## 2nd International Symposium

## Basal Ganglia Speech Disorders and Deep Brain Stimulation

## Aix en Provence, June 29-July 1, 2010


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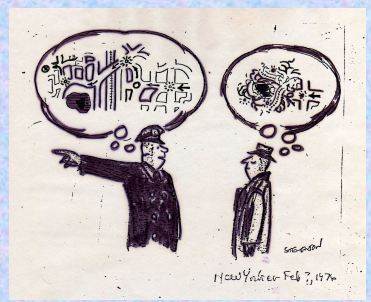
**One can wax philosophical about intelligibility**

## Some Dynamics of Intelligibility[1]

- ❖Speaker-listener dyad
  - Dialogic linguistics
- ❖Multifaceted construct[1]
- ❖Many contextual variables
  - semantic (linguistic) predictability
  - semantic (thematic) cohesion
  - length
  - shared knowledge
  - supplemental cues
  - listener experience
- ❖Comprehensibility vs intelligibility
- ❖Subjective vs objective measures
  - Ratings
  - Transcription

[1]Hustad & Weismer, 2007

Some recent studies of intelligibility in speech


Bunton, K., & Keintz, C. K. **(2008).**
Carter, C., Yorkston, K., Strand, E., & Hammen, V. **(1996).**
D'Alatri, L., Paludetti, G., Contarino, M. F., Galla, S., Marchese, M. R., & Bentivoglio, A. R. **(2008).**
De Letter, M., Santens, P., & Van Borsel, J. **(2005).**
De Letter, M., Santens, P., De Bodt., M., Van Maele, G., Van Borsel, J., & Boon, P. **(2007).**
Hustad, K. C. **(2006).**
Hustad, K. C. (**2006).**
Hustad, K. C. **(2007).**
Hustad, K. C. & Beukelman, D. R. (**2001).**
Hustad, K. C. & Beukelman, D. R. **(2002).**
Hustad, K. C. & Cahill, M. A. **(2003).**
Hustad, K. C., Dardis, C. M., & McCourt, K. A. **(2007)**.
Hustad, K. C. & Lee, J. (**2008)**
Hustad, K. C. & Weismer, G. **(2007)**.
Jaywant, A. & Pell, M. D. **(2009).**
Johnston, J. K. **(2009).**
Klasner, E. R., & Yorkston, K. M. **(2005).**
Liss, J. M., Spitzer, S. M., Caviness, J. N. & Adler, C. **(2002).**
Sitler, R., Schiavetti, N., & Metz, D. E. **(1983).**
Spitzer, S. M., Liss, J. M. Caviness, J. N. & Adler, C. **(2000).**
Tikofsky, R. S. & Tikofsky, R. P. **(1964).**
Tjaden, K. K. & Liss, J. M. **(1995).**
Weismer, G., & Martin, R. **(1992).**
Weismer, G., Jeng, J., Laures, J. S. & Kent, R. D. **(2001).**
Yorkston, K., Strand, E., & Kennedy, M. **(1996).**
Ziegler, W. **(2003).**


## One Can Wax Philosophical Over Intelligibility

Ambient conditions
- Noise
- Distance between speakers
- Attention vs distraction
- Recording qualities

Listener characteristics (many)
- **Subjective ratings**

Language parameters
- **Linguistic redundancy**
- Thematic content
- Lexical frequency
- Overlearned vs novel phrases

Speech features
- Speaker effects
  - Individual differences
- Rate
- Pausing
- **Task**
  - **Spontaneous speech**
  - **Repetition**

❖**Perspectives on linguistic redundancy**

-Transitional probabilities in verbal strings
syntactic
semantic
conventional phrases

