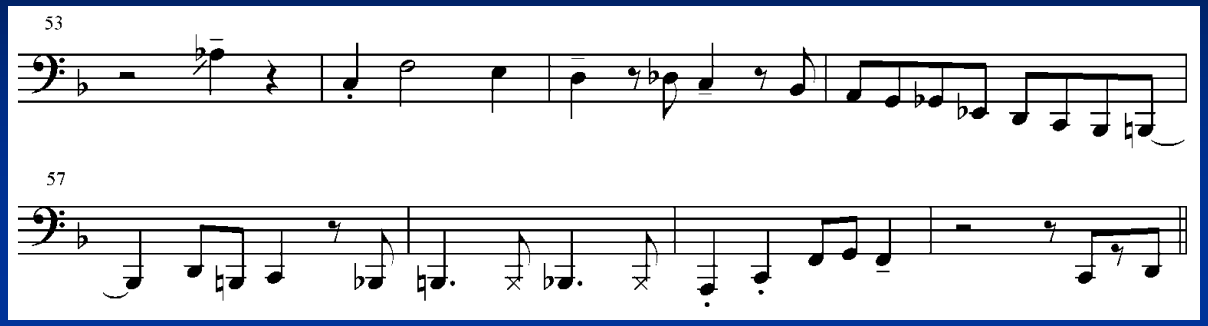
A Method for Identifying Motor Pattern Boundaries in Jazz Piano Improvisations

Martin Norgaard, Ph.D.
Georgia State University

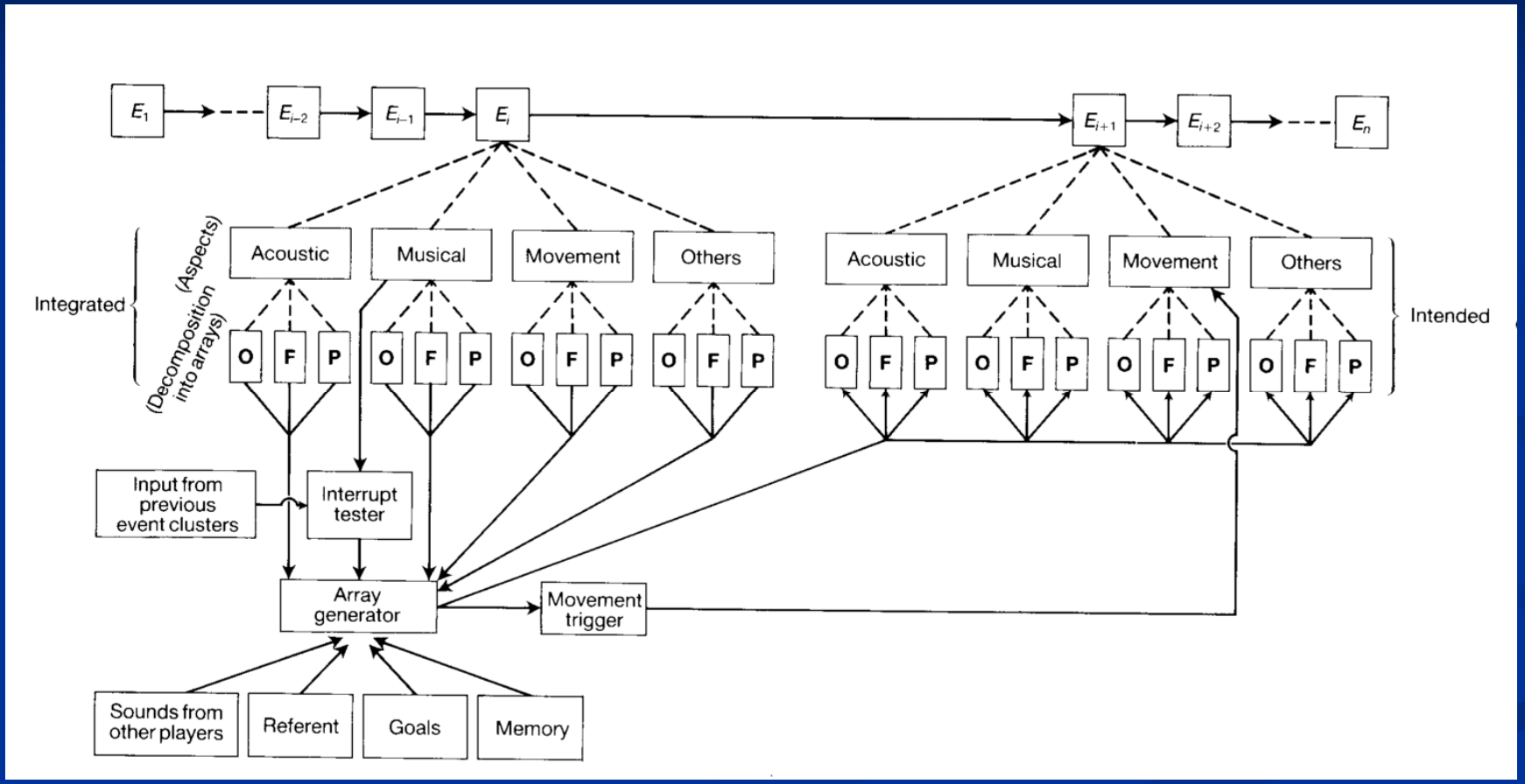
Monitoring: Mistakes



Bassist: “I got there too soon….I had to fix that..”

Norgaard, M. (2011). *Journal of Research in Music Education*

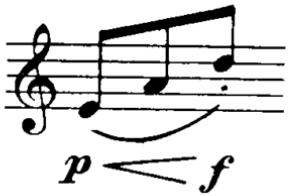
Pressing's Model



"Any improvisation may be partitioned into a sequence of non-overlapping sections" (Pressing, 1988, p. 152-153)

Pressing's Model: Example E_i

(1) Let E_i be



Example 7.2

played by the right hand at the piano.

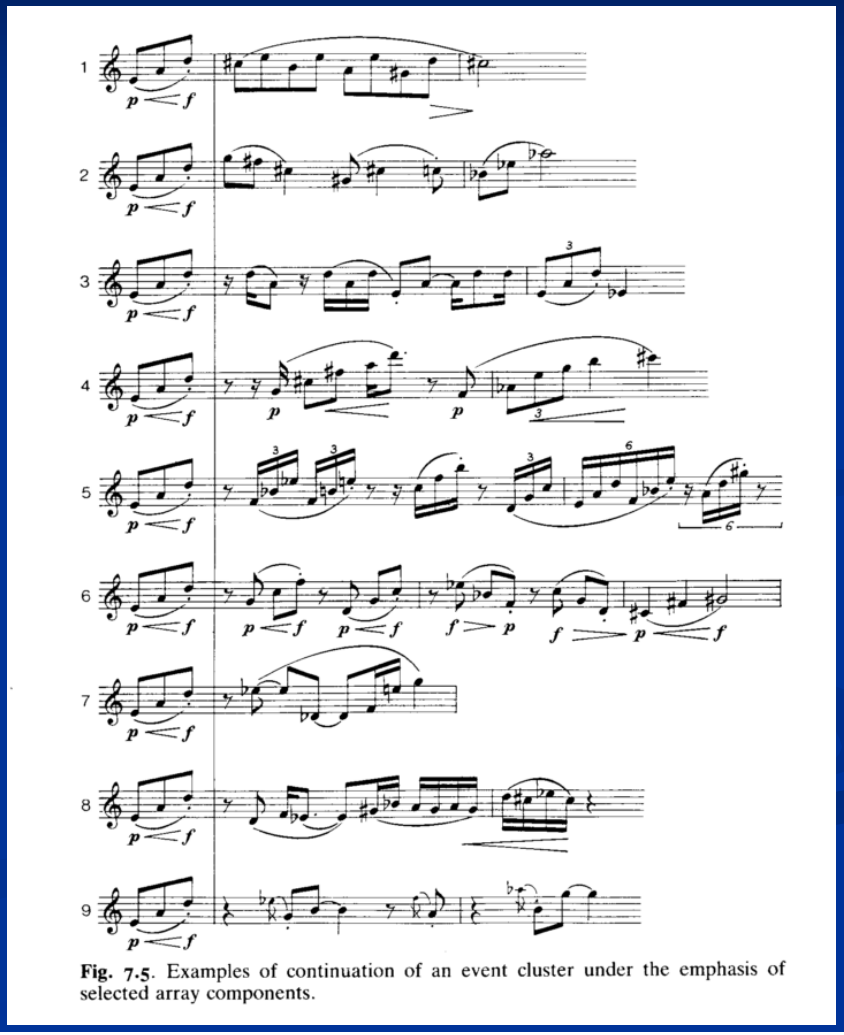


Fig. 7.5. Examples of continuation of an event cluster under the emphasis of selected array components.

