Perceptually significant features of granular processing

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I. Background

Granular processing

- Variation on granular synthesis
- Grains - short, windowed samples of audio recordings, 10 to 100 ms
- Allows for range of effects
  – Time expansion/contraction
  – Pitch manipulation
  – Unrelated sounds (“clouds”)

Perceptual features

- “What are the possible restrictive limits of human psychophysiology?” : Xenakis
  - minimum duration
  - Fletcher-Munson curves
    - minimum intensity
    - minimum pitch distinctions
  - 340,000 possible different grains

Perceptual features

- “Each of the control variables cited previously have a psychoacoustic correlate that may be more suggestive as a basis for compositional organization…” : Truax
  - duration → density
  - delay → secondary density

Perceptual features

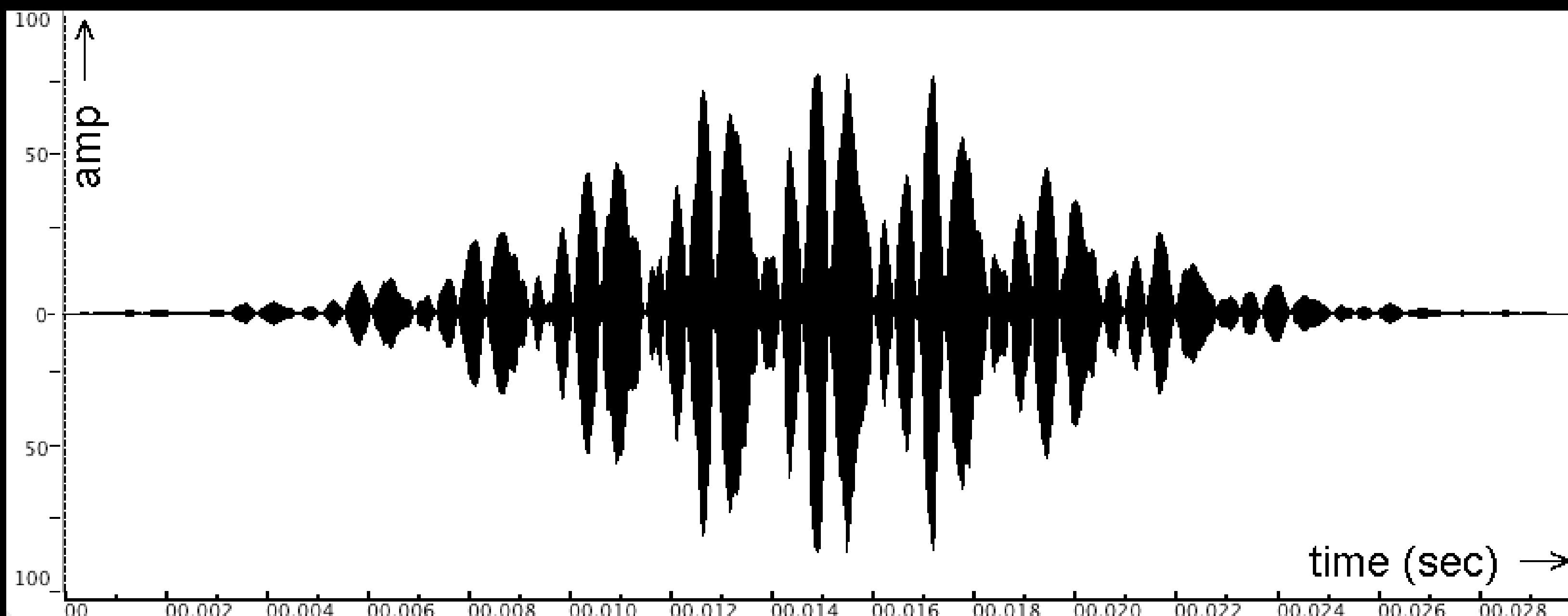
- "It takes a certain amount of training to learn how operations in the micro domain translate to acoustic perceptions on higher levels." : Roads
  - duration connected to spectrum
  - proposes high-level, descriptive controls

Software design thesis

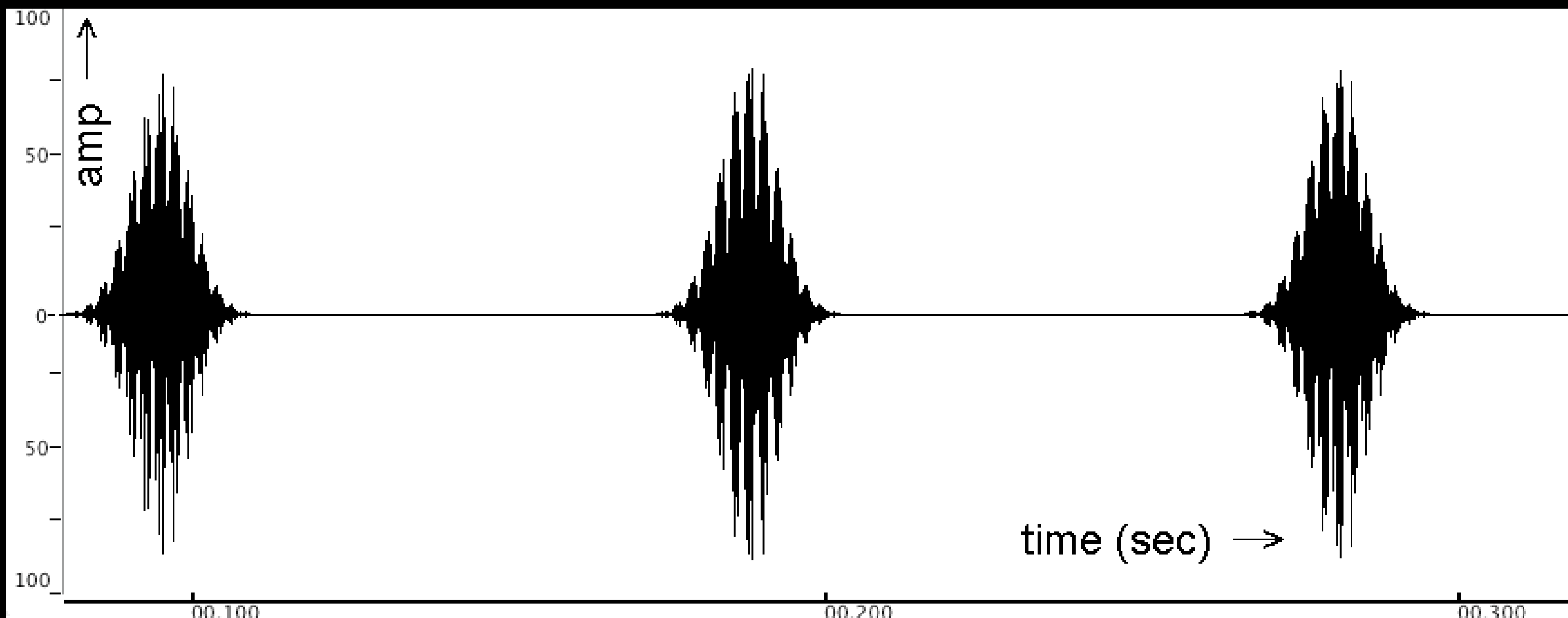
- ideally controls would match perception
- potential to ease the learning curve

- Q: How have others handled issue of control in the past?
  - survey of existing software/documentation
  - focus on key control parameters

Grain

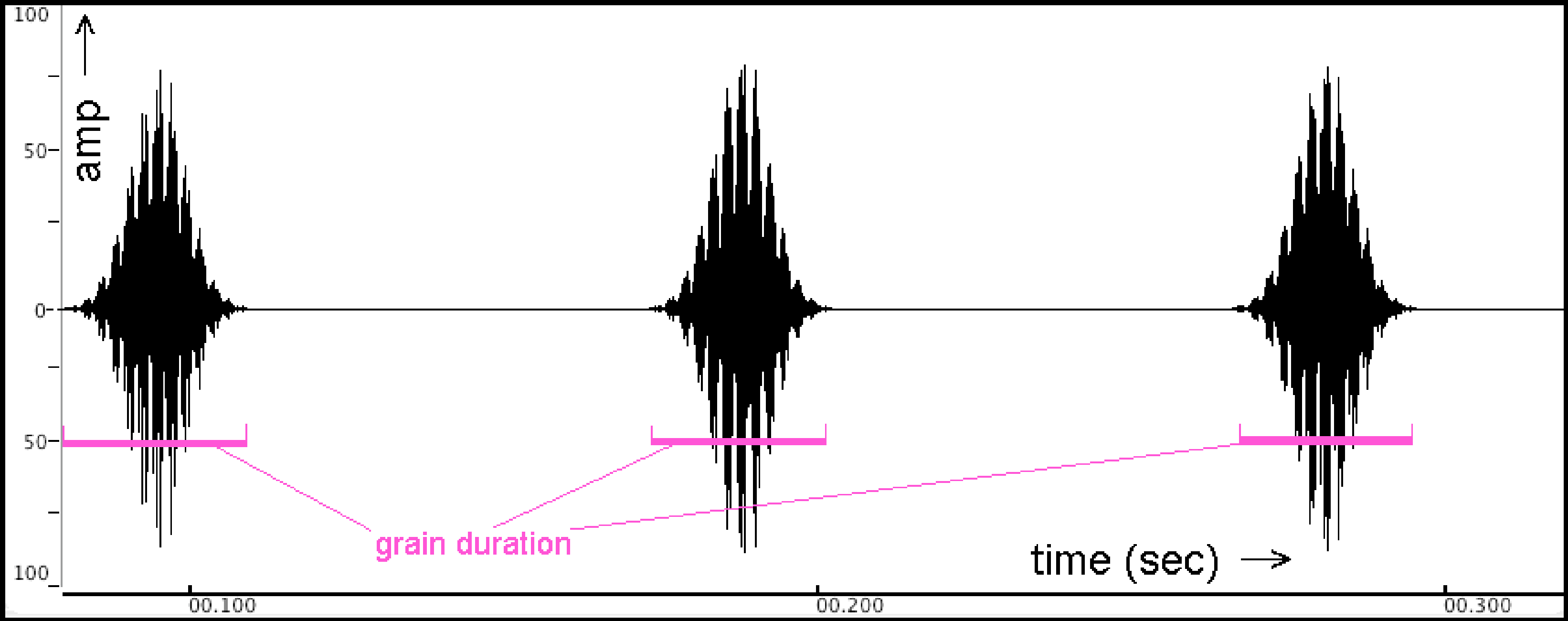

100
50
0
50
100
amp
time (sec)
00
00.002
00.004
00.006
00.008
00.010
00.012
00.014
00.016
00.018
00.020
00.022
00.024
00.026
00.028