-Top-down interacting with bottom-up processing

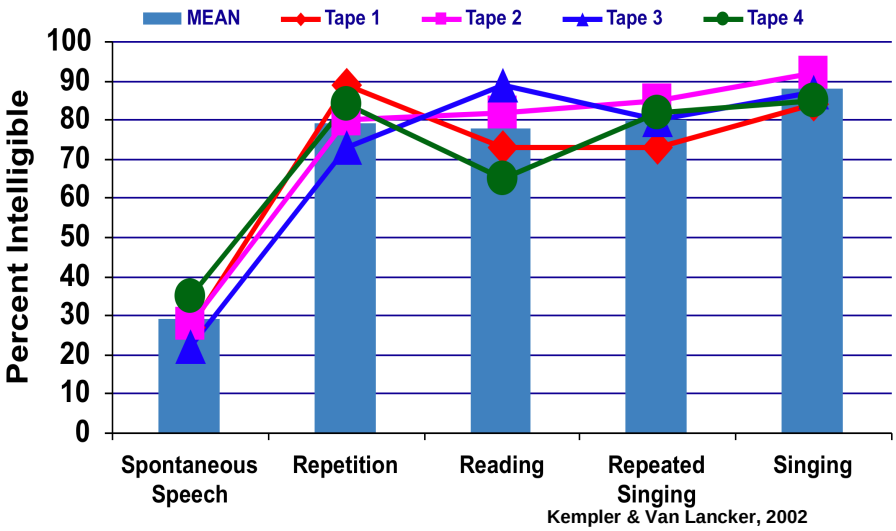
❖**Previous studies on task effects**

-Various uses of the term *task*
-Study by Kempler & Van Lancker, 2002

Severe dysarthria, single case
Intention: compare effects of singing

KEMPLER, D.; VAN LANCKER, D. (2002). The effect of speech task on intelligibility in dysarthria: case study of Parkinson's disease. Brain and Language, 80, 449-464.
KENT, R.D.; KENT, J.F. (2000). Task-based profiles of the dysarthrias. *Folia Phoniatrica et Logopaedica, 52,* 48-53.

## Intelligibility in five vocal tasks: previous study



## Intelligibility Study with 6 PD DBS ON-OFF & 5 PD Subjects

- Language parameters
  - Linguistic redundancy
    - (observed accuracy from written responses alone)
- Speech features
  - Task (matched utterance types)
    - Spontaneous speech
    - Repetition
- Listener characteristics
  - Inexperienced with material
  - Native speakers of English
  - Difficulty ratings

PD-DBS subjects

| # | Age | Years of Education | Age at Diagnosis | Years since diagnosis | Months since DBS |
|---|---|---|---|---|---|
| 1 | 59 | 15 | 49 | 10 | 9 |
| 2 | 62 | 18 | 47 | 15 | 2 |
| 3 | 61 | 14 | 50 | 11 | 12 |
| 4 | 49 | 16 | 40 | 9 | 4 |
| 5 | 62 | 16 | 51 | 11 | 56 |
| 6 | 56 | 18 | 45 | 11 | 37 |
| means | 58.17 | 16.17 | 47.00 | 11.17 | 20.00 |

PD subjects

| # | Age | Years of Education | Age at Diagnosis | Years Since Diagnosis |
|---|---|---|---|---|
| 1 | 73 | 17 | 65 | 8 |
| 2 | 71 | 16 | 61 | 10 |
| 3 | 60 | 15 | 53 | 7 |
| 4 | 70 | 20 | 60 | 10 |
| 5 | 62 | 15 | 47 | 15 |
| means | 67.2 | 16.6 | 57.2 | 10 |

Subjects had mild to no dysarthria

## Acquisition of speech samples

- Five minute conversational samples were recorded from each subject--OFF and ON DBS and nonDBS PD.
- 30 phrases free of proper nouns or specialty vocabulary were excerpted from the recording.
- These 30 phrases were re-ordered and presented to the subject in a repetition format. The repeated phrases were recorded for later analysis.

## Design of listening task

**Ten phrases were chosen out of the 30 obtained from each subject.**

**Conversational phrases were matched for each subject and for DBS on and off on number of words (+/- 1) and number of syllables (+/- 4).**

**Paired repetition productions were randomized into the list.**

**Conversation and repetition exemplars were separated for listening.**

| | CD A | CD B |
|---|---|---|
| **120 Phrases PD + DBS 6 subjects** | CON | CONREP |
| | • 5 ON-short | • 5 ON-short |
| | • 5 OFF- long | • 5 OFF-long |
| | CONREP | CON |
| | • 5 ON- long | • 5 ON- long |
| | • 5 OFF-short | • 5 OFF- short |
| **50 Phrases PD 5 Subjects** | CON | CONREP |
| | • 5- short | • 5- short |
| | CONREP | CON |
| | • 5- long | • 5- long |