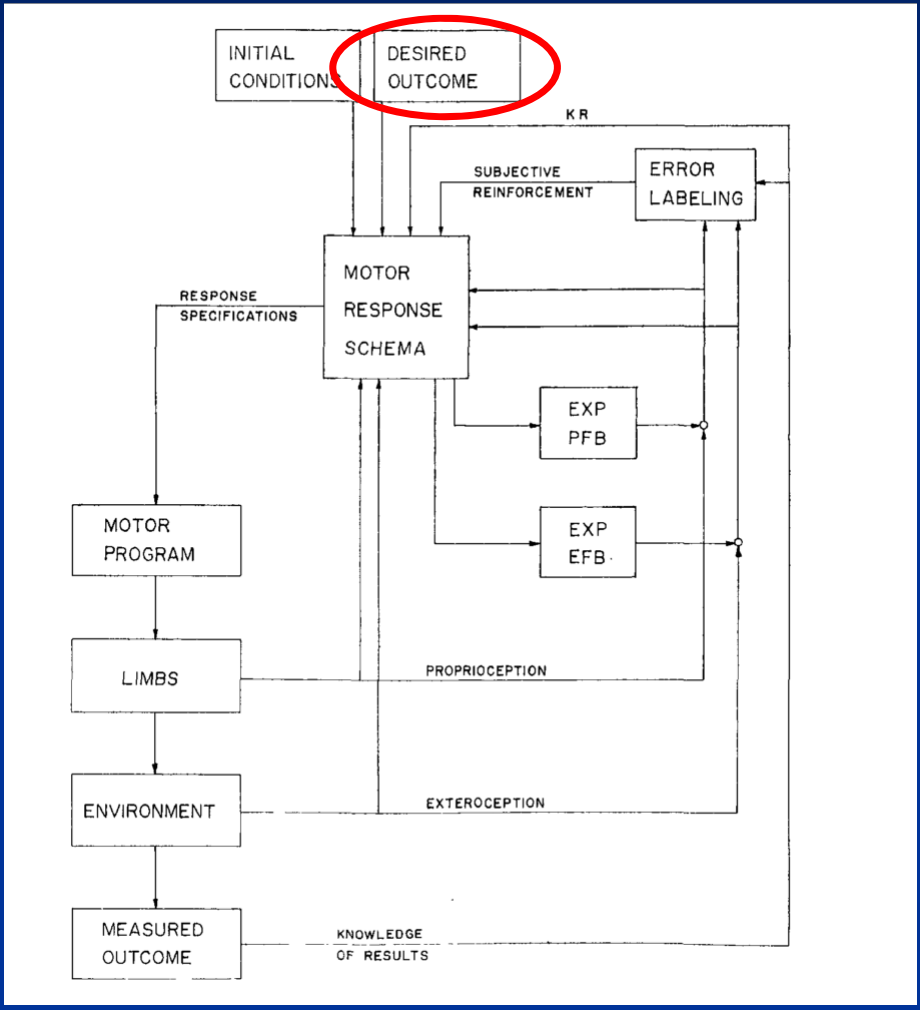
Pressing, J. (1988). Improvisation: Methods and model. In J. A. Sloboda (Ed.), *Generative processes in music* (Paperback, pp. 129–178). Oxford, England: Oxford University Press.

Schmidt's Generalized Motor Patterns (GMPs)

"The strongest human evidence for the motor program notion seems to be that subjects can initiate, carry out, and stop a limb movement within 100 msec, implying that decisions about when to stop the movement must have been made prior to the initiation of the movement."

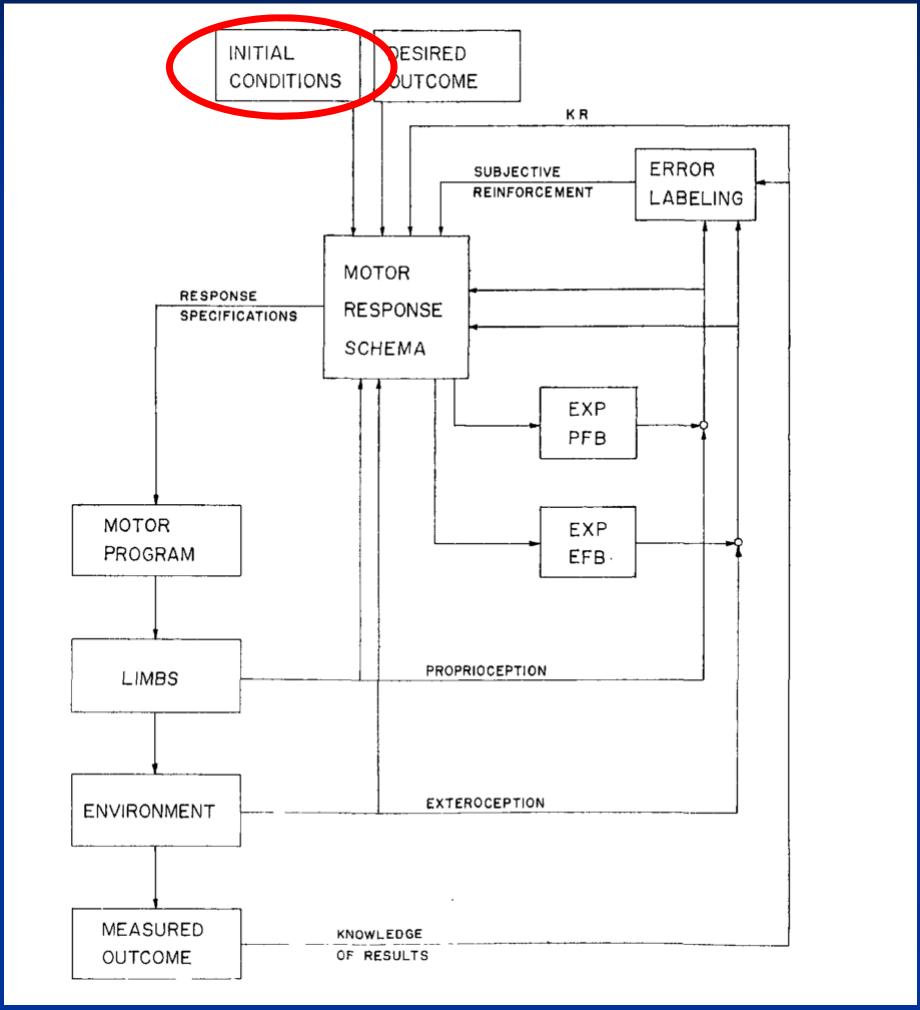
Schmidt, R. A. (1975). A schema theory of discrete motor skill learning. *Psychological Review*, *82*(4), 225–260. (3005 citations, September 22, 2016)

Before Movement Begins:



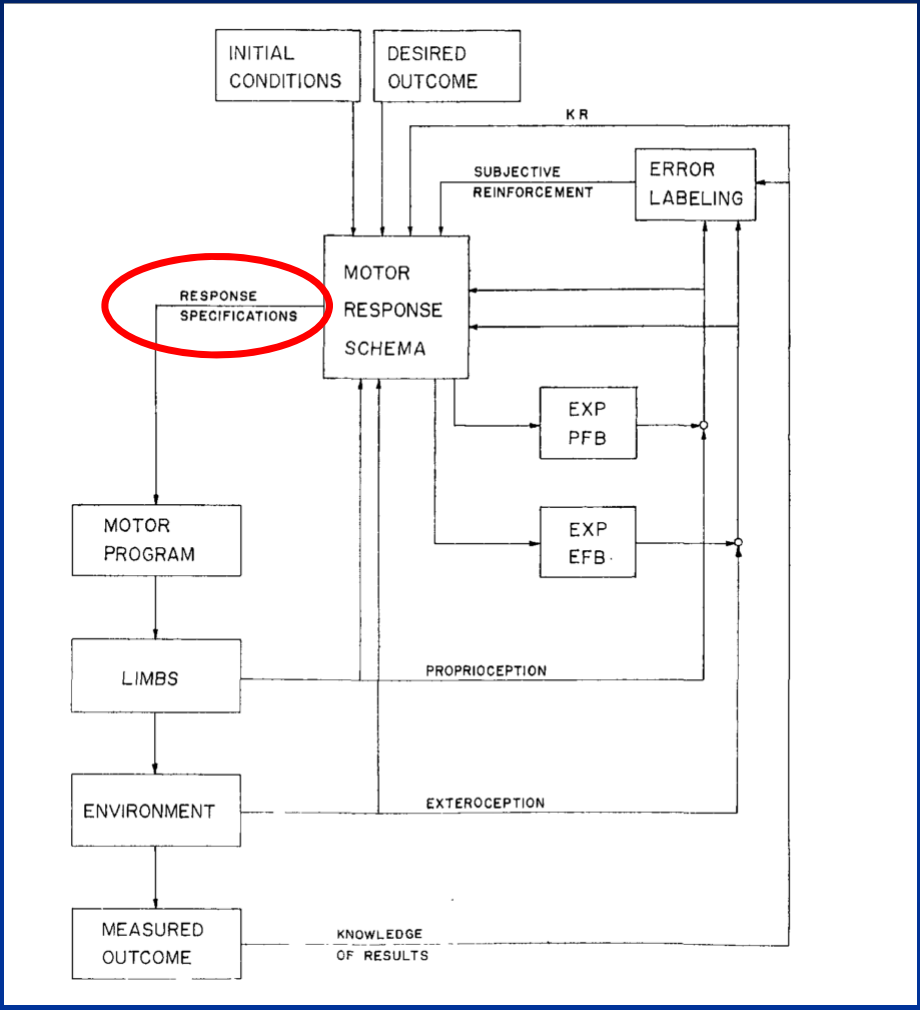
1. Specification of desired outcome.

Before Movement Begins:



1. Specification of desired outcome.
2. determination of the initial conditions.

Before Movement Begins:



1. Specification of desired outcome.
2. determination of the initial conditions.
3. From the relationship established in past responses between outcomes and response specifications (recall schema), new specifications for the motor program are selected.