Multiple grains



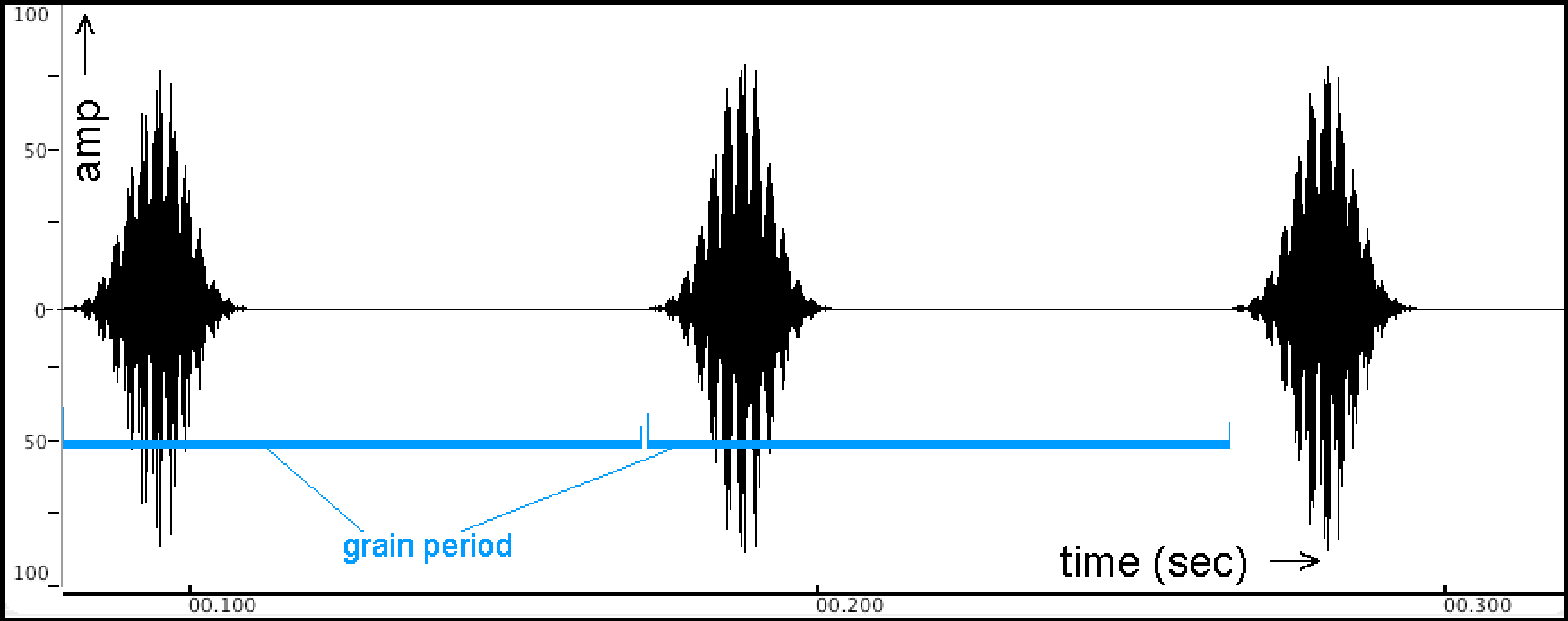
Grain duration (ms)

grain length or grain size (ms)

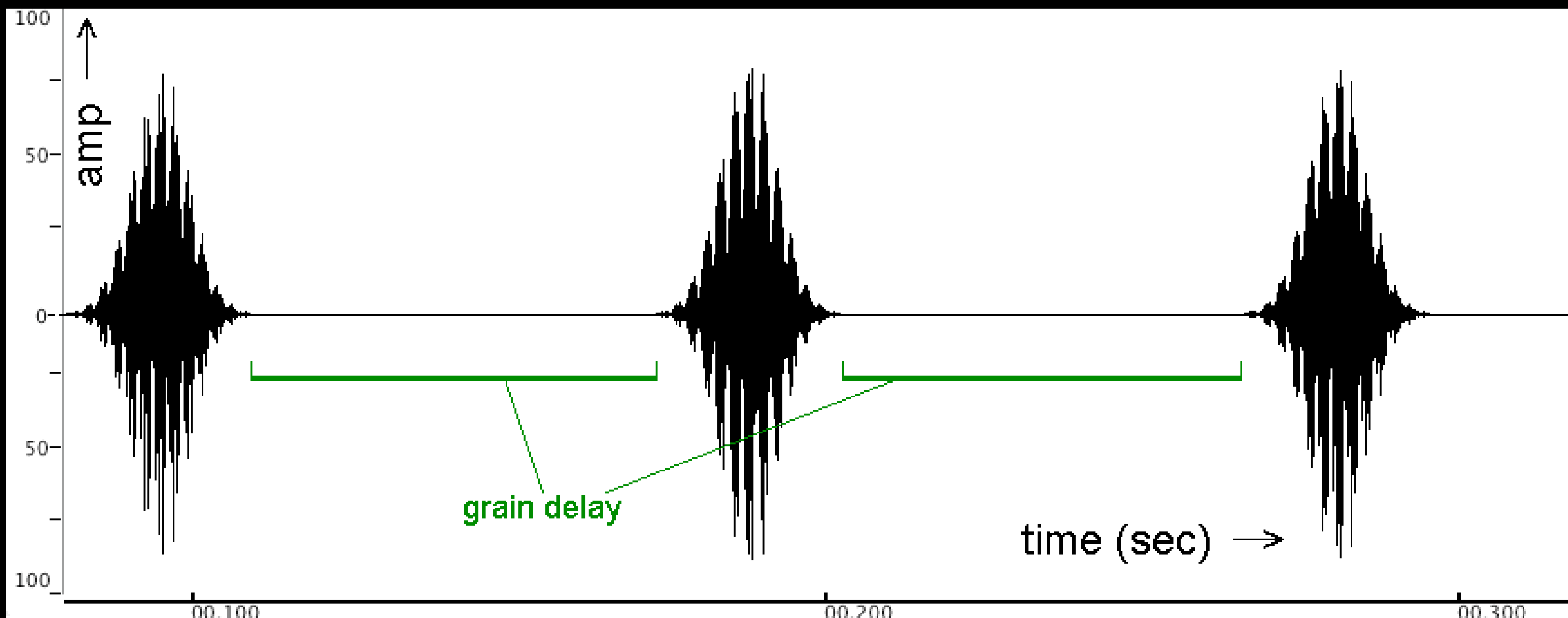


Granular period (ms)

inverse = density or rate (gps)



Grain delay (ms)



Parameters of interest

15 programs surveyed

- Grain duration
  - direct (9) or indirect (4)
- Voice organization
  - density (8), delay (4) or period (1)
- Randomization
  - min/max (6), mean/bw (3) or combo (1)

II. Experimental Methods and Procedures

Multi-dimensional Scaling

- Participants rate similarity of each unique pairing
- Similarity ratings used as basis for graphic representation of relationships
- Distance relates to amount of similarity

- Used in studies of timbre
  - (Grey 1977; Wessel 1979; Kendall and Carterette 1991; Iverson and Krumhansl 1993)

Experiment Design

- Stimuli generated using two sound sources
  - both processed using same set of 9 parameter settings, producing 18 unique stimuli total
- 18 stimuli contain 171 unique pairs
- Practice session used to prepare participants
- Focus on parameters of grain duration, voice organization and randomization