**ANSWER SHEETS: Provided linguistic support**

**Audio: practice items with feedback.**

| Utterance | | Degree of Difficulty (1=least difficult, 5=most difficult) | | | | | |
|---|---|---|---|---|---|---|---|
| | | easy | | | | | hard |
| Practice A: | We tried to relax | 1 | 2 | 3 | 4 | 5 | |
| Practice B: | I _____ know why | 1 | 2 | 3 | 4 | 5 | |
| Practice C: | I'm still a _____ _____ | 1 | 2 | 3 | 4 | 5 | |
| Practice D: | This was _____ _____ story | 1 | 2 | 3 | 4 | 5 | |

**Sample test items for listening and writing protocols**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1) | He _____ it | 1 | 2 | 3 | 4 | 5 |
| 2) | I'm pretty happy _____ | 1 | 2 | 3 | 4 | 5 |
| 3) | _____ _____ my _____ to agree | 1 | 2 | 3 | 4 | 5 |
| 4) | I didn't _____ | 1 | 2 | 3 | 4 | 5 |
| 5) | The dog is _____ | 1 | 2 | 3 | 4 | 5 |

**Characteristics of participants: listening & writing**

| | Average Age | Age Range | Average Years of Education | Years of Education Range | # of Males | # of Females |
|---|---|---|---|---|---|---|
| CD A Listeners | 41 | 18--66 | 16 | 12--22 | 2 | 13 |
| | | | | | | |
| CD B Listeners | 41.9 | 17--82 | 14.5 | 10--18 | 5 | 10 |
| | | | | | | |
| Writing | 41 | 22--60 | 16 | 12--20 | 8 | 7 |

(Conversation & conversation-repetition modes for same utterance type appeared in separate listening protocols (CDs A &B) to avoid order effects)

***Instructions to participants***

***Listeners:*** Headphones; volume adjusted to comfort during practice session; no more changes; guess even if you're not sure.

***Writers***: No "right" answers; guess even if you're not sure.

## Results for listening & writing

- **Listening: high intelligibility**

- **Writing results**: Average of 27.3 (6.4 %) of 426 words across writers were correctly identified.

  The same 12 words were correctly identified by 50% of writers; these words were eliminated in listening summaries.

| 426 Target Words | % Correct |
|---|---|
| | |
| CD A Listeners | 90.0 |
| | |
| CD B Listeners | 87.7 |
| | |
| Writing | 6.4 |

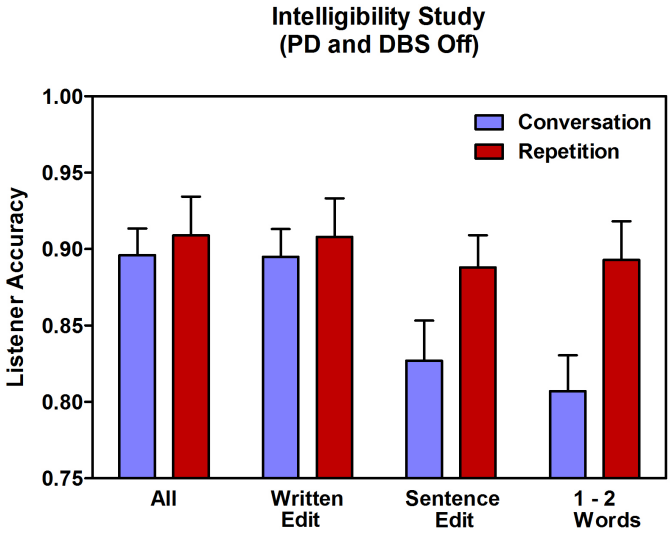
- **Listening results: Sentences removed for analysis:**

  - Removed conversation stimuli with 100% ID by listeners
    - Both conversation & conversation-repetition pairs removed

