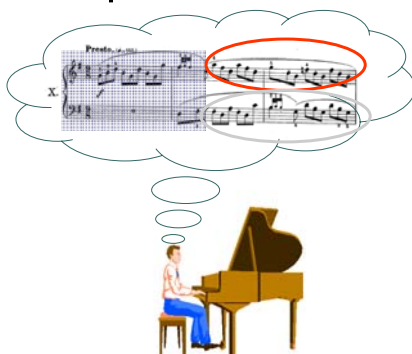
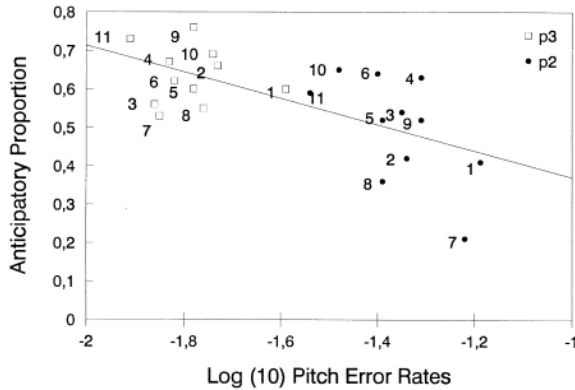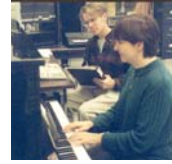

Errors move toward boundaries (but do not cross…)
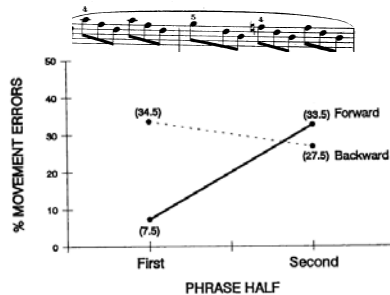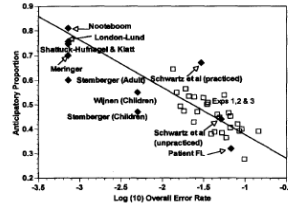
Palmer & van de Sande, 1995

Anticipations are GOOD
(Drake & Palmer, 2000)

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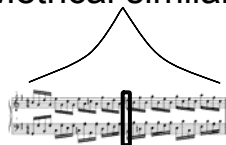*(Dell, Burger, & Svec, 1997)*

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 $\quad S_x = a^{(|x|/n)}.$
  - Metrical similarity $\quad M_x(i) = sim(m_i, m_{i+x}) = 1 - \dfrac{|m_i - m_{i+x}|}{m_i + m_{i+x}} = 1 - \dfrac{\Delta m}{2\bar{m}}.$

(Serial proximity)   (Metrical similarity)

The range model

Event Activation

Level 2   X   X   X   X   X   X
Level 1   X X X   X X X X   X X X X X

Metrical Grid

Current (planned) event

Serial = "tapering off" from current
Metrical = "up/down" pattern

$$Y_{x,i} \; = \; S_x * M_{x,i} = \left[a^{\left(x/t \right)} \right] * \left[1 - \frac{\left| m_i - m_{i+x} \right|}{m_i + m_{i+x}} \right]$$

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:
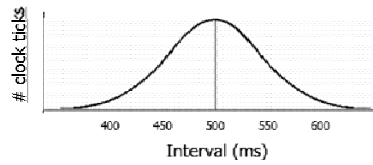 - Ornaments (Desain & Honig, 1994)
  - "Swing ratios"