Pre-qualification

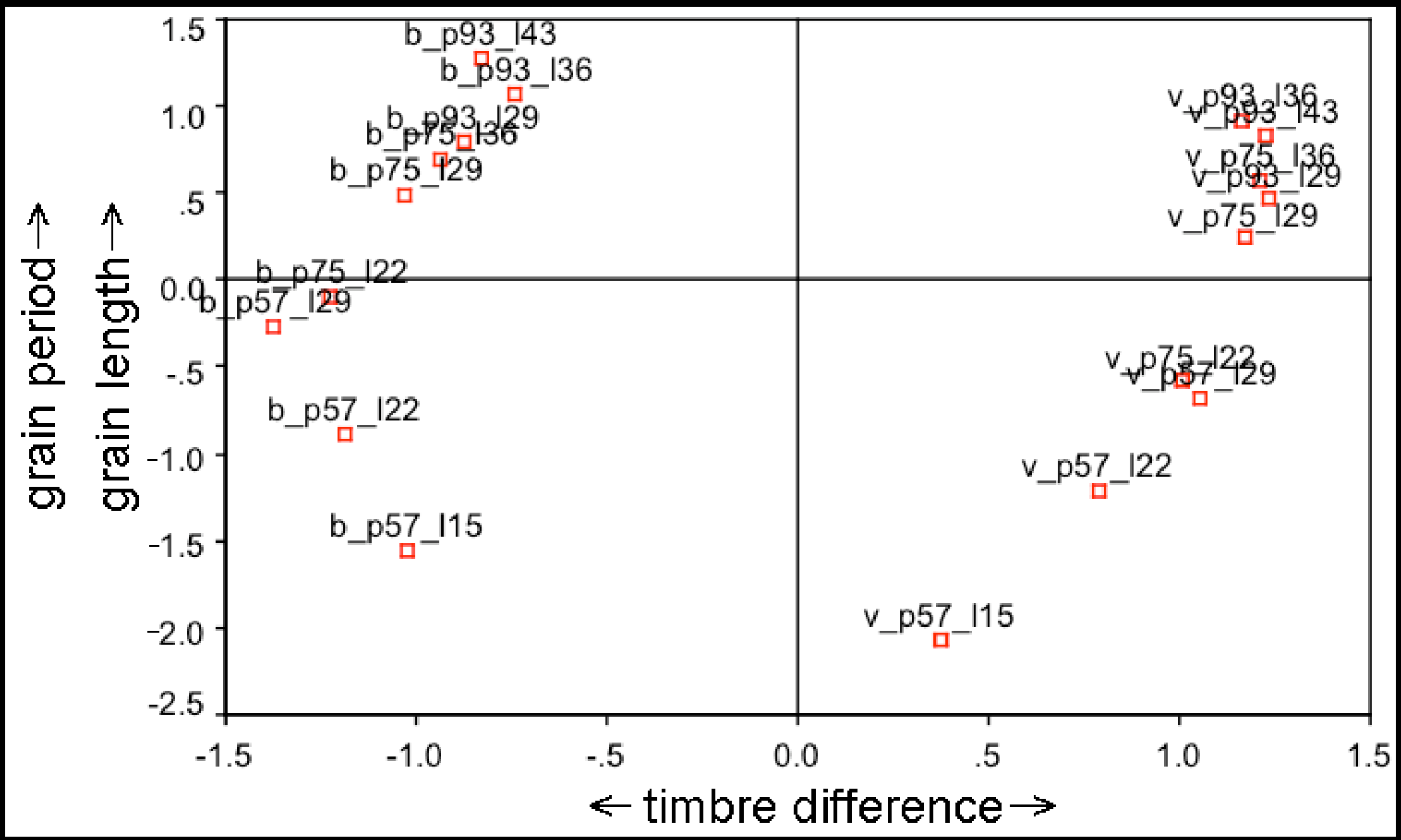
- Potential participants screened based on prior experience
  - All subjects reported at least four combined years of experience within the areas of music and audio technologies
- Secondary inquiry related to experience with electroacoustic music
  - no significant differences found
  - responses averaged for MDS

Experiment 1

- 20 participants
- 9 settings
- No randomization
- 2 sources

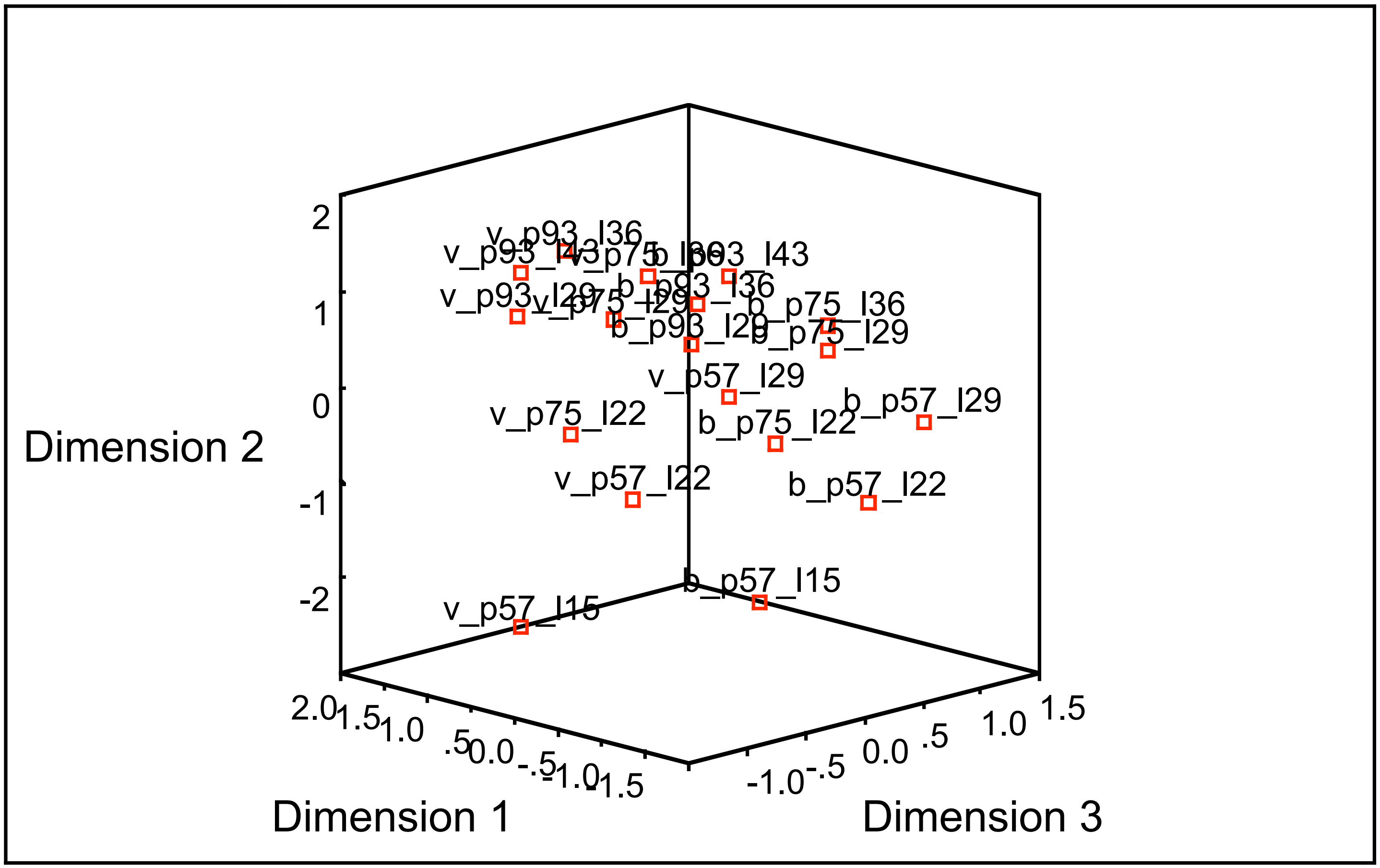
period	duration
57	15
57	22
57	29
75	22
75	29
75	36
93	29
93	36
93	43