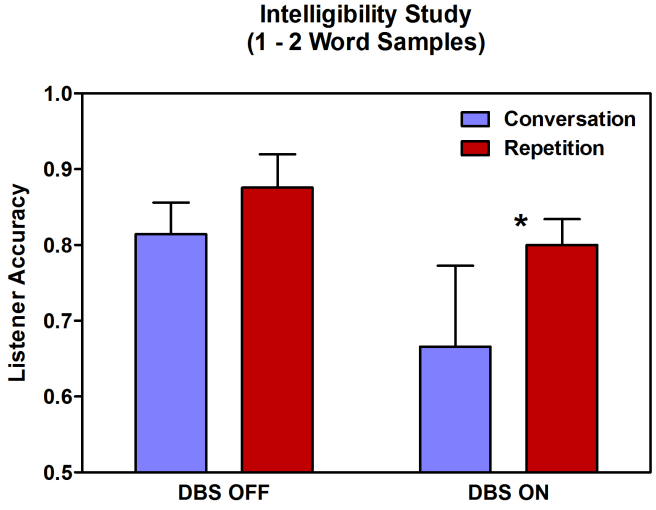
      120 sentences (of 340) removed for statistical comparisons;
      220 sentences were analyzed (110 con/con-rep pairs)

- **Analyzed target utterances with only 1 or 2 words to identify**
  - Reduces contextual support
  - Enhances difficulty

- **DBS OFF and PD subjects combined for statistical procedure**




Task x listening set: $F(3,30) = 7.15$; $p = 0.001$



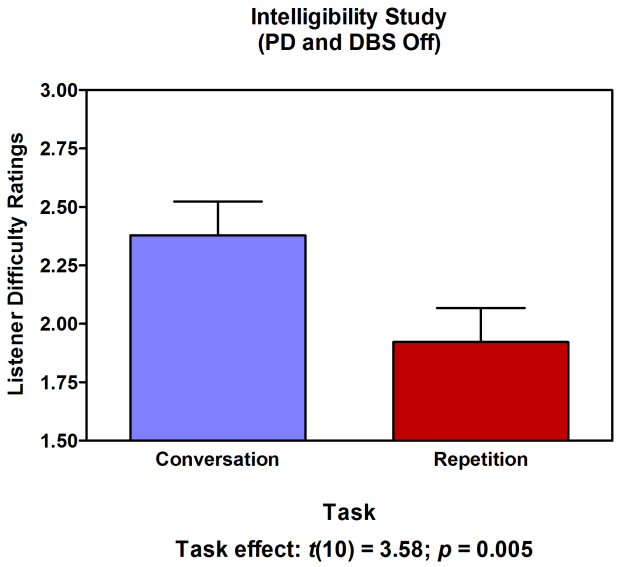

* $t(5) = -4.207$; $p = 0.008$

## Summary

- Speech samples from DBS OFF and PD were combined for analysis.
- A significant effect of “listening set” – whether easy or difficult– was found.
- A significant interaction between task and type of listening set was found.
- This suggests that for the most difficult items in the intelligibility listening protocol, both DBS state and task play a role in intelligibility.
- Intelligibility is higher for repetition than conversation.
- Intelligibility is higher for DBS-OFF than DBS-ON.
- DBS ON has a negative effect on intelligibility in conversation.

## Subjective ratings of difficulty

- Ratings from samples taken from DBS OFF and PD were combined.
- Items spoken in **conversation mode** were rated significantly more difficult than those in **repetition mode**.
- These results support objective intelligibility measures.




## Acoustic measures and perceptual ratings of speech

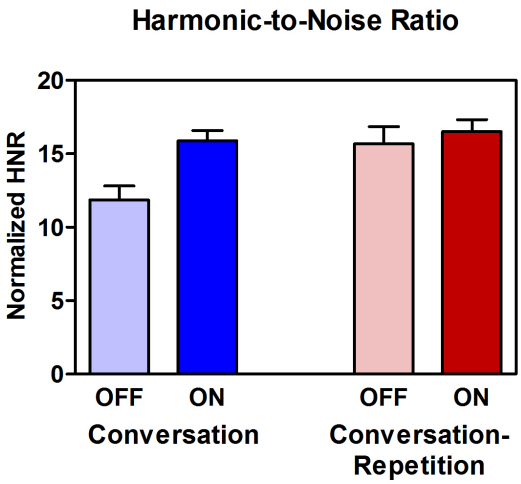
- **Previous results from 7 DBS subjects***