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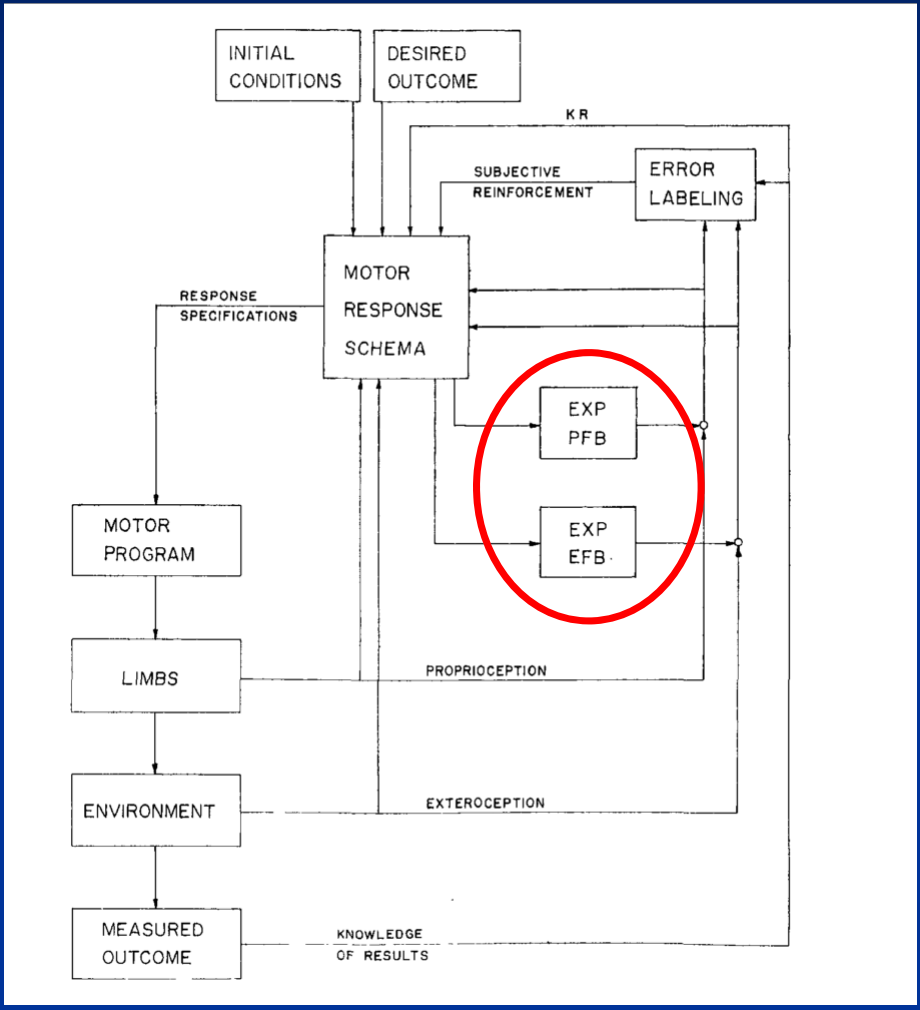
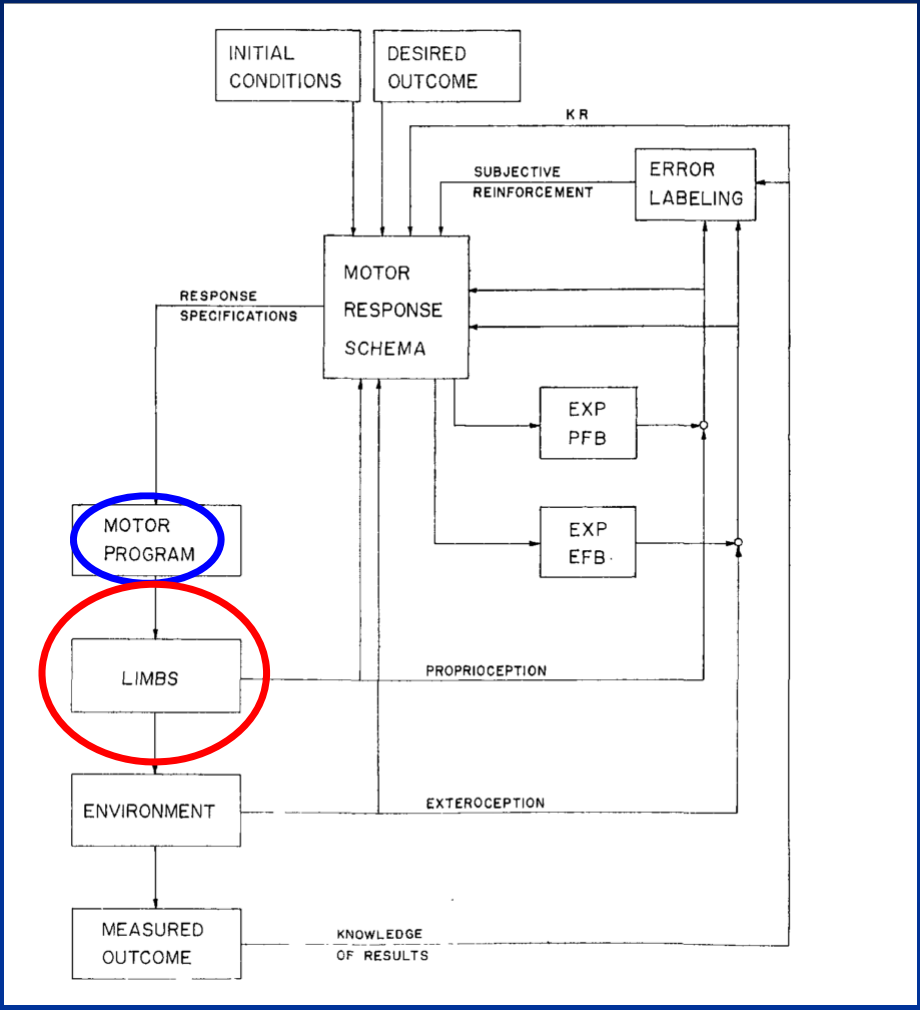


1. Specification of desired outcome.
2. determination of the initial conditions.
3. From the relationship established in past responses between outcomes and response specifications (recall schema), new specifications for the motor program are selected.
4. selection of the expected proprioceptive feedback and exteroceptive feedback (based on recognition schema).

While Movement Takes Place:



1. impulses begin to flow out to the muscular system with all of the details of at least the first 200 msec of the movement specified.

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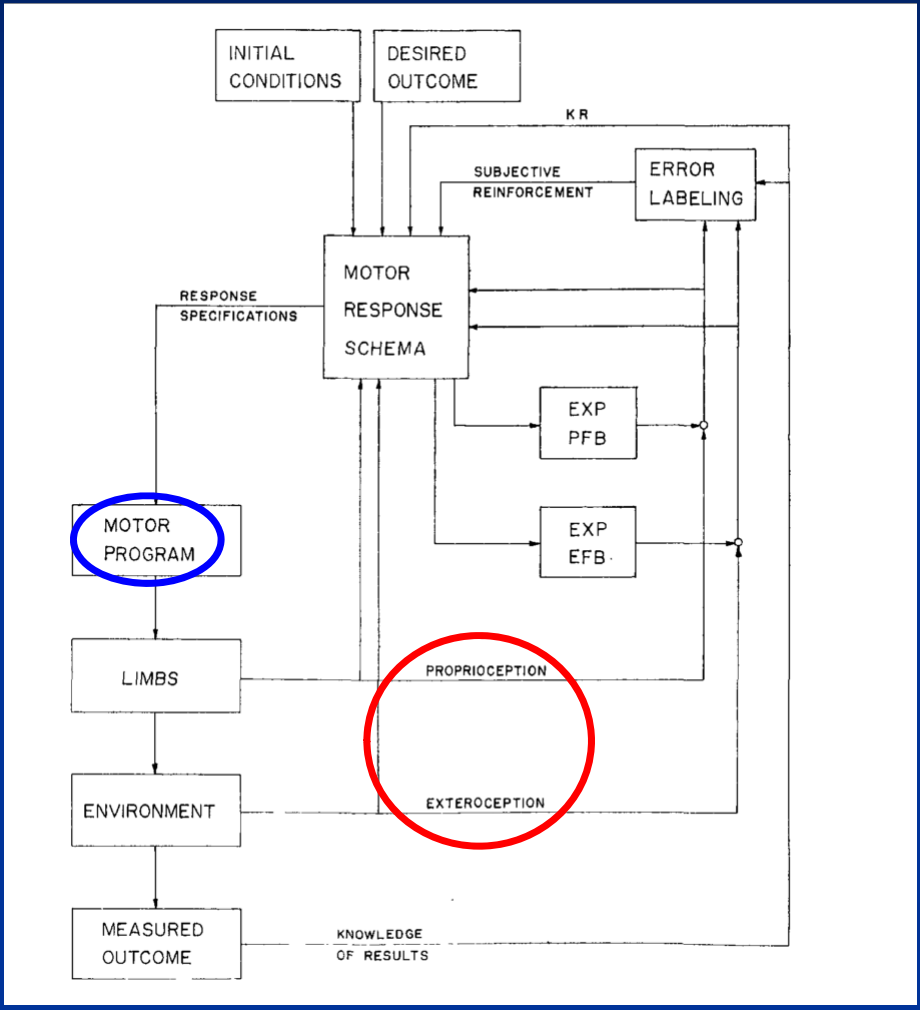

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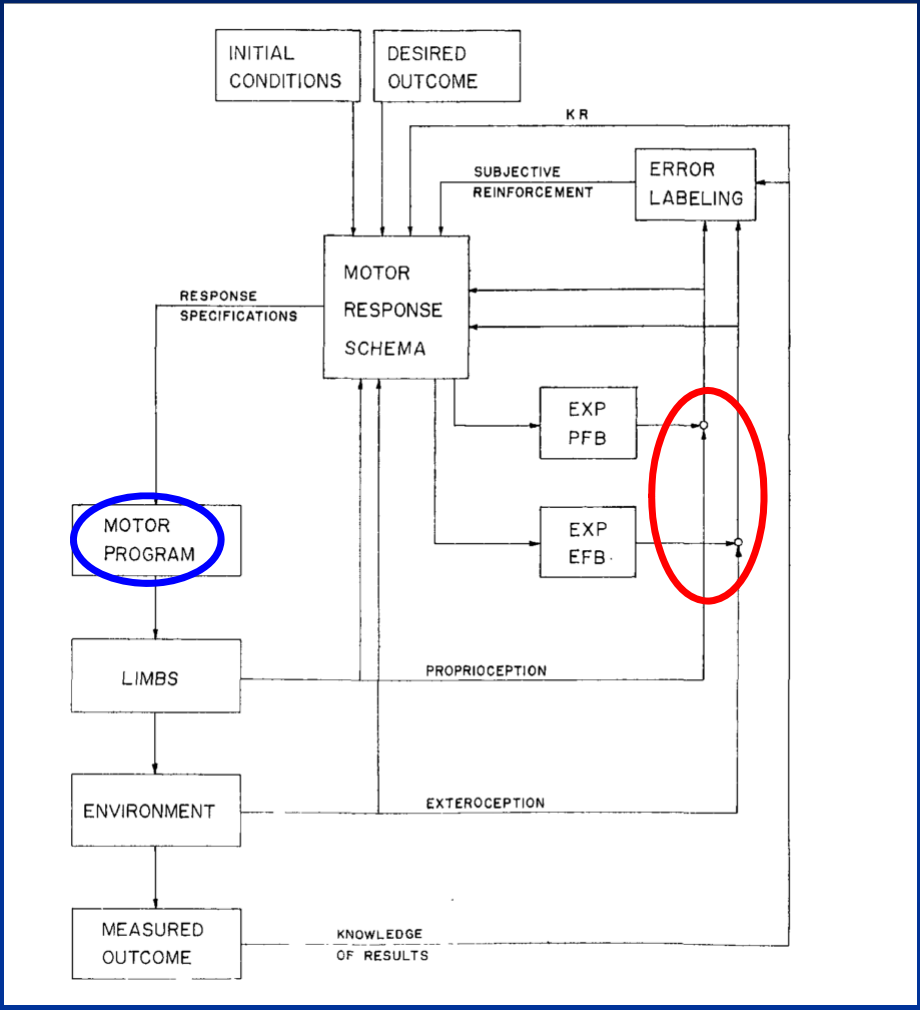