Exp 1 - 2d MDS solution



Stress = 0.13587, R^2 = 0.90542

Exp 1 - 3d MDS solution



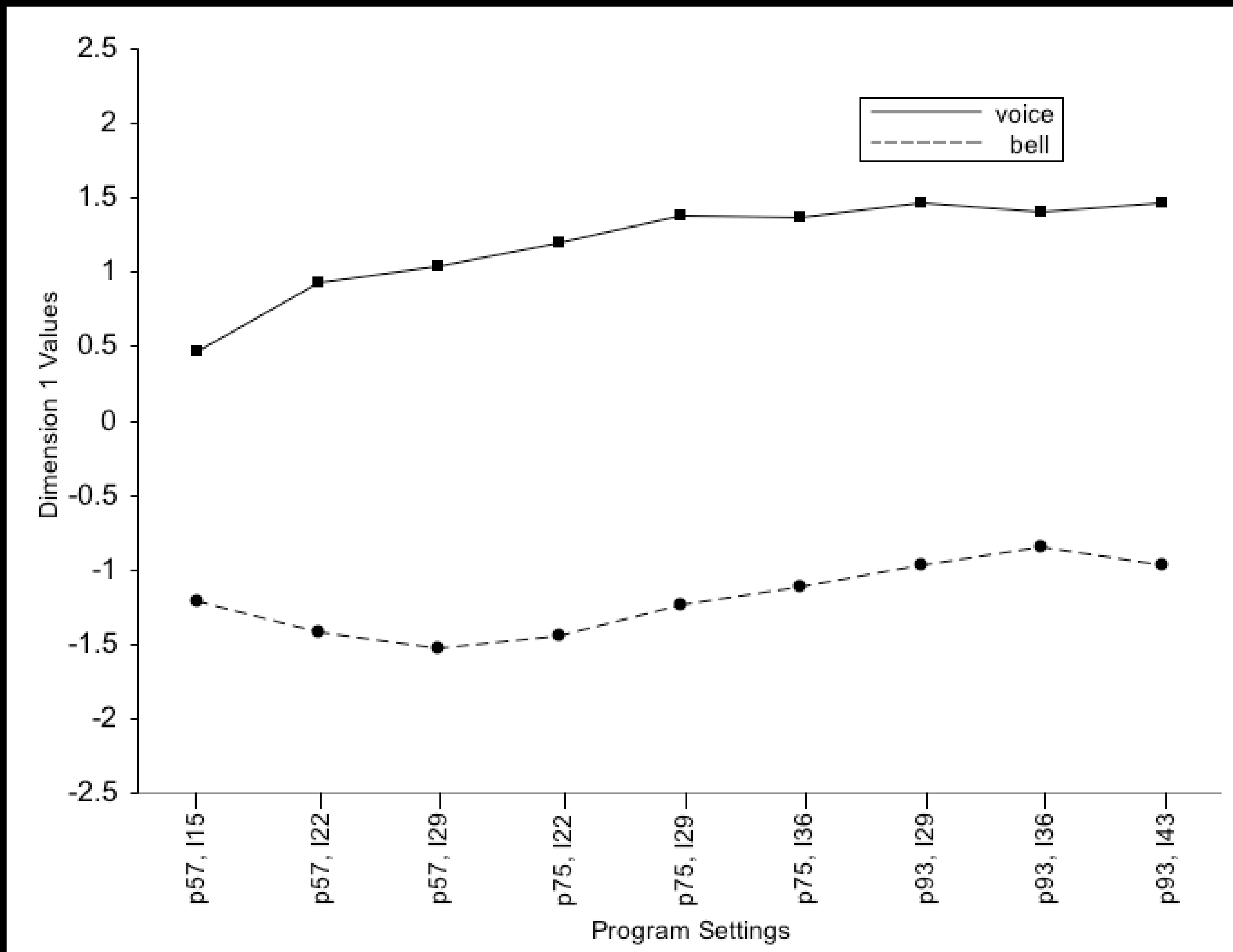
Stress = 0.08832, R^2 = 0.9444

Problems with 3d MDS

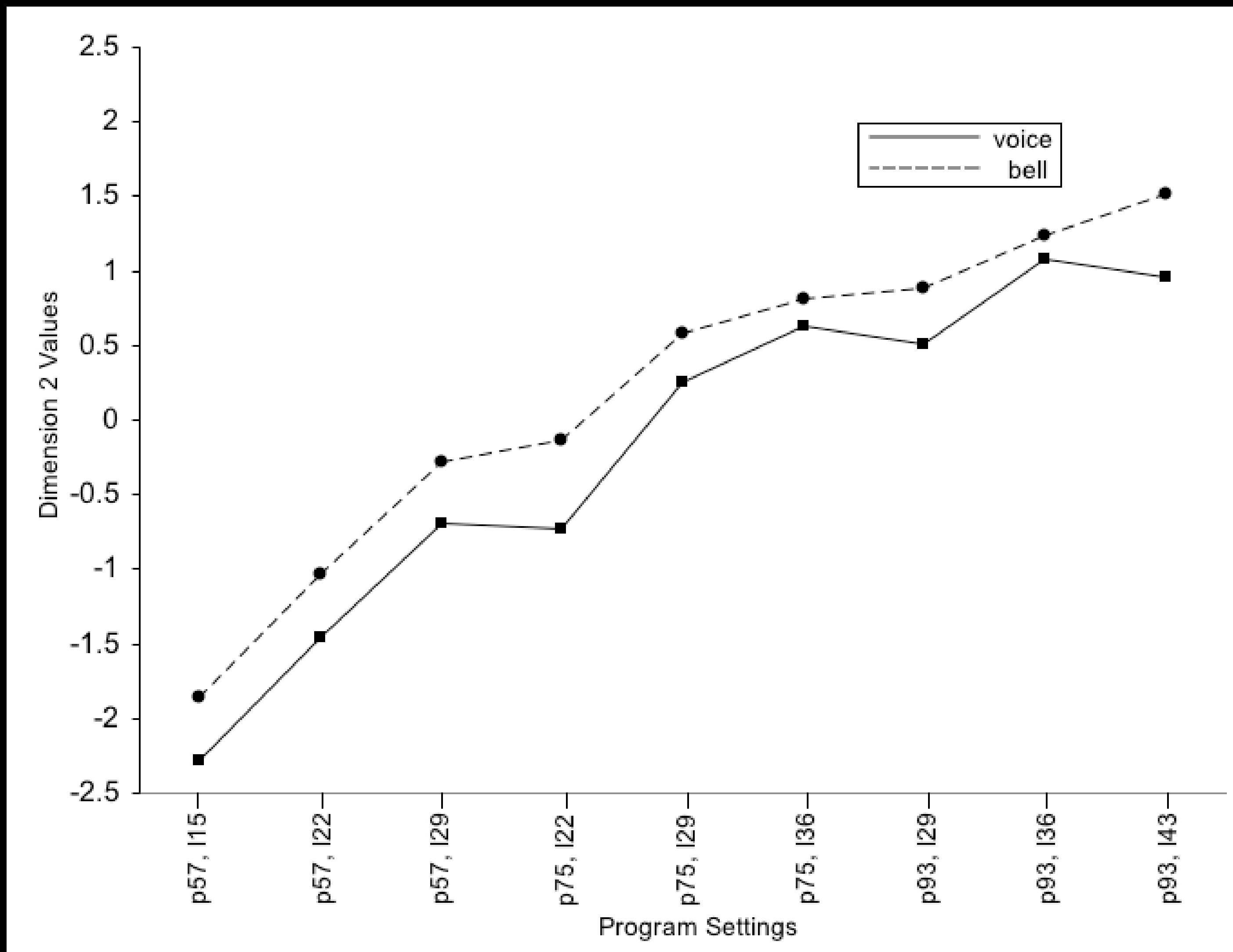
- Difficult to interpret
  - proximity of some stimuli
  - 2d computer presentation

- Solution - plot dimensions individually
  - analyze each separately
  - trends became easier to observe