  1. Acoustic measures of voice (HNR) and fluency (syllable counts)

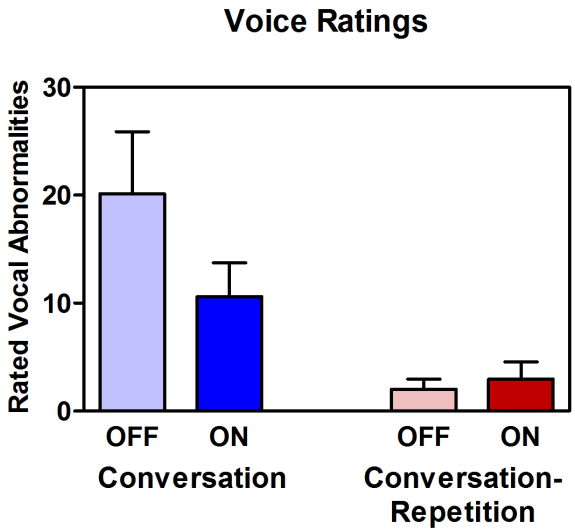
  2. Perceptual ratings of voice and fluency

- **Consistent with objective and subjective measures of intelligibility from listeners**

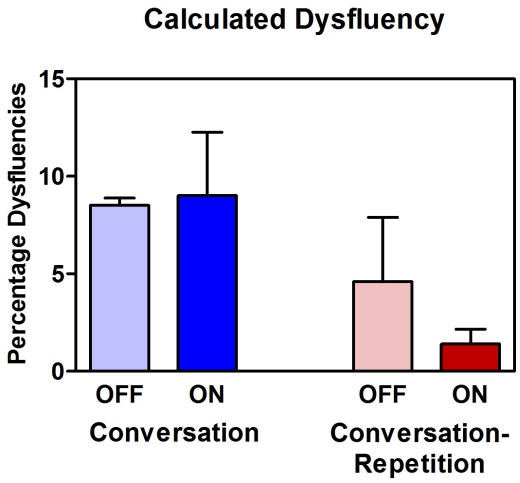
*Sidtis, D., Rogers, T., Godier, V., Tagliati, M., & Sidtis, J.J. (2010). Voice and fluency changes as a function of speech task and deep brain stimulation. Journal of Speech Language and Hearing Research, in press



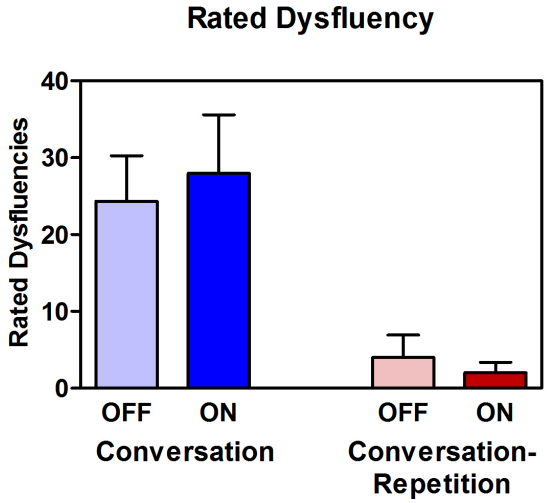

Significant effect of task $F(1,6) = 8.05$; $p = 0.03$




Significant effect of task $F(1,6) = 6/96$; $p = 0.039$




Significant reduction in the percent of dysfluencies during conversation-repetition compared to conversation [$F(1,6) = 7.86$; $p = 0.031$].




Significant effect of task $F(1,6) = 15.82$; $p = 0.007$

## Summary for this phase of intelligibility study

- Naturalistic speech was used
- PD subjects had mild or no dysarthria
- Two speech tasks directly compared (same utterance types)
- Linguistic redundancy played a small role
- Shorter speech stimuli were less intelligible
  - Due to vocal accommodation in longer items?
- Speech of PD with/without DBS was highly intelligible
- Both task and DBS state affected intelligibility scores
- Results are consistent with acoustic measures and perceptual ratings from previous study

## Second phase (in preparation)

- 30 new listeners (15 on each CD)
- Increase difficulty and naturalness of demand on listener
- Response sheets with no contextual support
- Compare with previous results
- Possibly more sensitive to intelligibility range
  - Compare target words and entire sentences
  - Perform comparisons on task and DBS state