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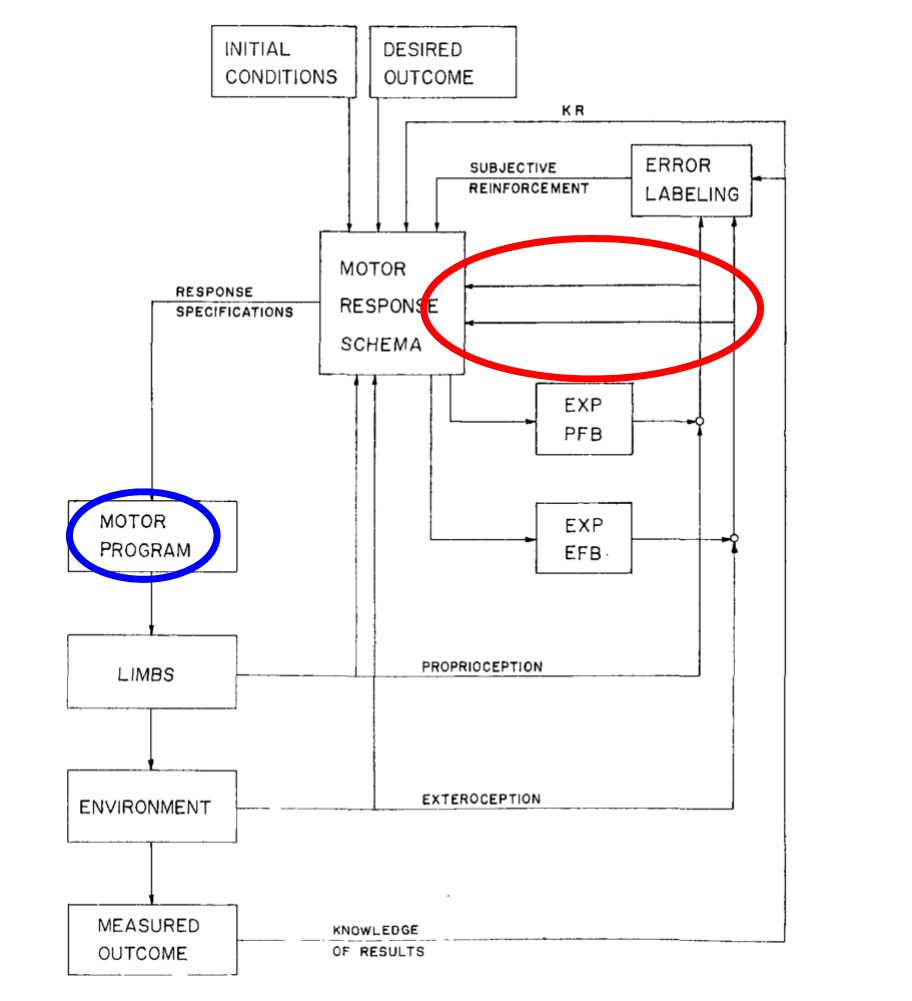

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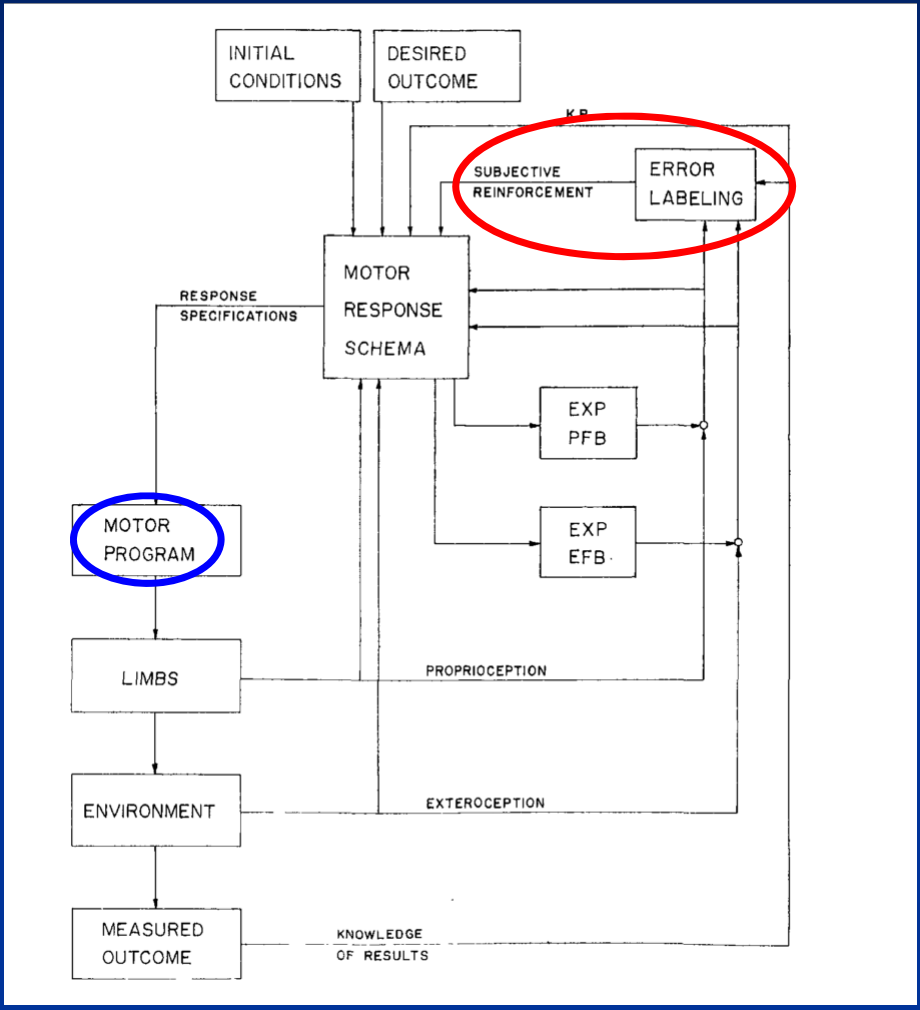

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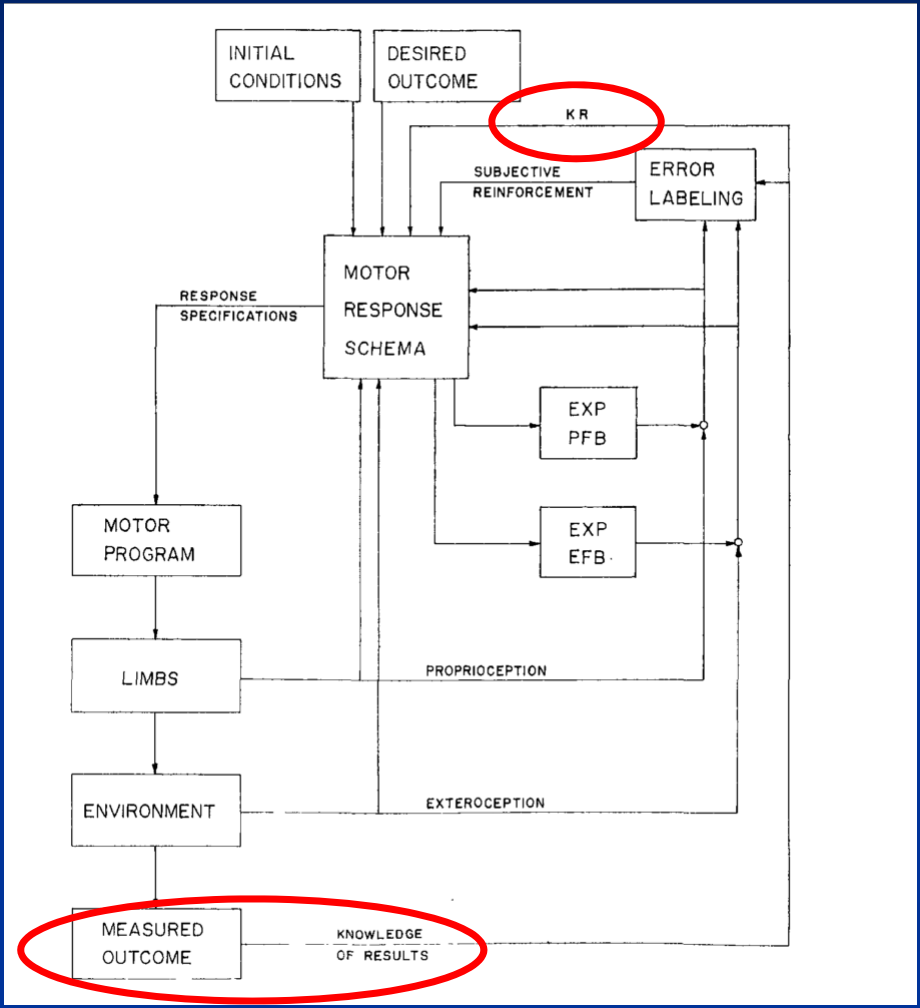
3. Discrepancy between these anticipated and actual states represents an error in responding.
4. error is fed back to the schema so that adjustments can be made to reduce the error to zero.
5. error is also fed to the error labeling system, where the subject assigns a reportable label to it, and this resulting subjective reinforcement is then fed back to the schema as subjective information.