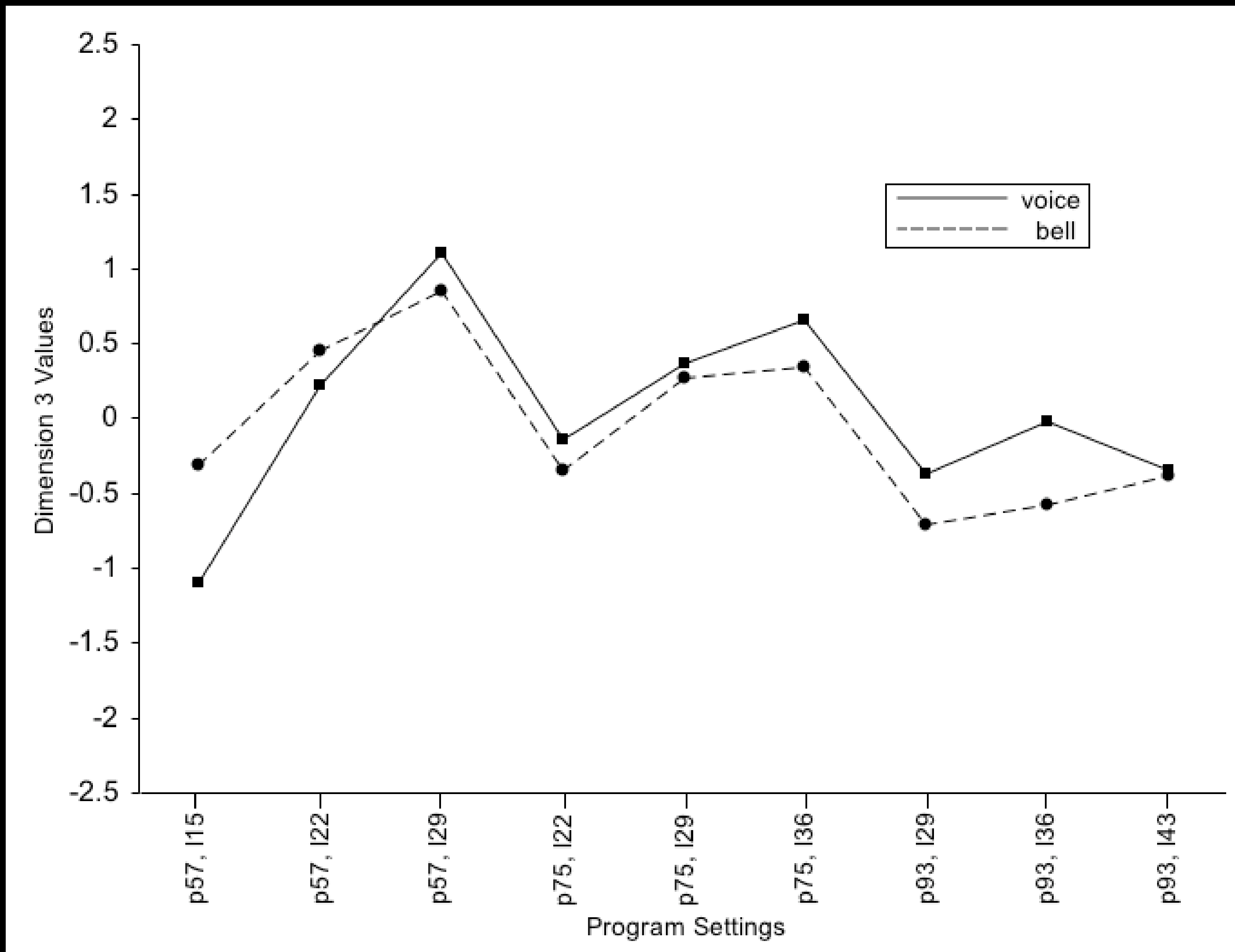
Exp 1 - 3d MDS, Dim 1



Exp 1 - 3d MDS, Dim 2

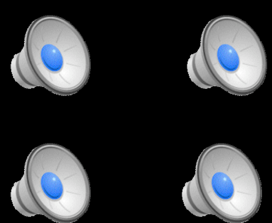


Exp 1 - 3d MDS, Dim 3



Experiment 2

- 20 participants
- 9 new settings
- randomization
- same 2 sources

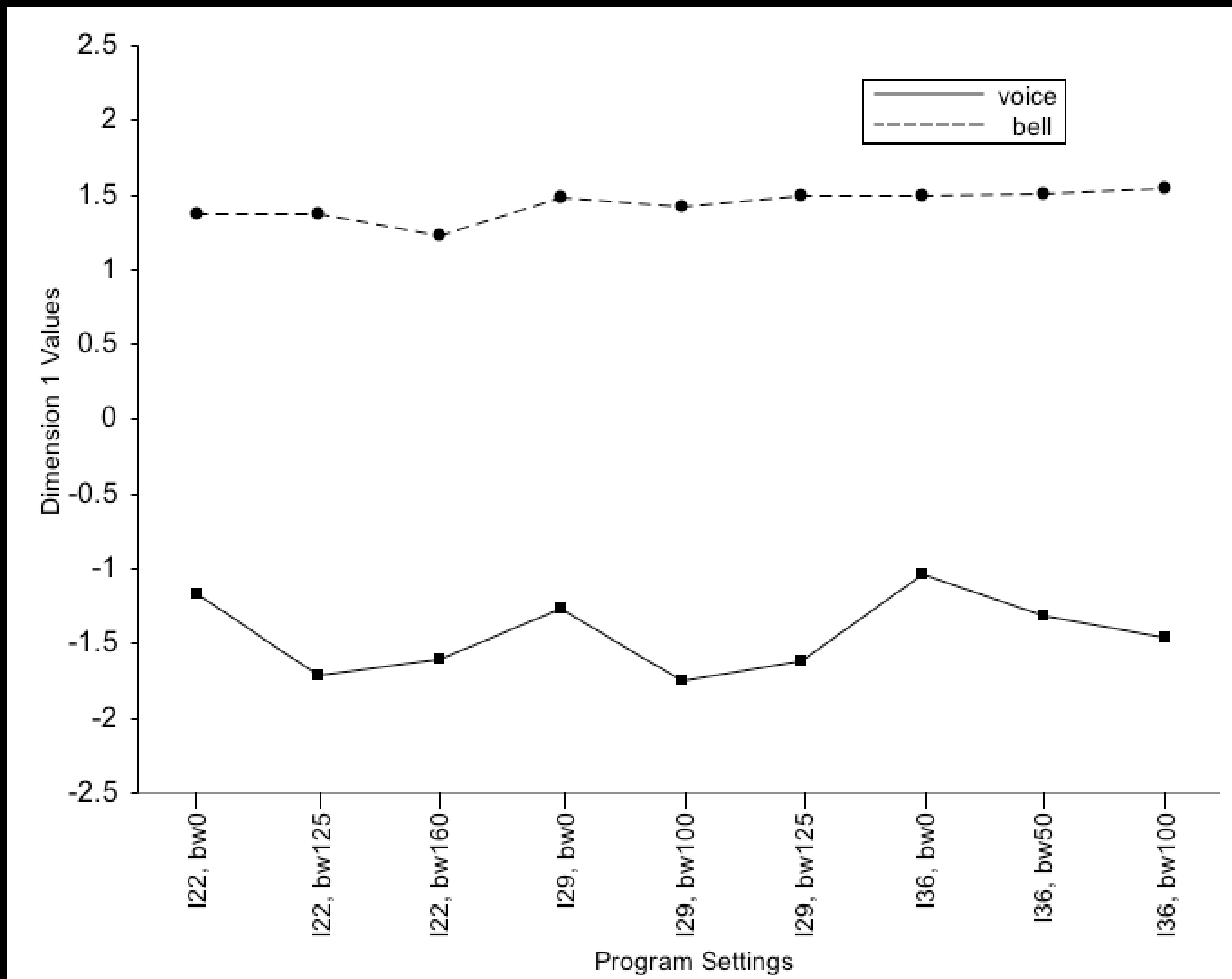


duration	random %
22	0
22	125
22	160
29	0
29	100
29	125
36	0
36	50
36	100

Exp 2 - 3d MDS

- Improved measures over 2d
  - Stress = 0.08268
  - R^2 = 0.96403
- Again graphed dimensions separately

Exp 2 - 3d MDS, Dim 1



Experiment 3

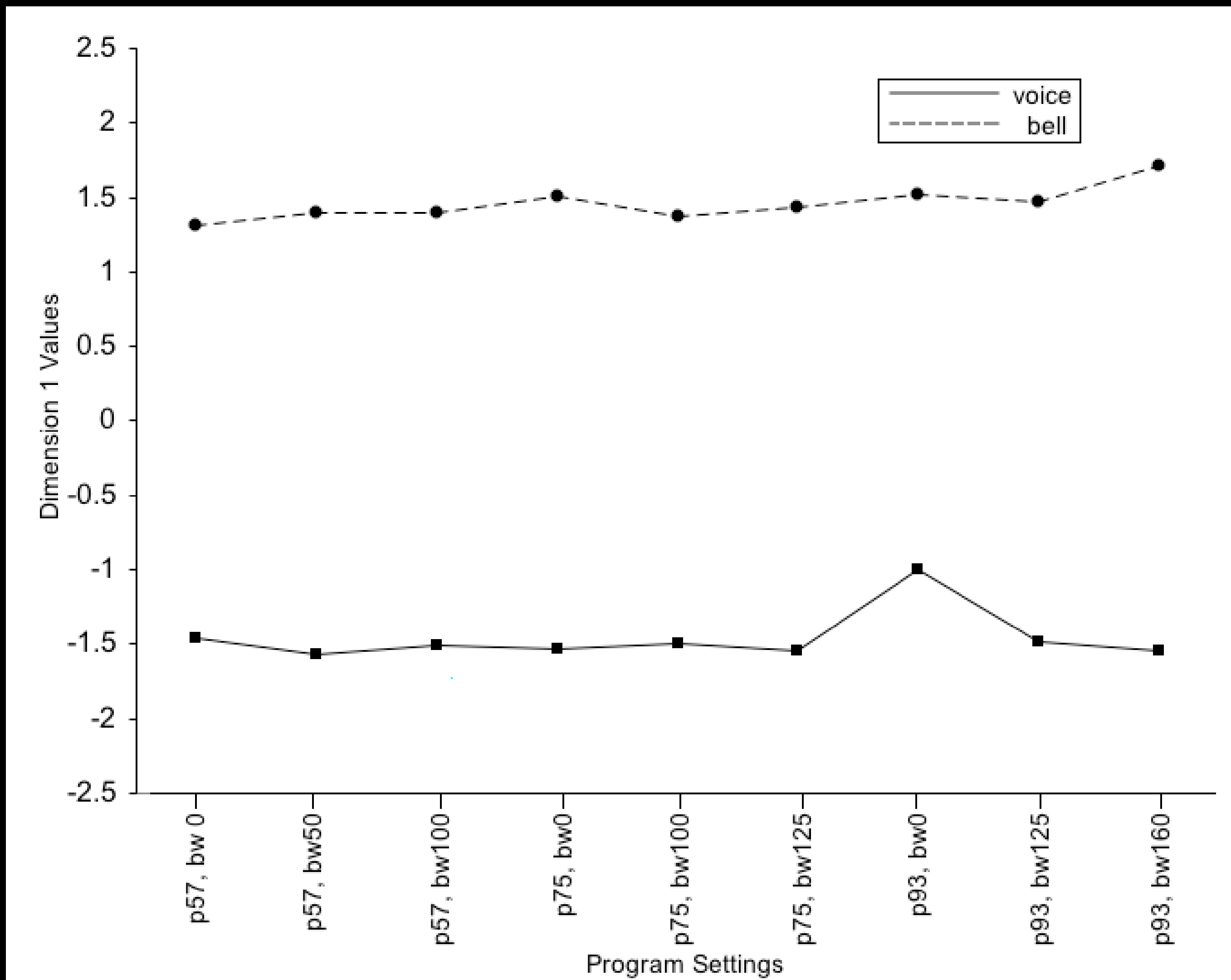
- 22 participants
- 9 new settings
- randomization
- same 2 sources

period	random %
57	0
57	50
57	100
75	0
75	100
75	125
93	0
93	125
93	160

Exp 3 - 3d MDS

- Improved measures over 2d
  - Stress = 0.07481
  - R^2 = 0.97175
- Again graphed dimensions separately

Exp 3 - 3d MDS, Dim 1



Preliminary Conclusions

- meaningful patterns in MDS
  - low stress & high variance
- sound source clearly differentiated
- processing clear focus of listening
- parameters not obvious in results
- secondary inquiry inconclusive

III. Analysis of Results

MDS correlation

- Acoustic measures of timbres
  - Iverson and Krumhansl, 1993
  - Kendall, Carterette and Hajda, 1999
- Statistical correlation to dimensions
  - treated as independent variables
  - significant correlations noted