The Wing & Kristofferson model

KEY C_j Interval between timekeeper trigger pulses
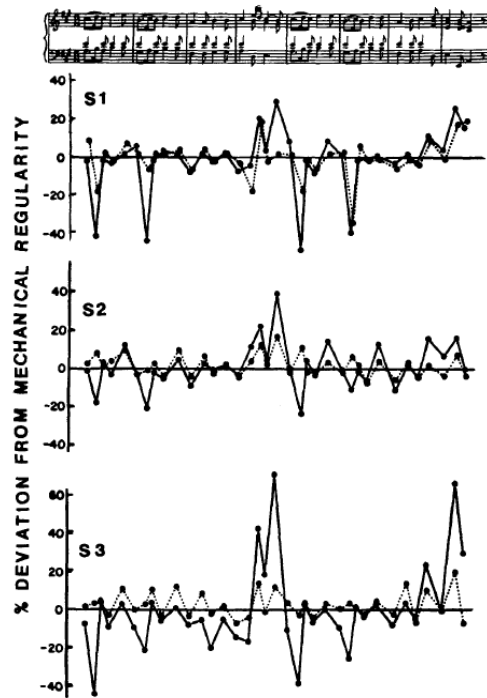D_j Response delay
I_j Interresponse interval
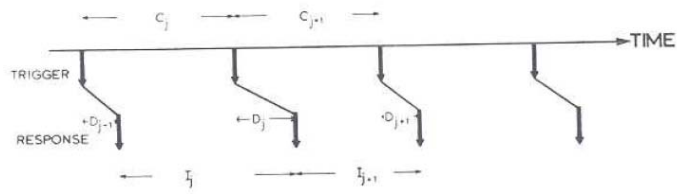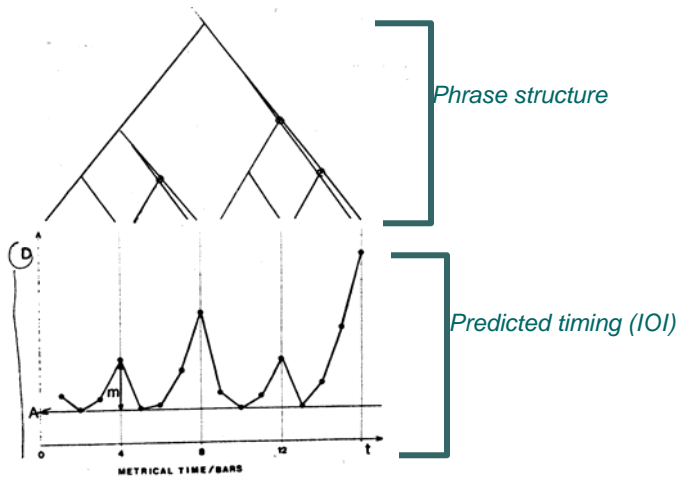
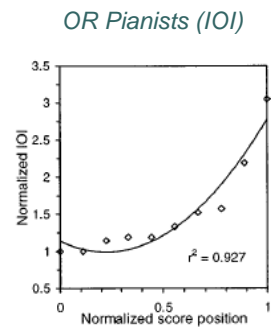"Clock" variability

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"Metronomic" performance?

Palmer, 1989

Music and Structure

(Todd, 1985)

Phrase structure

Predicted timing (IOI)

Music and Motion

(Friberg & Sundberg, 1999)

Runners

Pianists (tempo)

OR Pianists (IOI)
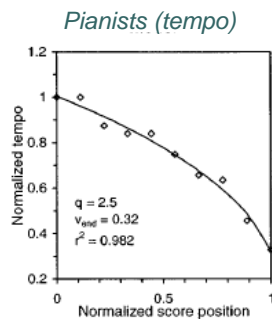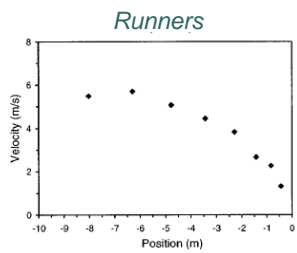
$$v(x) = \left[1 + (v_{\text{end}}^{q} - 1)x \right]^{1/q}.$$

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:
$IOI_i = \beta * x_i$
Where β = tempo (base IOI)
and x_i is the ratio for each IOI