After Movement Completion:



1. KR (knowledge of results) is being fed back to the schema for updating the schema rules (e.g. "the ball missed the target by 20 cm to the left").

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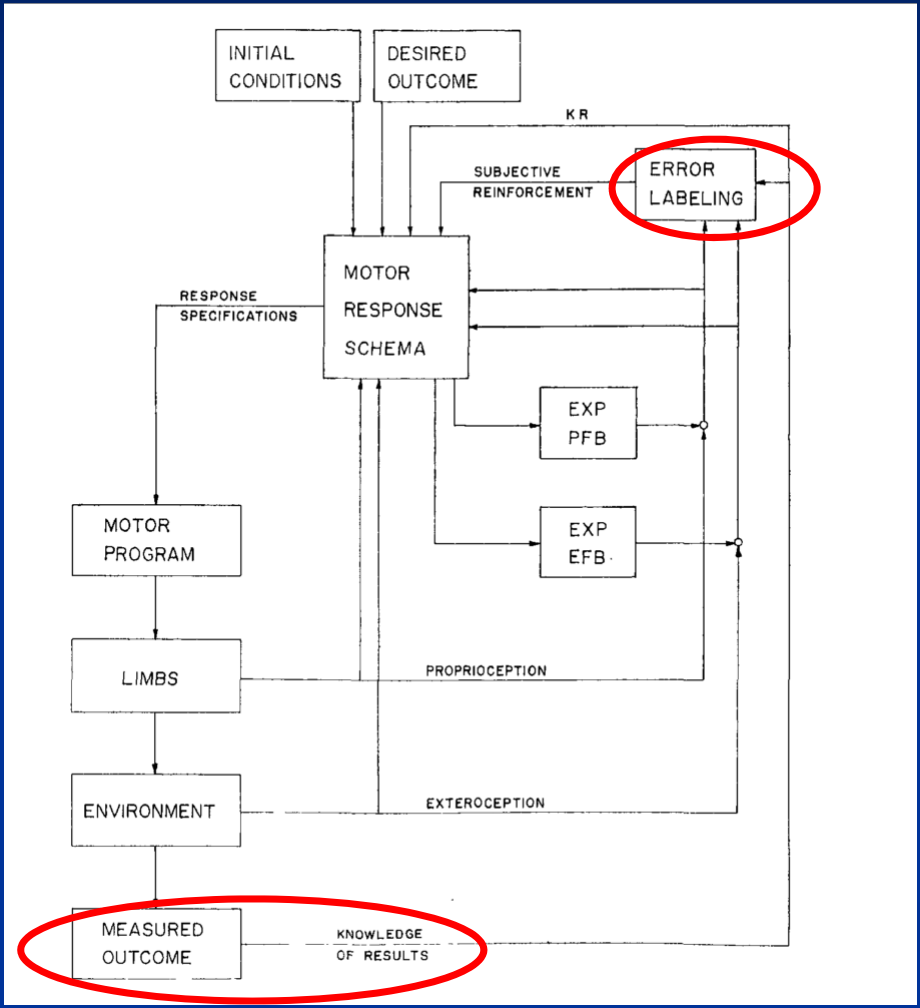


1. KR (knowledge of results) is being fed back to the schema for updating the schema rules (e.g. "the ball missed the target by 20 cm to the left").
2. The KR information is also fed to the error labeling system to enable this system to improve its accuracy in labeling future error signals

Shea & Wulf's update, 2005

DEFINITION:
GMPs are scaled in that way, the sequencing, relative timing, and relative force are assumed to remain invariant.

THEORY SUPPORT:
The empirical independence of the movement structure (GMP) and the movement parameters has been demonstrated in numerous experiments.

Shea, C. H., & Wulf, G. (2005). Schema Theory : A Critical Appraisal and Reevaluation. *Journal of Motor Behavior*, *37*(2), 85–101.

Applications in Music

PREDICTION:

Compared with constant (or limited variability) practice experience, variable parameter practice facilitates the development of a schema rule.

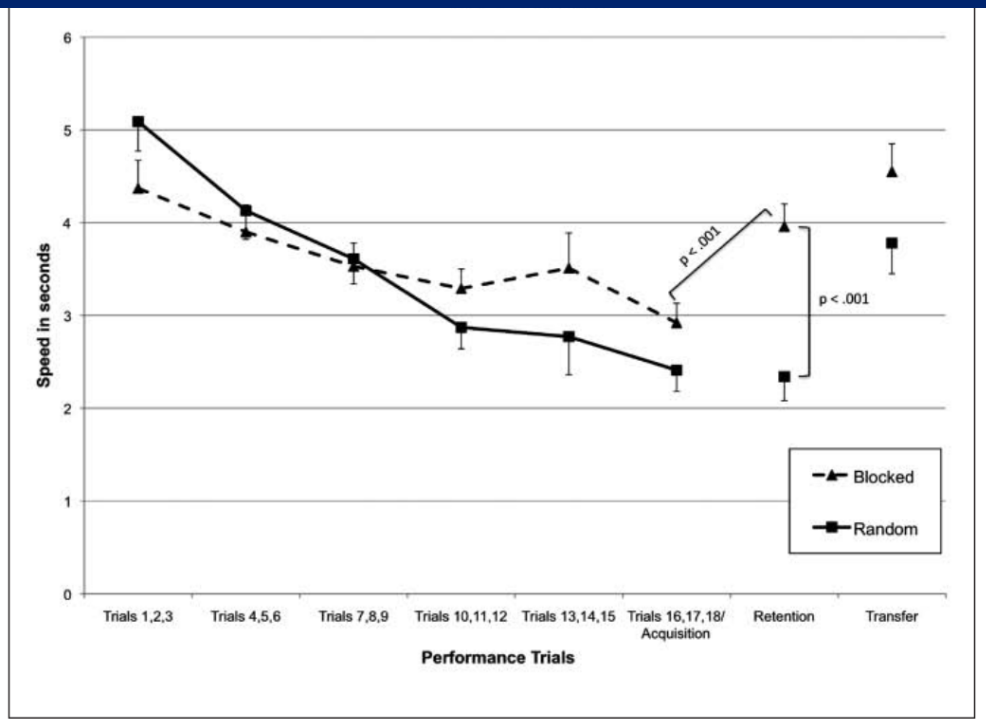
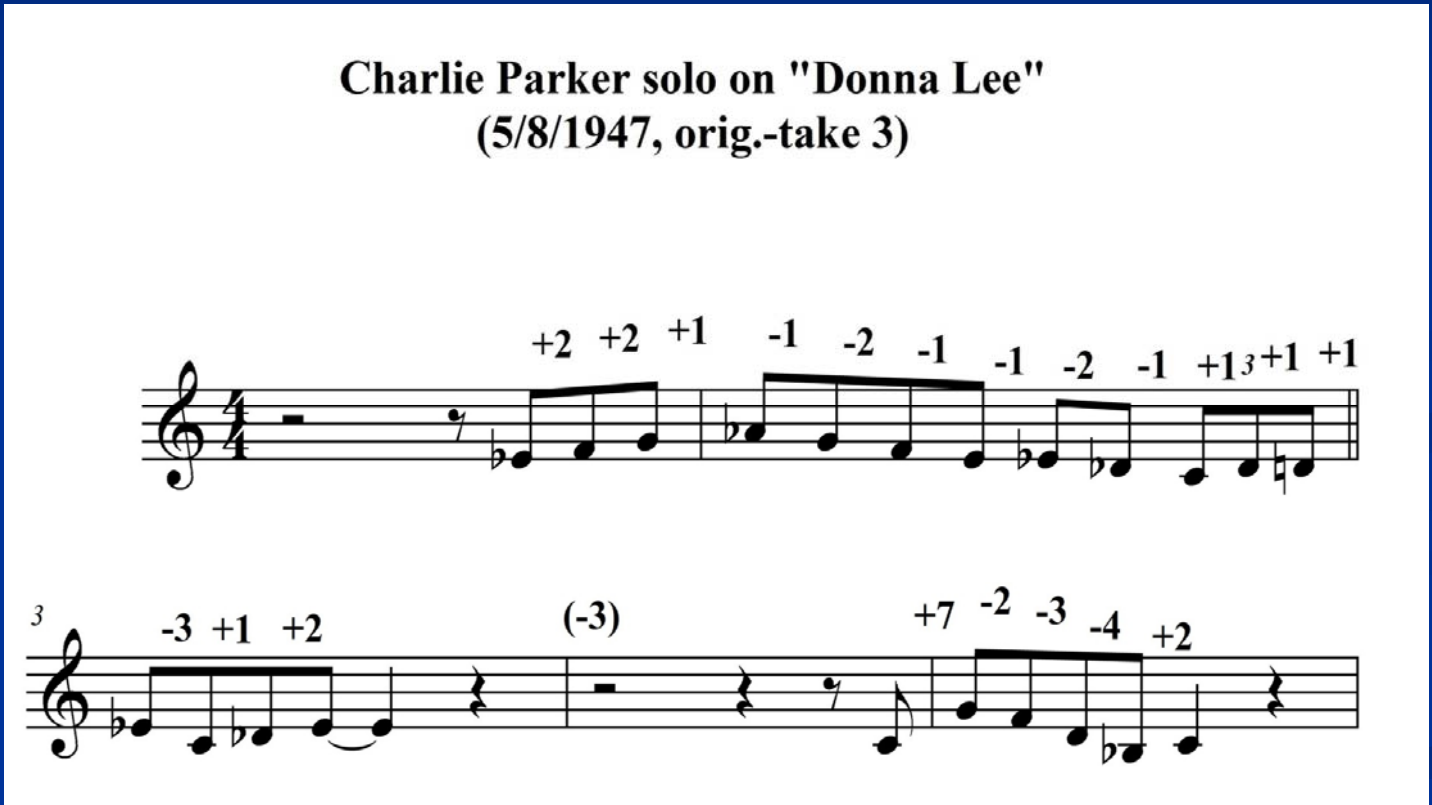


Figure 2. Adjusted means and standard error for accuracy and speed
Source: Data points represent the average of three trials.