**Study underway (n = 9) in collaboration with colleagues at with Mt. Sinai Hospital Movement Disorders Clinic**

- ❖ DBS subjects: 3 stimulation settings: OFF, mid, high

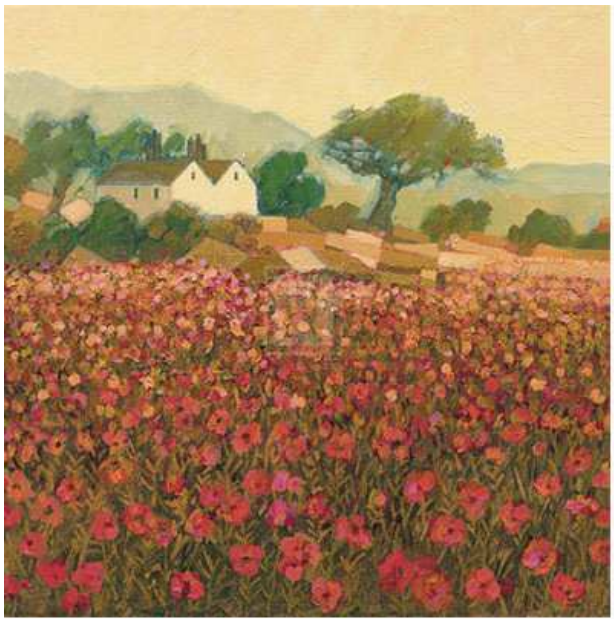
- ❖ Speech protocol at each setting
  - Reading Rainbow Passage
  - Cookie theft description
  - Sustained phonation
  - Conversation (3 minutes)
  - Conversation-repetition (phrases from conversation)
  - Verbal fluency
  - Automatic speech (counting and days of the week)
  - Pataka
  - CVC syllables (peep-poop-pop)
  - Assessment of Intelligibility of Dysarthric Speech (Yorkston & Beukelman)

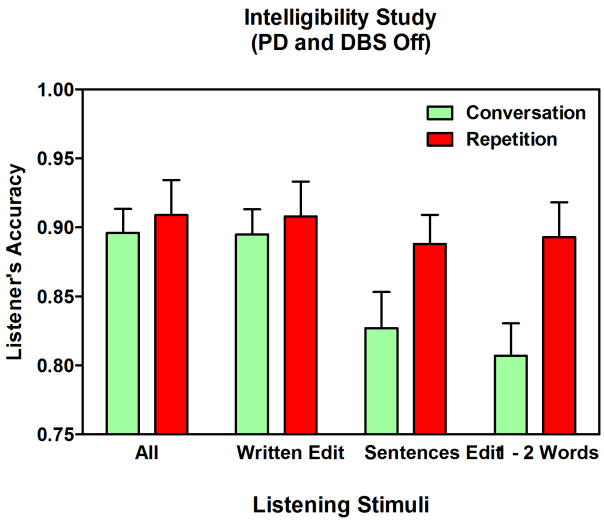
- ❖ Other tests at each settings
  - Grooved pegboard
  - Finger tapping