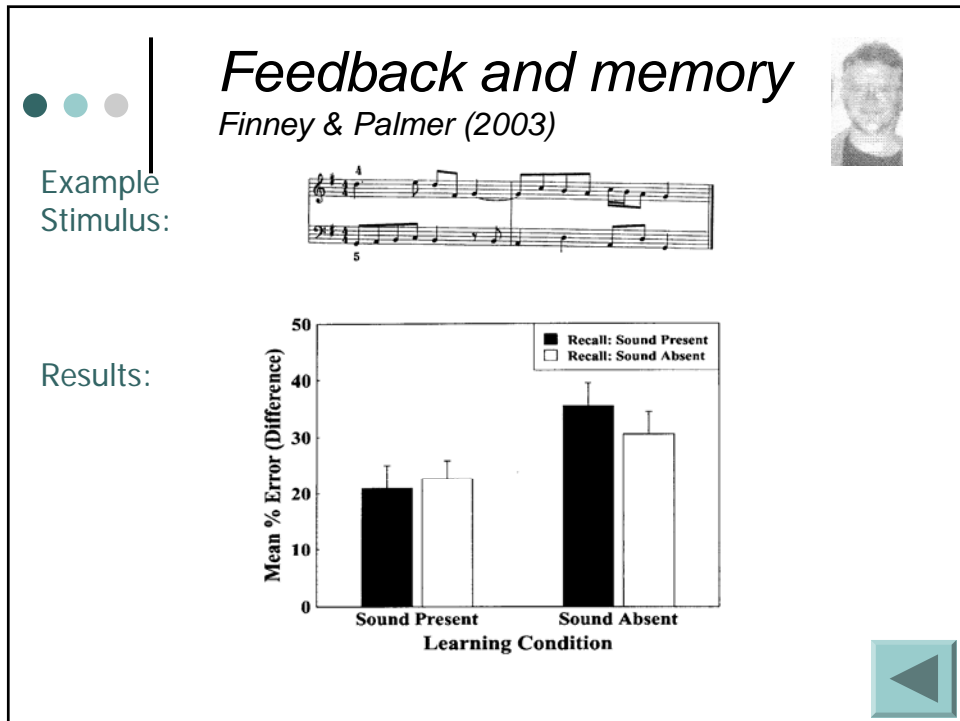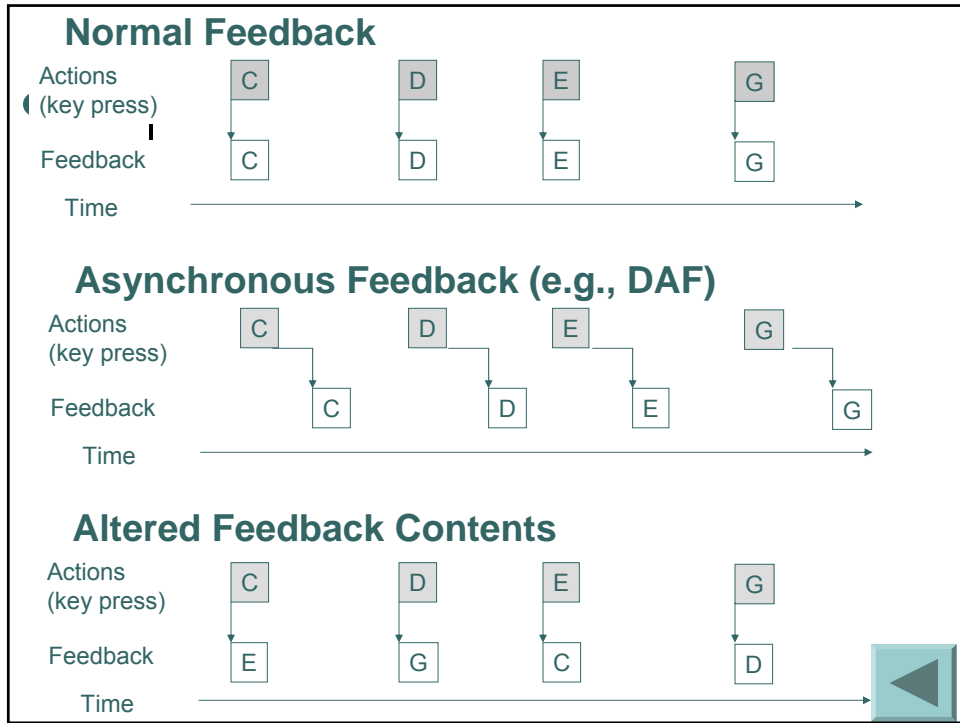$\beta * [1 \quad .5 \quad .5]$, where β = 500 or 800

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
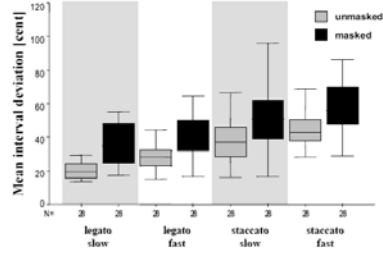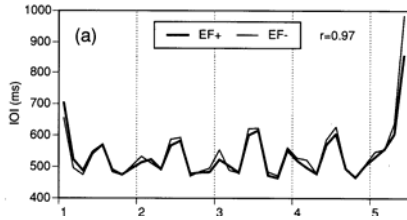   - Probably function of rhythm