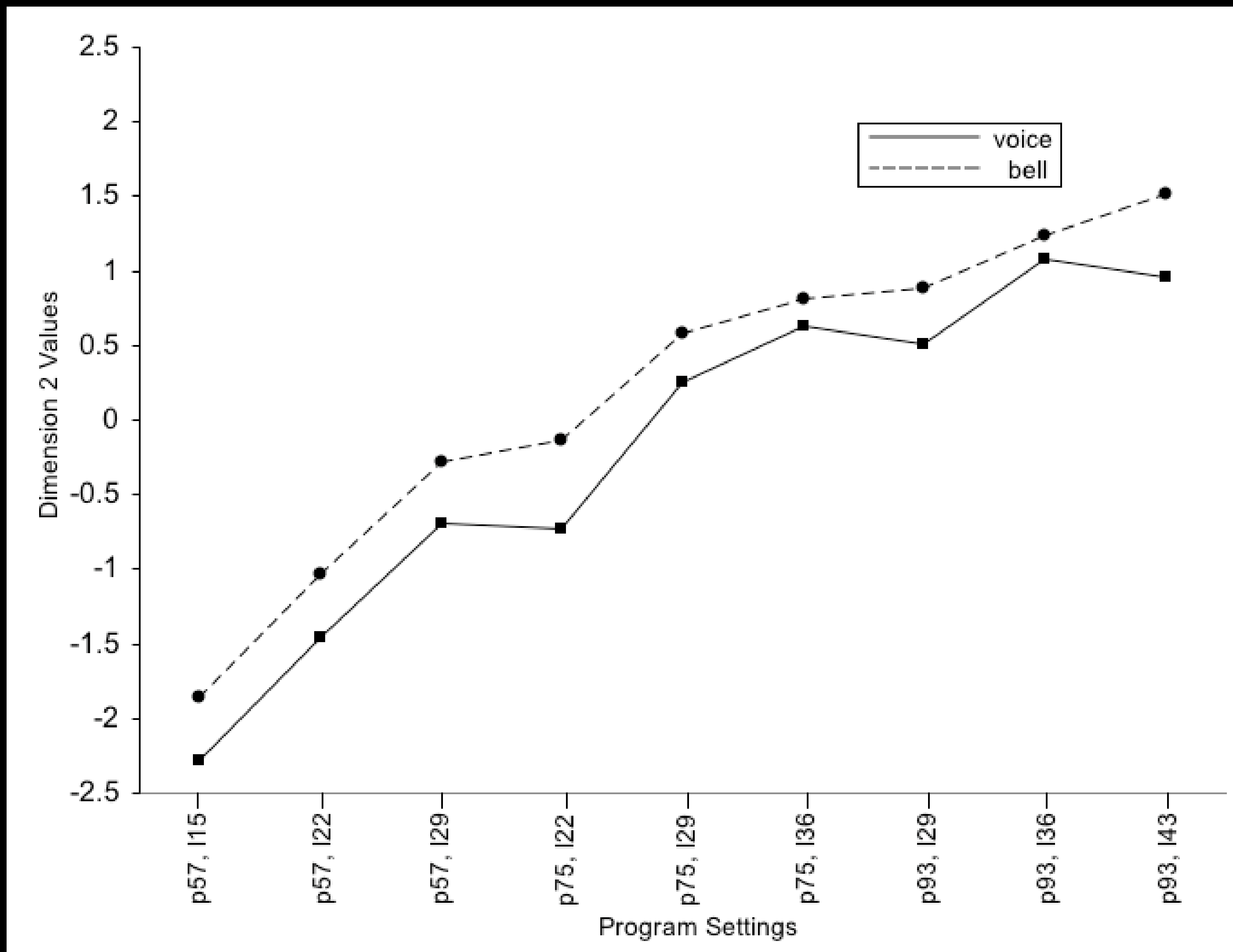
Analytical Method

- List of potential descriptors
  - settings-based
    - actual and literature
  - measurements-based in 2 & 3
- Computed Pearson correlation
  - Nearly all were significant (*$p<0.01$)*
  - Highest coefficient noted

Exp 1 - period & duration

- 2d MDS - dimension 2
  - length scaled by log-2 & 1000/L
  - significant at *p*<.001 level
- 3d MDS - dimension 2
  - length scaled by log-2
  - significant at *p*<.001 level

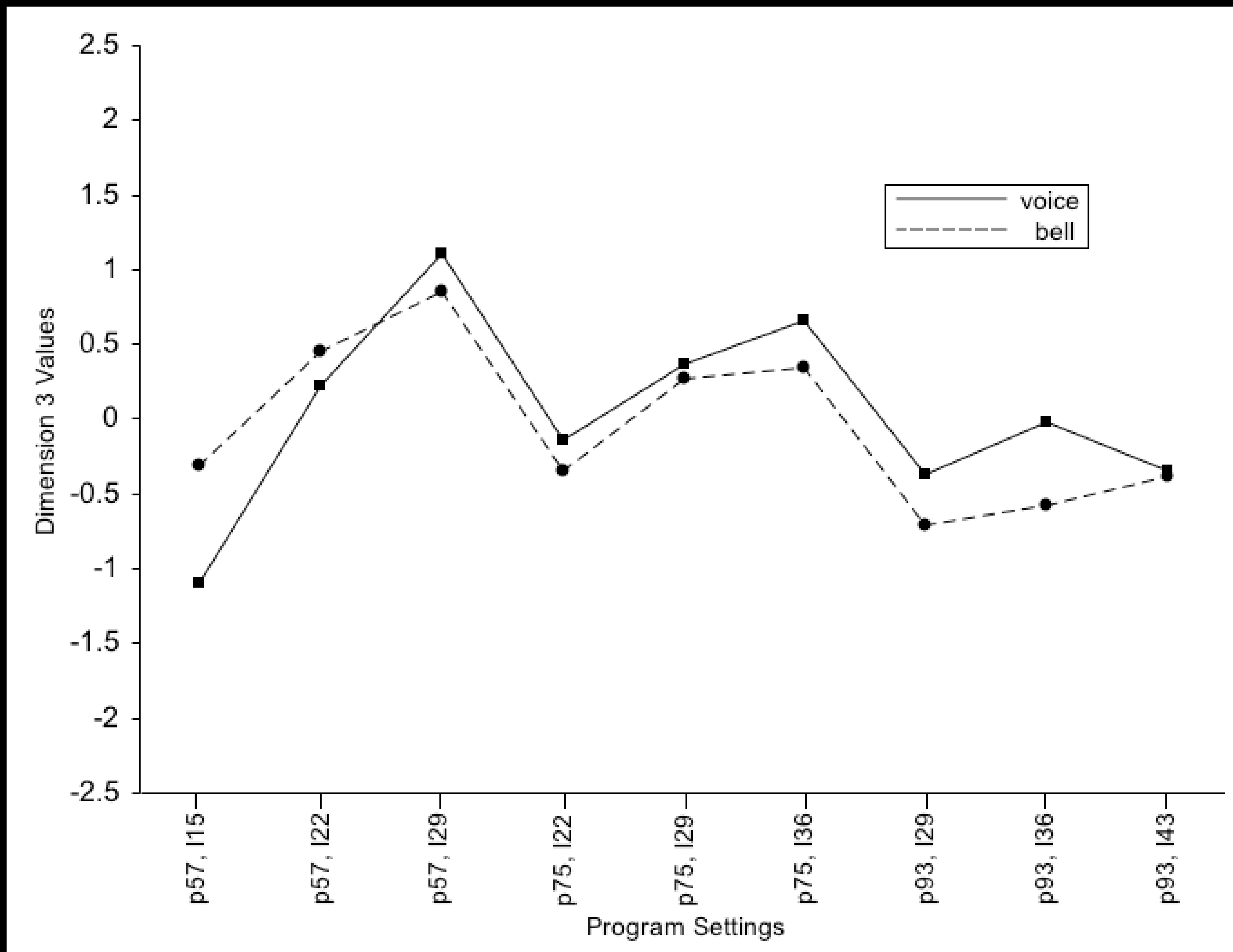
Exp 1 - 3d MDS, Dim 2



Exp 1 - period & duration

- 3d MDS - dimension 3
  - grain width • density
  - significant at *p*<.001 level

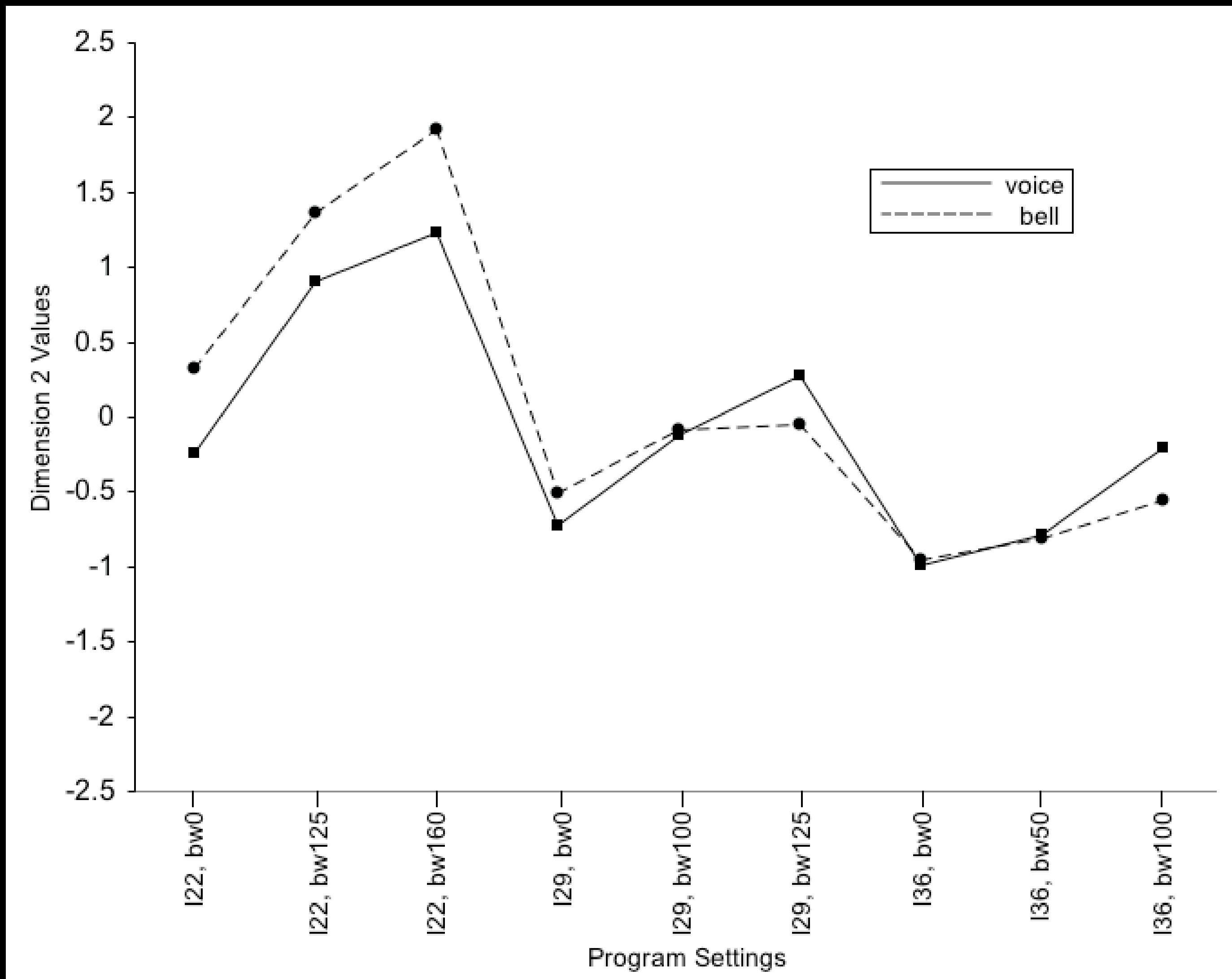
Exp 1 - 3d MDS, Dim 3



Exp 2 - randomized duration

- 2d & 3d MDS - dimension 2
  - minimum length scaled by log-2
  - settings & measurements agree
  - significant at p<.001 level