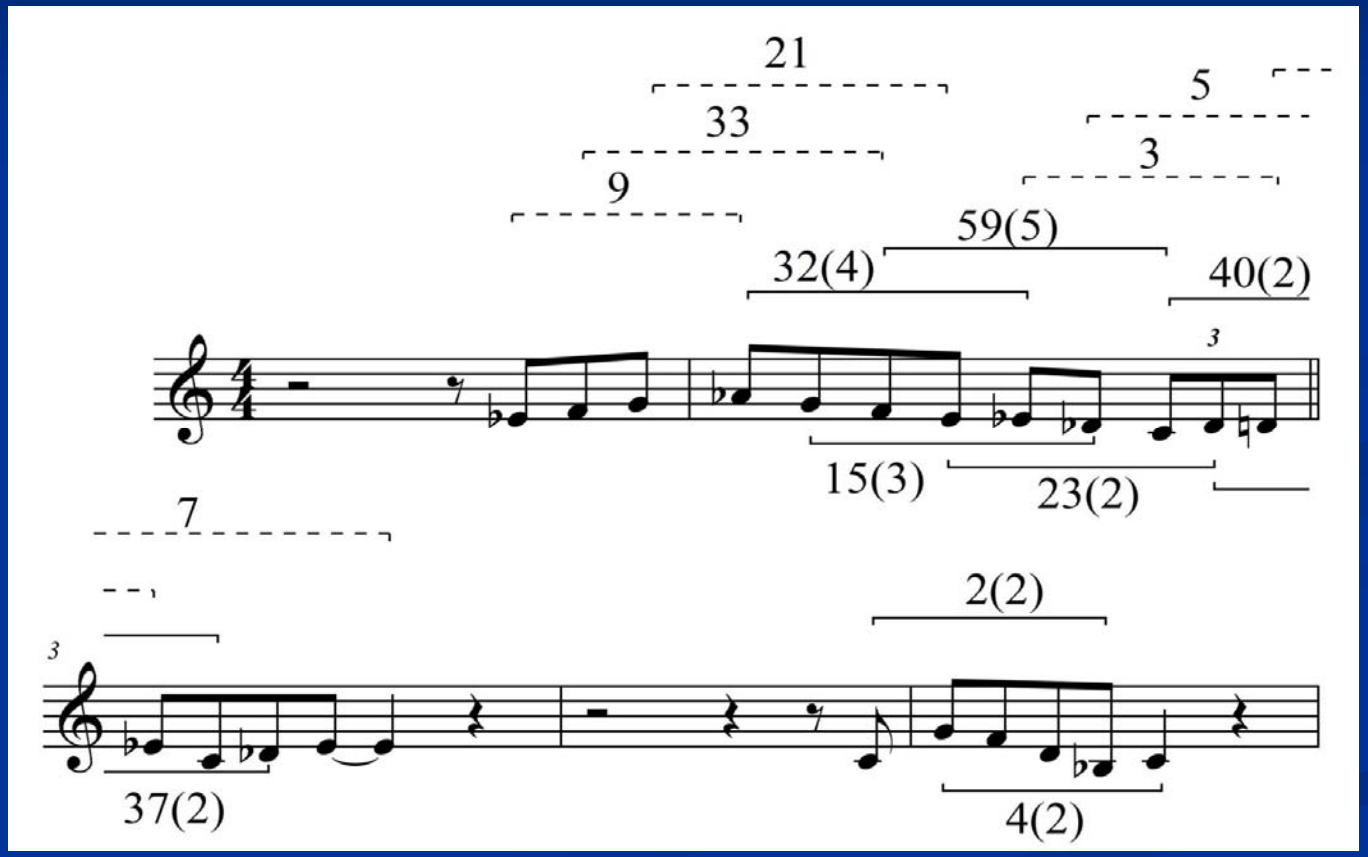
Stambaugh, L. A. (2011). When Repetition Isn't the Best Practice Strategy: Effects of Blocked and Random Practice Schedules. *Journal of Research in Music Education*, *58*(4), 368–383.

Patterns in Jazz

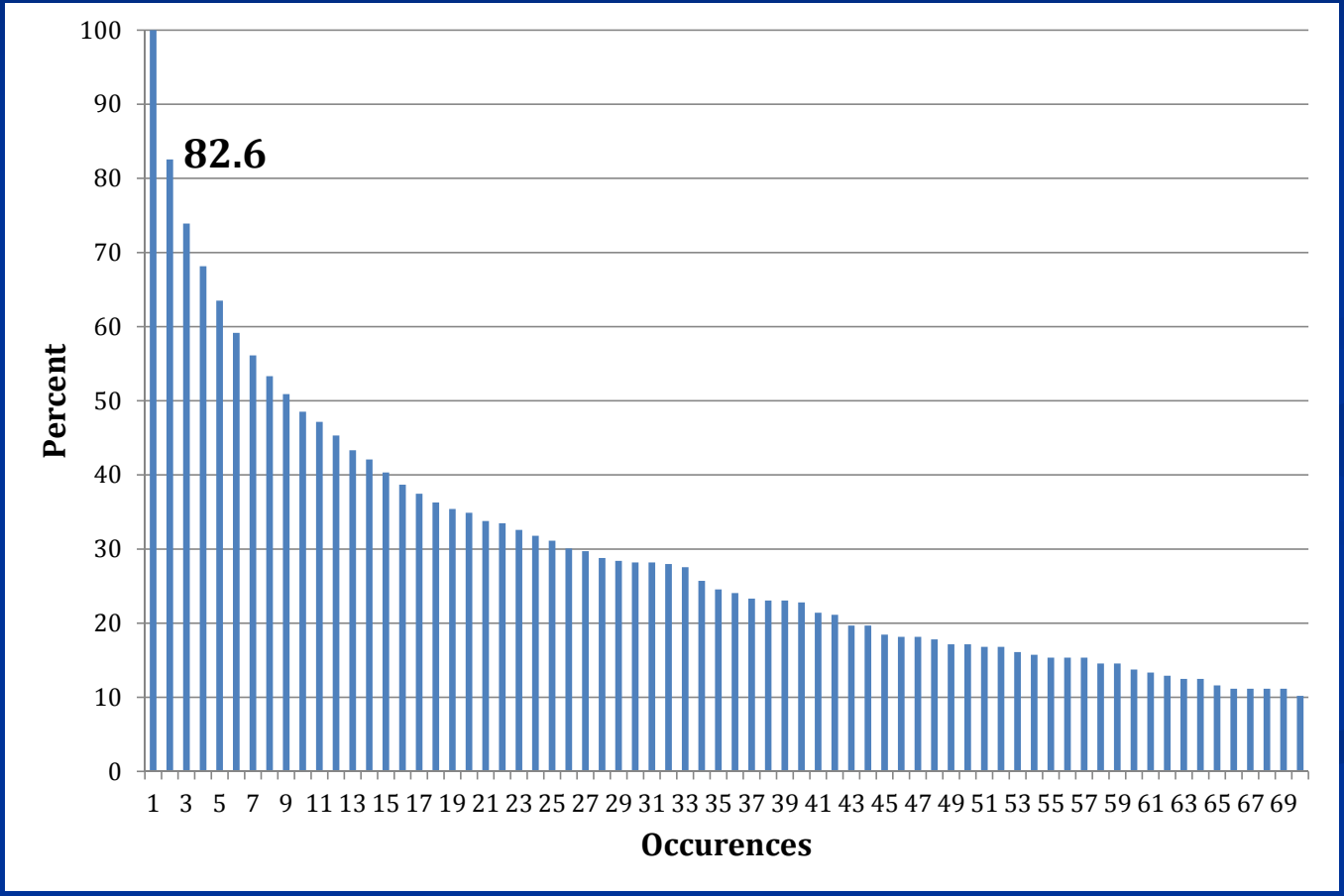


Norgaard (2014) *Music Perception*)