Normal Feedback

Actions
(key press)

| C | D | E | G |

Feedback

| C | D | E | G |

Time

Asynchronous Feedback (e.g., DAF)

Actions
(key press)

| C | D | E | G |

Feedback

| C | D | E | G |

Time

Altered Feedback Contents

Actions
(key press)

| C | D | E | G |

Feedback

| E | G | C | D |

Time

Feedback and memory
Finney & Palmer (2003)

Example
Stimulus:

Results:

Legend: Recall: Sound Present (filled), Recall: Sound Absent (open)
Y-axis: Mean % Error (Difference)
X-axis: Learning Condition — Sound Present, Sound Absent

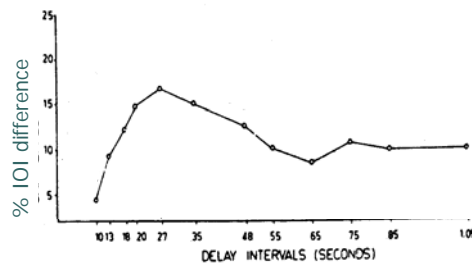# Disruption from feedback absence?

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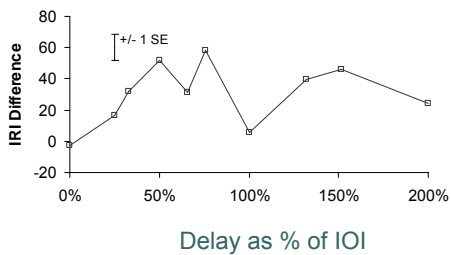
Voice: Mürbe et al., 2003

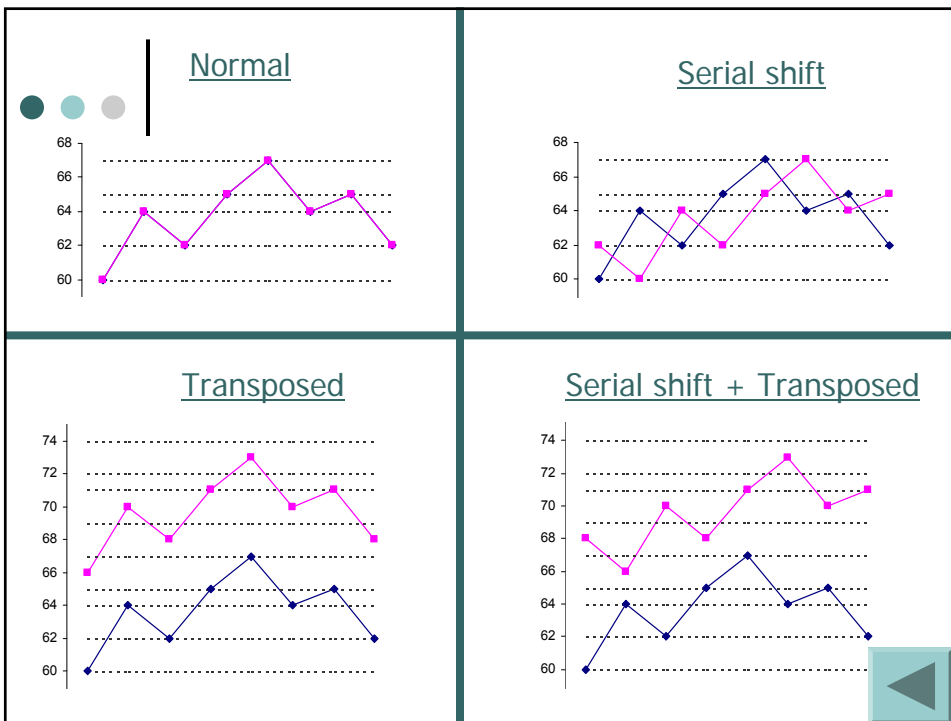# Delayed auditory feedback

Absolute time:
Gates et al. (1974)