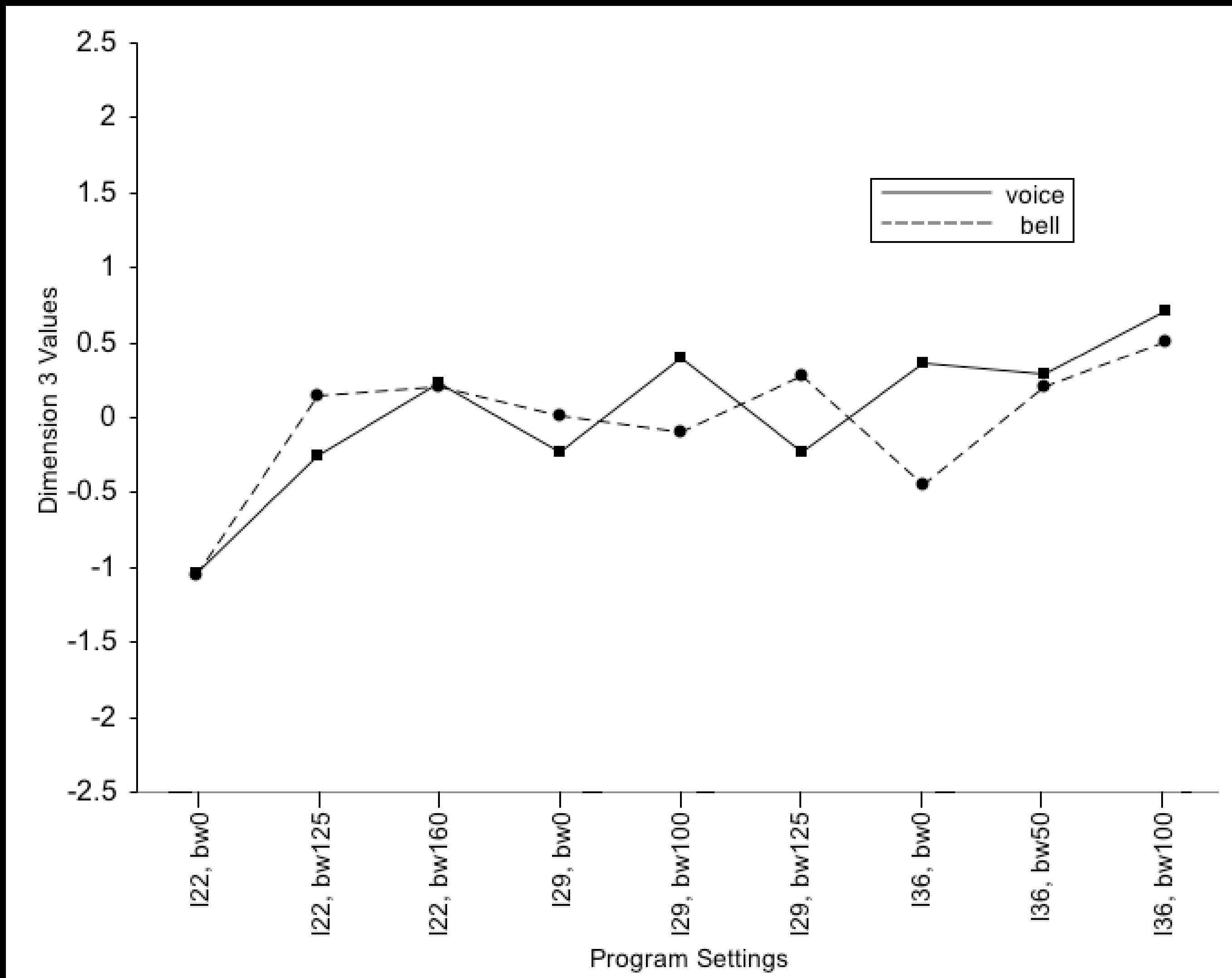
Exp 2 - 3d MDS, Dim 2



Exp 2 - randomized duration

- 3d MDS - dimension 3
  - maximum length scaled by log-2
  - settings & measurements agree
  - significant at $p<.001$ level

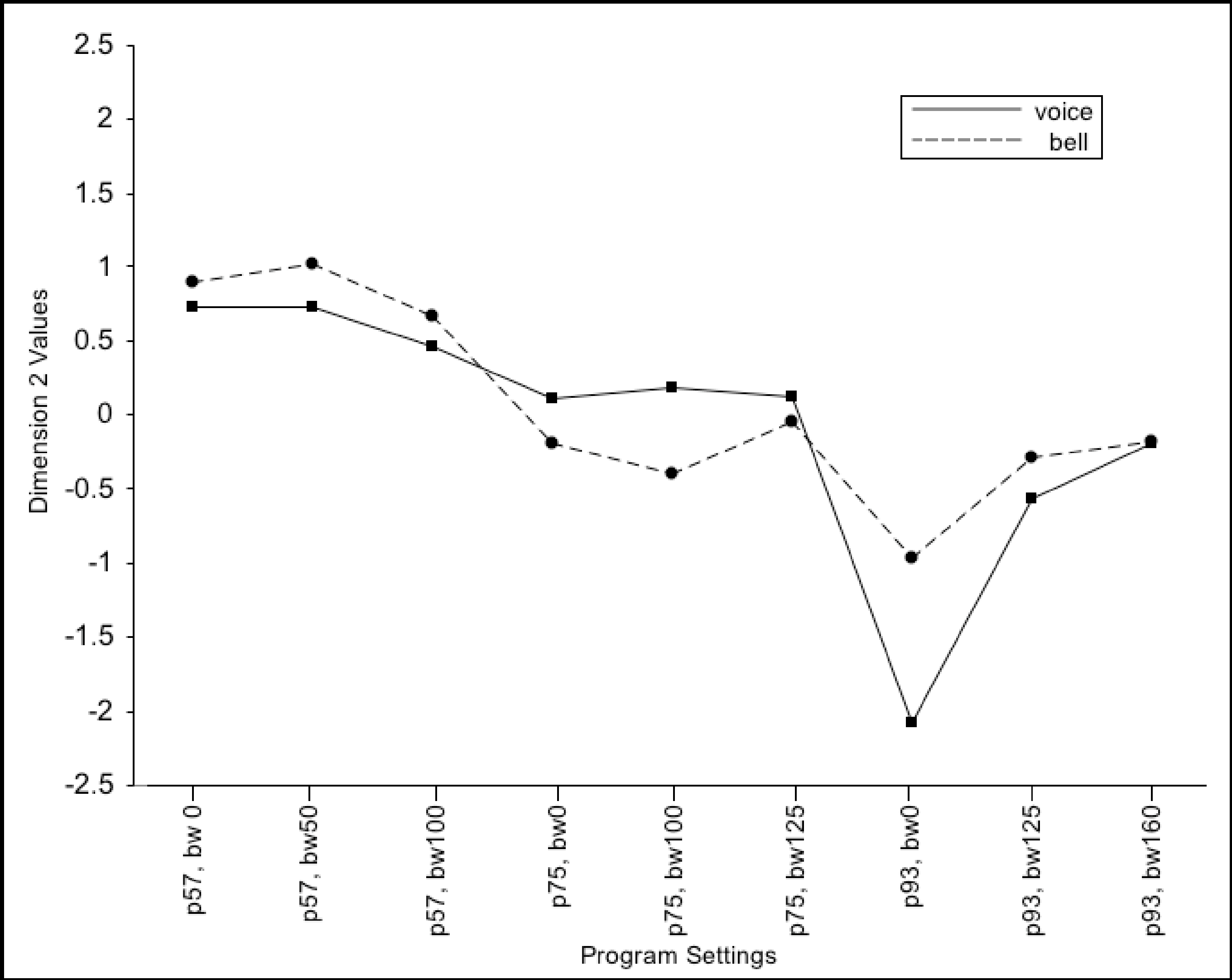
Exp 2 - 3d MDS, Dim 3



Exp 3 - randomized period

- 2d & 3d MDS - dimension 2
  - grain period & grain delay
  - significant at $p<.001$ level
  - perfectly correlated to each other