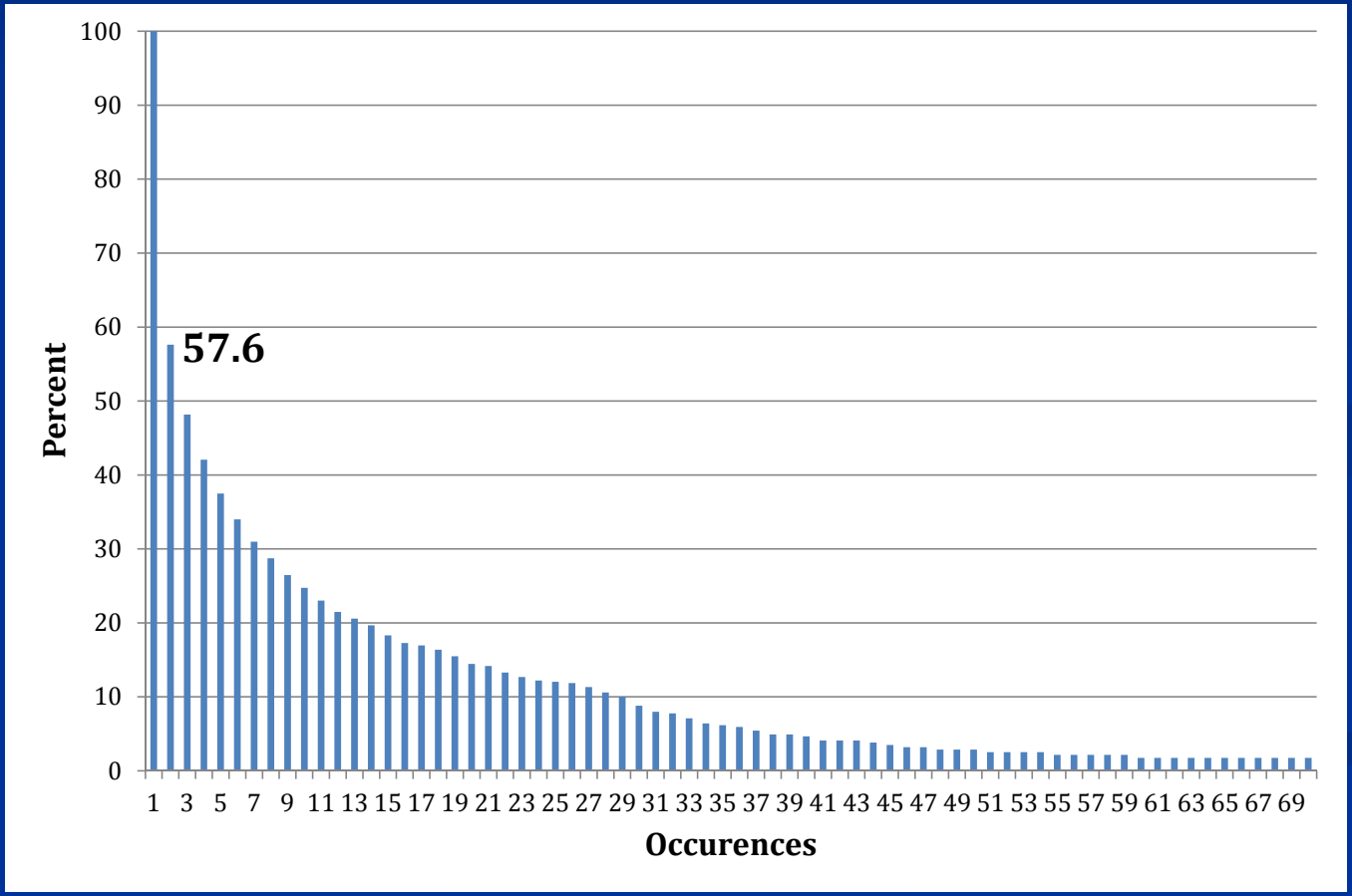
Patterns within Collection



Note Positions with Four-interval Patterns



Note Positions with Four-interval and Rhythm Patterns

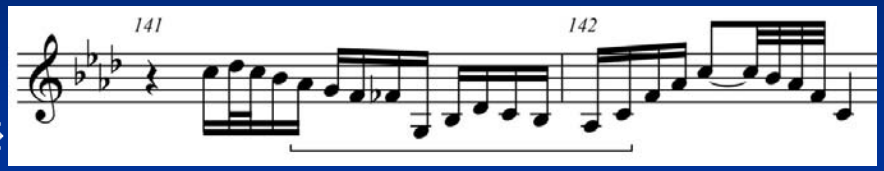


Actual Patterns

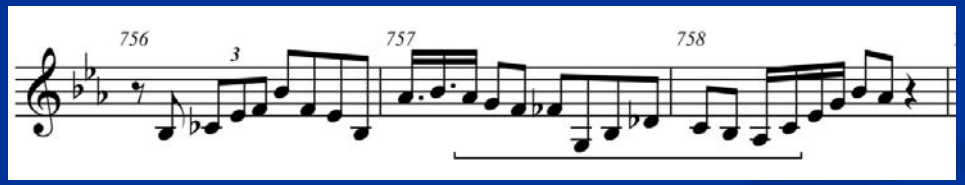
#	Pattern			
184	-2	-1	-2	-2
171	-1	-1	-1	-1
147	-2	-1	-2	-1
139	-1	-2	-2	-1
121	-2	-2	-1	-2
117	-2	-1	3	3
95	2	-2	-1	-2
92	-1	-2	-1	3
87	3	-2	-1	-2
87	1	3	4	3
86	1	2	-2	-1
80	3	4	3	-3

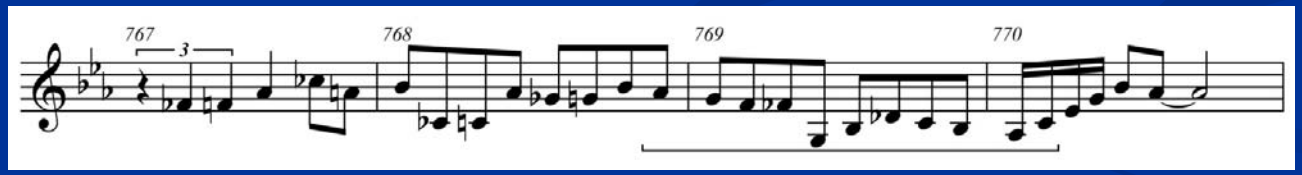
10-intervals: Where are the boundaries?

Bird of Paradise

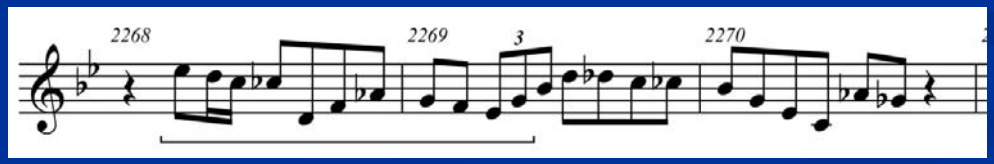


I Get a Kick Out of You

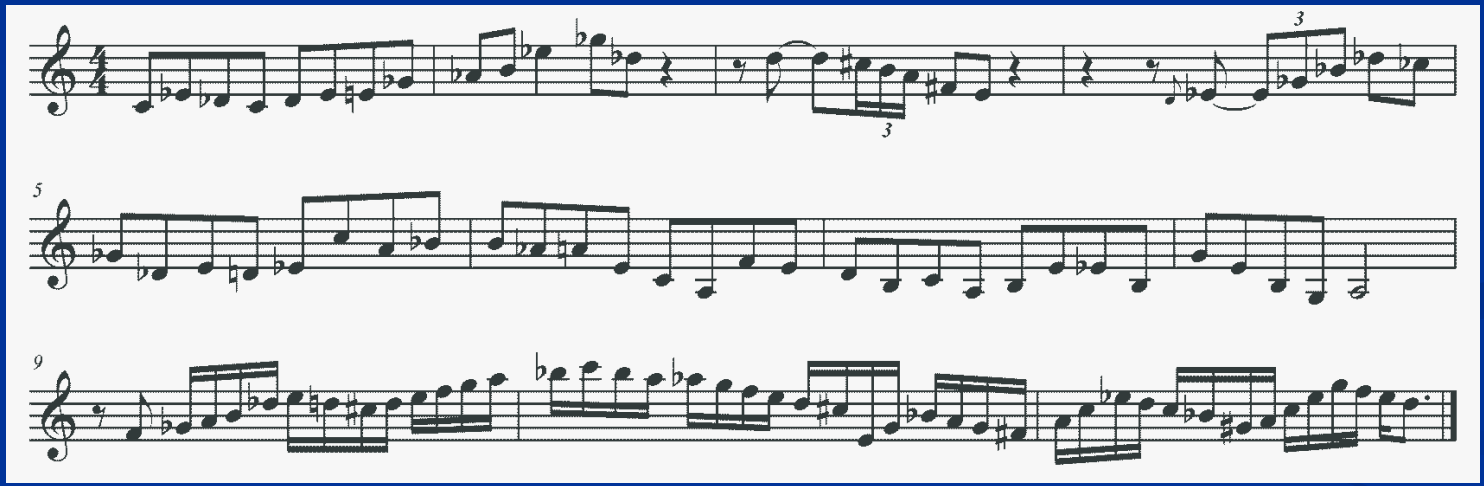




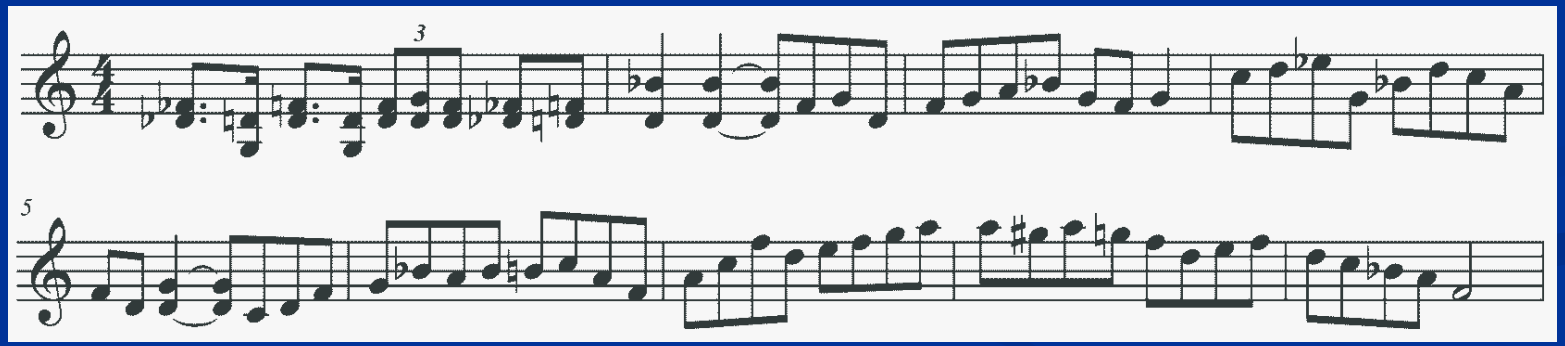
She Rote



Computer Modeling: Rhythm and Pitch Patterns Related



Computer Modeling: Alternate Corpus



Norgaard, M., Spencer, J., & Montiel, M. (2013). *Psychomusicology: Music, Mind, and Brain*.

Schmidt: Finding Unit Boundaries

"A unit is defined as a segment of behavior governed by a single GMP, for which relative timing is invariant. If so, the correlations (within subjects, over trials) among the times of various kinematic landmarks within the unit should be close to 1.0; correlations between two landmarks in different units should below."

Schneider, D. M., & Schmidt, R. A. (1995). Units of Action in Motor Control: Role of Response Complexity and target Speed. *Human Performance*, *8*(1), 27–49.