Relative time:
Pfordresher & Benitez
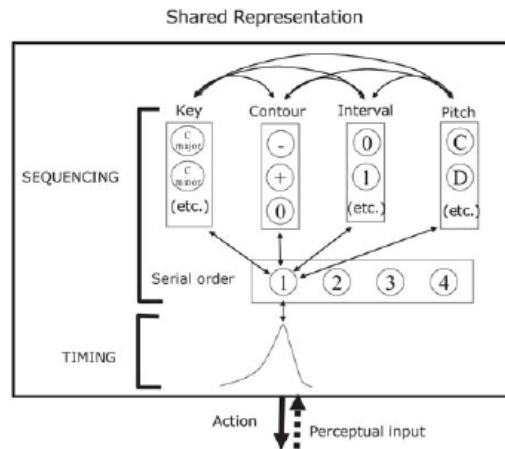*(2007)*

Delay as % of IOI

10

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)

Normal

Serial shift

Transposed

Serial shift + Transposed

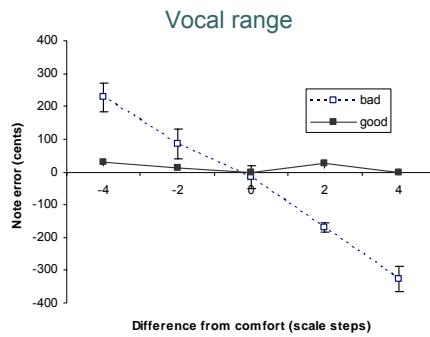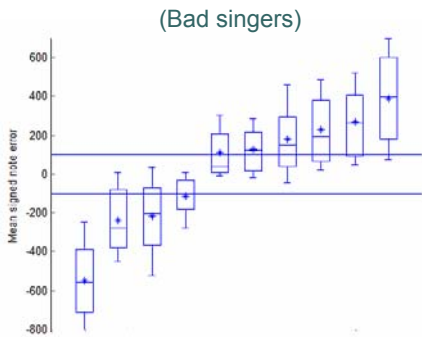# A framework for auditory feedback *(Pfordresher, 2006)*

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)
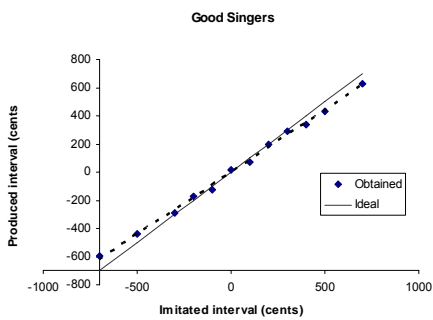
Bad singing and mistuning

(Bad singers)

Vocal range

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

Bad singing and pitch intervals

Pfordresher & Brown (2007)

Good Singers

Bad Singers

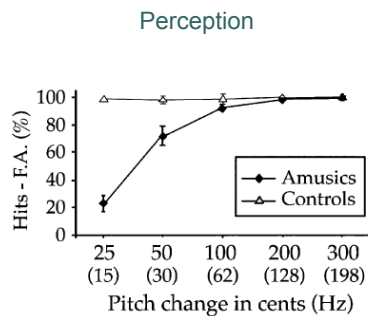Slope = .88
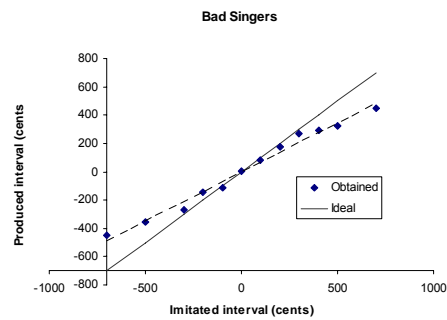
Slope = .69
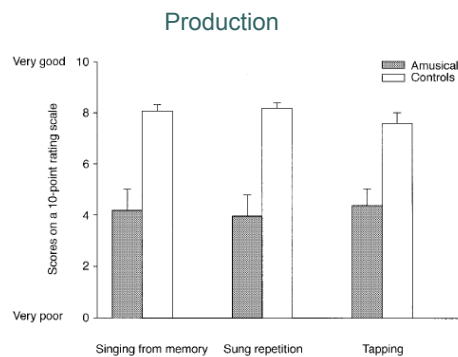
NOTE: Both are good fits

"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"

Congenital amusia and singing

Perception

Production

Hyde & Peretz, 2004

Ayotte, Peretz, & Hyde, 2004