- ❖ UPDRS III & gait examination

**Approaches to intelligibility…**

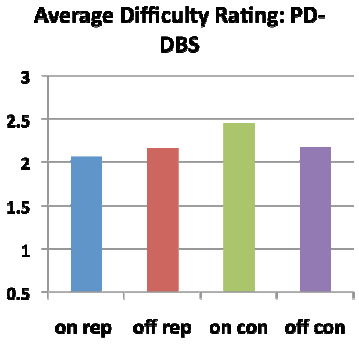

**Questions and Comments, please!**

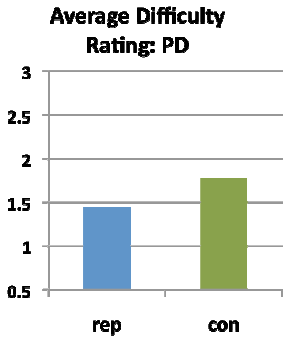


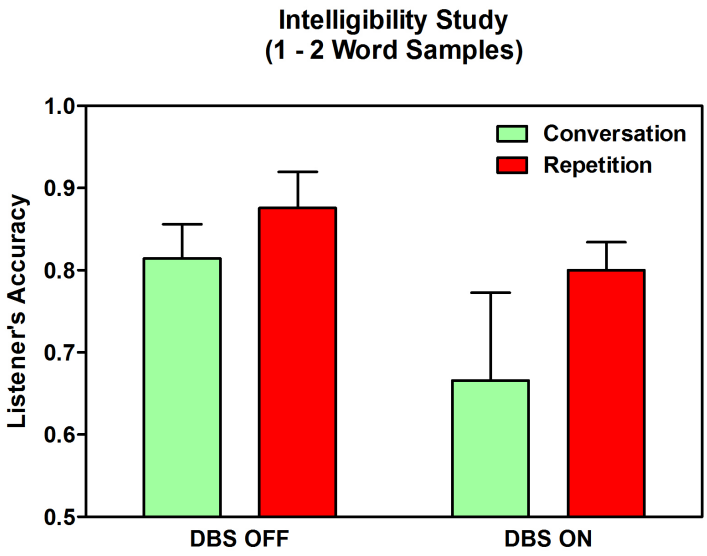



[Task by listening set: F(3,30) = 7.15; $p$ = 0.001]

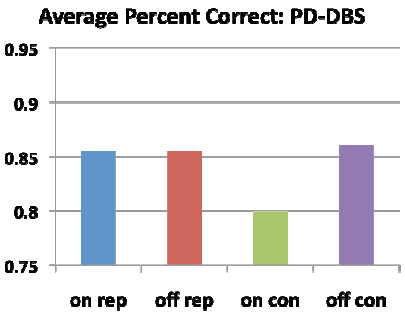
**Difficulty ratings (1-5 scale): all audio stimuli**

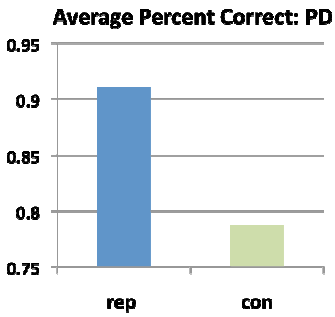


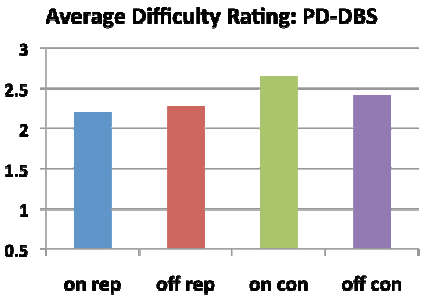

Task effect for DBS ON: t(5) = -4.207; *p* = 0.008

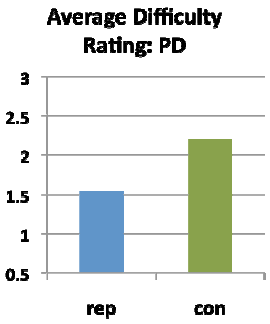


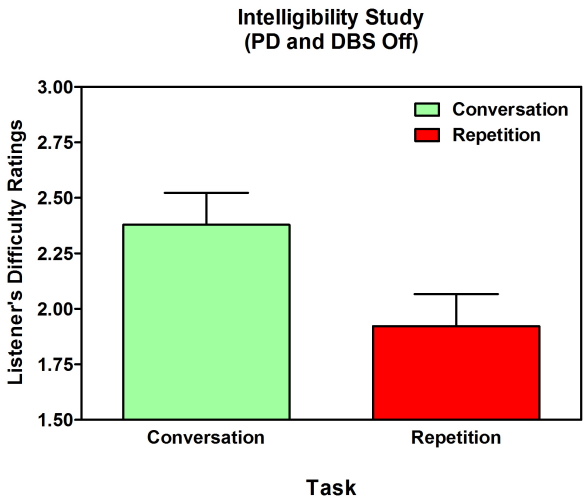




Listeners' responses
(minus 12 words from written protocol & 120 sentences identified in listening protocol)

**Mean Difficulty Ratings: High performance sentences removed**






Effect of task: t(10) = 3.58; $p$ = 0.005

**Selected sentences with least linguistic context**