Schmidt: Finding Unit Boundaries

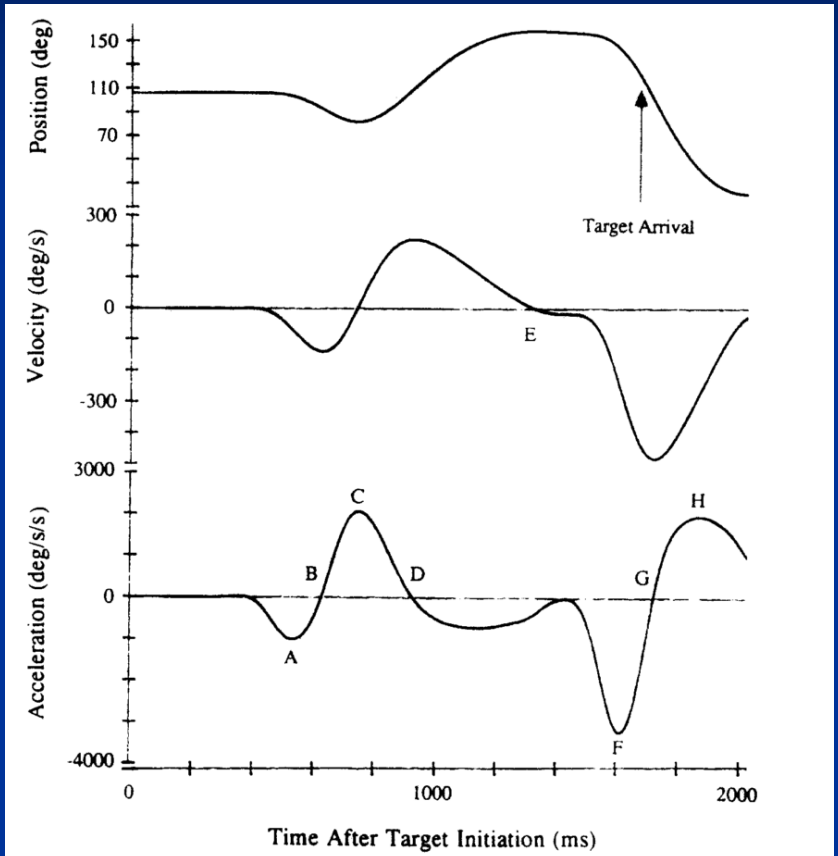


FIGURE 3 Position–time, velocity–time, and acceleration–time functions for a single trial from one subject in the slow condition, showing the temporal locations of Landmarks A through H.

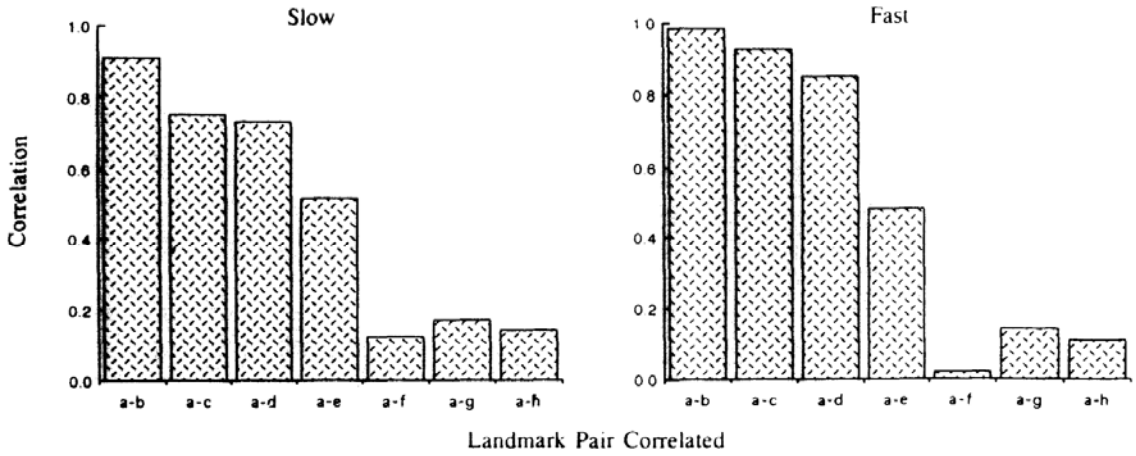


FIGURE 4 Mean within-subject correlations between the time of the first landmark (A) and the times of the later landmarks (B through H).

Schneider, D. M., & Schmidt, R. A. (1995). Units of Action in Motor Control: Role of Response Complexity and target Speed. *Human Performance*, *8*(1), 27–49.

Proposed Method for Identifying Boundaries in Jazz Piano Improvisations

1) Record midi files from jazz piano improvisations
    a. Current sample 25 advanced jazz pianists (From Norgaard et al. 2016)
    b. Task: Play improvisations on major blues in familiar (mostly F) and unfamiliar keys (often B or Gb) to given drum track
    c. Total corpus: 1000 choruses

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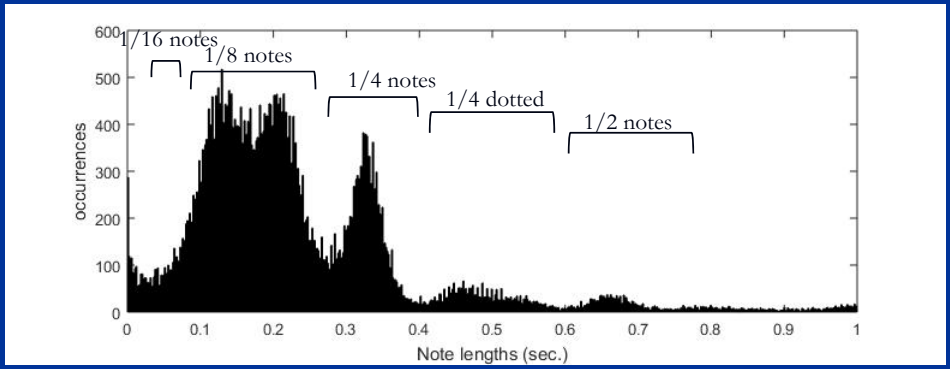

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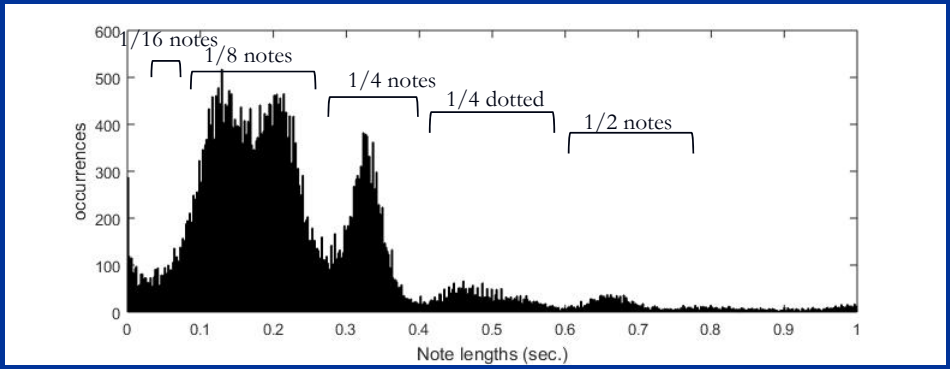

3) Identify pitch and rhythm patterns
   a. Here 5-note patterns occurring 10 times or more

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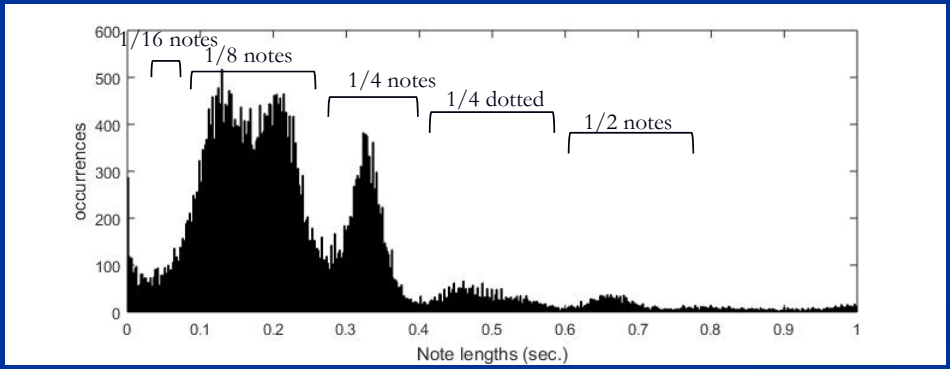

3) Identify pitch and rhythm patterns
   a. Here 5-note patterns occurring 10 times or more
4) Run correlations between note pairs using velocities (force) and onset times
   a. Here of notes 1-2, 1-3, 1-4, 1-5, 1-6

Pilot Results

21	B5b	A5	A5b	G5	G5b	0.784883	0.56324	0.271513	0.640749	0.174541
16	B5b	B5	C6	D6b	D6	0.276651	0.419107	0.661665	0.763259	-0.34729
27	C5	D5b	D5	E5b	E5	-0.10752	0.276989	-0.29912	0.465029	-0.16521
34	C5	B4b	G4	A4b	A4	0.034991	0.832236	0.580363	0.177571	0.10996
19	C5	B4b	A4b	A4	C5	0.272737	0.23192	-0.18117	0.303108	0.089931
16	D4	E4b	E4	F4	G4b	0.512575	0.088212	0.060172	0.119392	0.179843
46	D5	E5b	E5	F5	G5b	0.53268	0.494053	0.550254	0.566645	0.612607
17	D5	C5	B4b	G4	A4b	0.181366	0.167109	0.2325	0.089093	0.160755
15	D5	C5	B4b	A4	G4	-0.3527	0.008725	-0.30427	0.252792	-0.17472
29	D5b	D5	E5b	E5	F5	0.776541	0.430877	0.656158	0.244644	0.601927

Six of the 36 patterns showed strong correlations in both force and timing indicating that most of the 25 participants used stored motor patterns to execute these patterns. Interestingly, all of these patterns were either ascending or descending eighth note chromatic lines. Future research could use this method to analyze output from one participant, which could identify the player's idiosyncratic patterns.

Thank You

- Mariana Montiel, Department of Mathematics and Statistics, Georgia State University.
- Jonathan Spencer, Department of Computer Science, Georgia State University
- Mukesh Dhamala, Department of Physics, Georgia State University
- James Fidlon, Post Doc, University of Texas at Austin