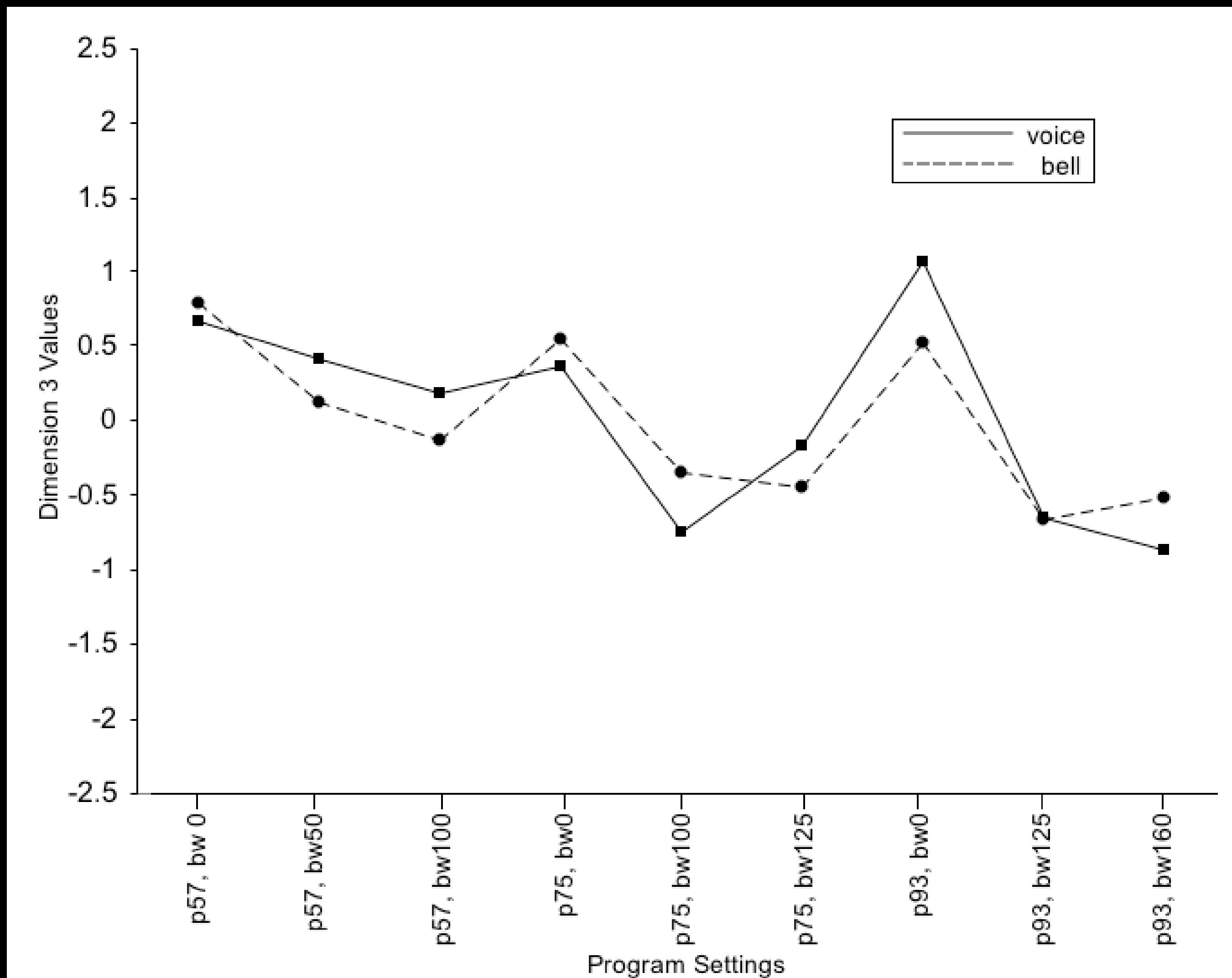
Exp 3 - 3d MDS, Dim 2



Exp 3 - randomized period

- 3d MDS - dimension 3
  - grain period bandwidth in ms
  - settings separate ms from %
  - significant at p<.001 level

Exp 3 - 3d MDS, Dim 3



Summary of Findings

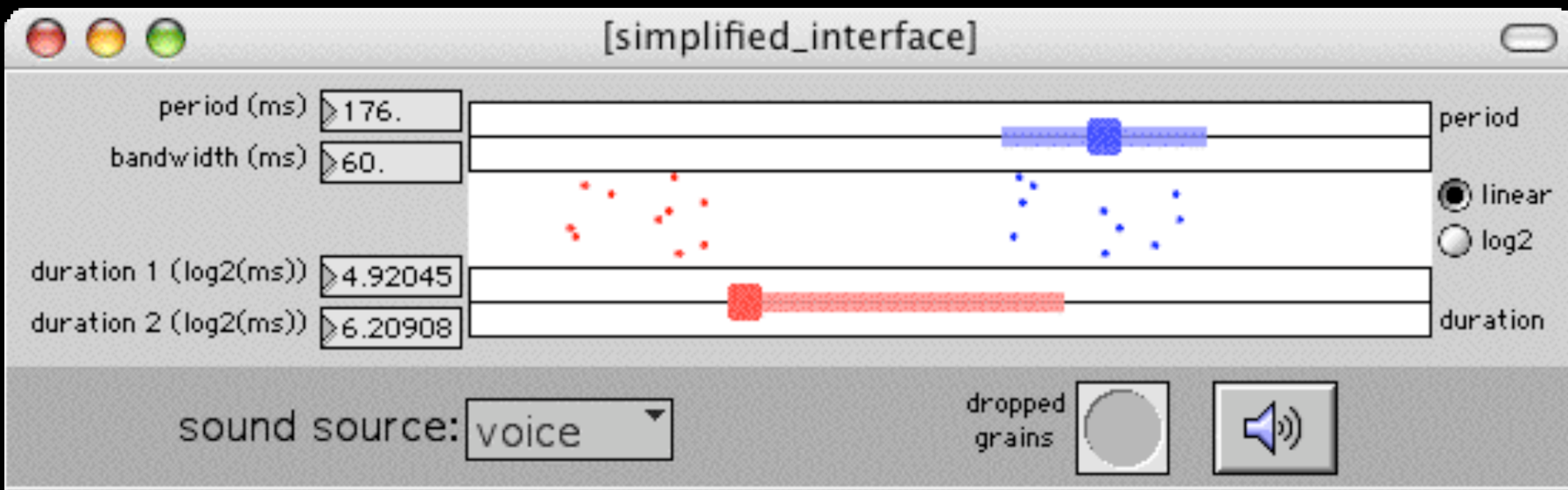
- durations
  - specified directly
  - log-2 scaling
  - max/min when randomized
- voice organization
  - period vs. others
  - mean/bw when randomized
- settings vs. measurements

IV. Application of Findings

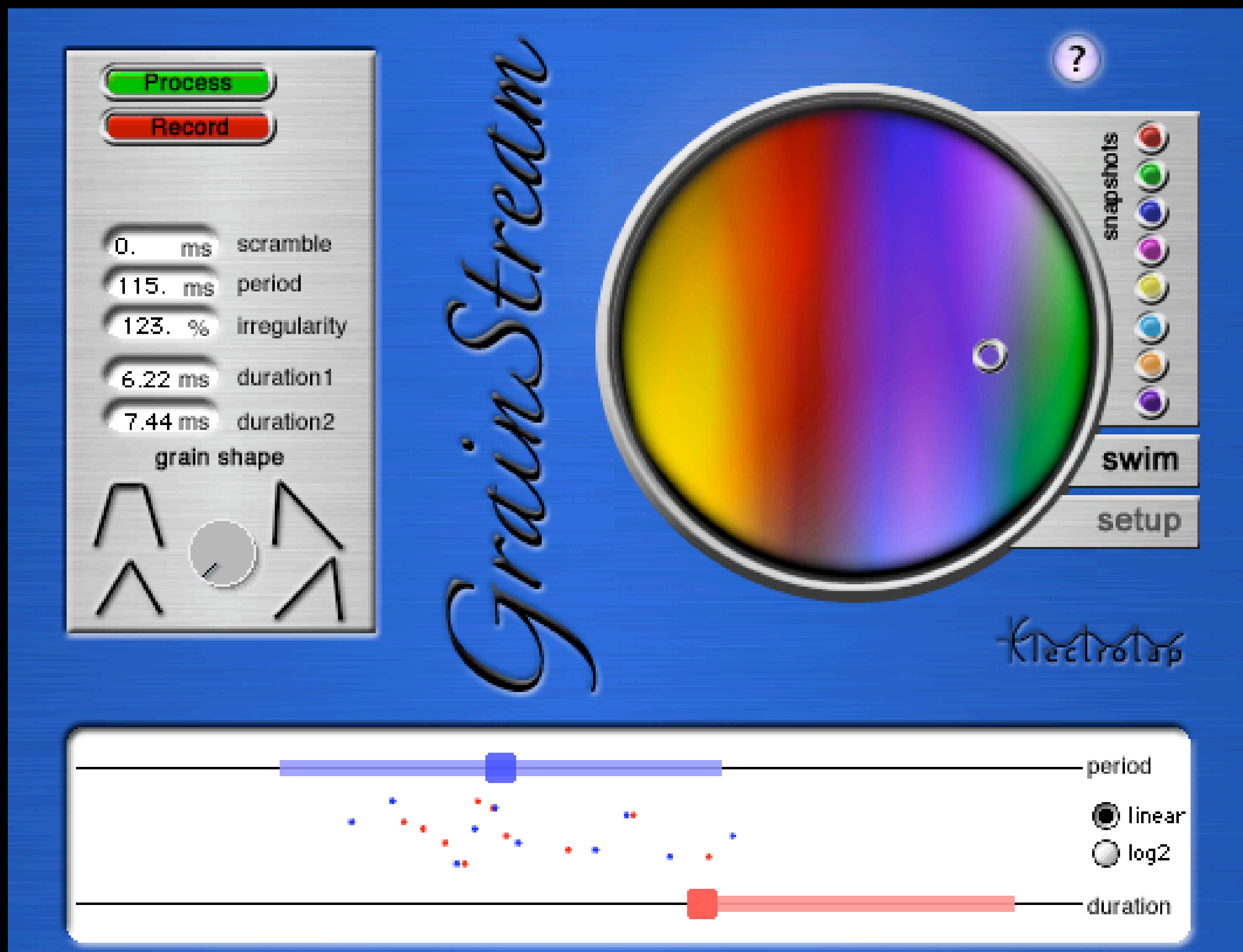
GUI Design Issues

- Sliders
  - visibly define range and current setting
  - one click per parameter change
- Audio Output
  - randomization results in differences between control settings and output
- different scaling functions
- different randomization controls

Prototype Interface



GrainStream Interface



Reflections

- use of new scaling for duration
- UI design based on findings
- results countered earlier intuitions
- evidence to support revision

Future Directions

- examine scaling issue directly
- study other granular parameters
- study more complicated textures
- revisit secondary inquiry directly
- use of other methods, not MDS

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