Beyond speech recognition performances: The effort that older adults must deploy to process speech in noise

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The earlier series of experiments were part of the doctoral work completed by :

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Preface

Audiology:

- use % speech recognition scores to characterize speech perception
- DIAGNOSIS (e.g., APD, correspondence audiogram, difference bet. ears)
- Other dimensions of speech processing are important but not considered

Depending on the circumstance, speech understanding can be more or less effortful

- People with hearing loss
- Processing speech in L2
- Noise, talker accent, content of message, etc…

The interaction between sensory/perceptual processing and speech/cognitive processing

Age-related difficulties in hearing has an influence on cognitive/ linguistic processing

The effects of mild hearing loss on speech under-standing in noise

(Crandell et al., 1995)

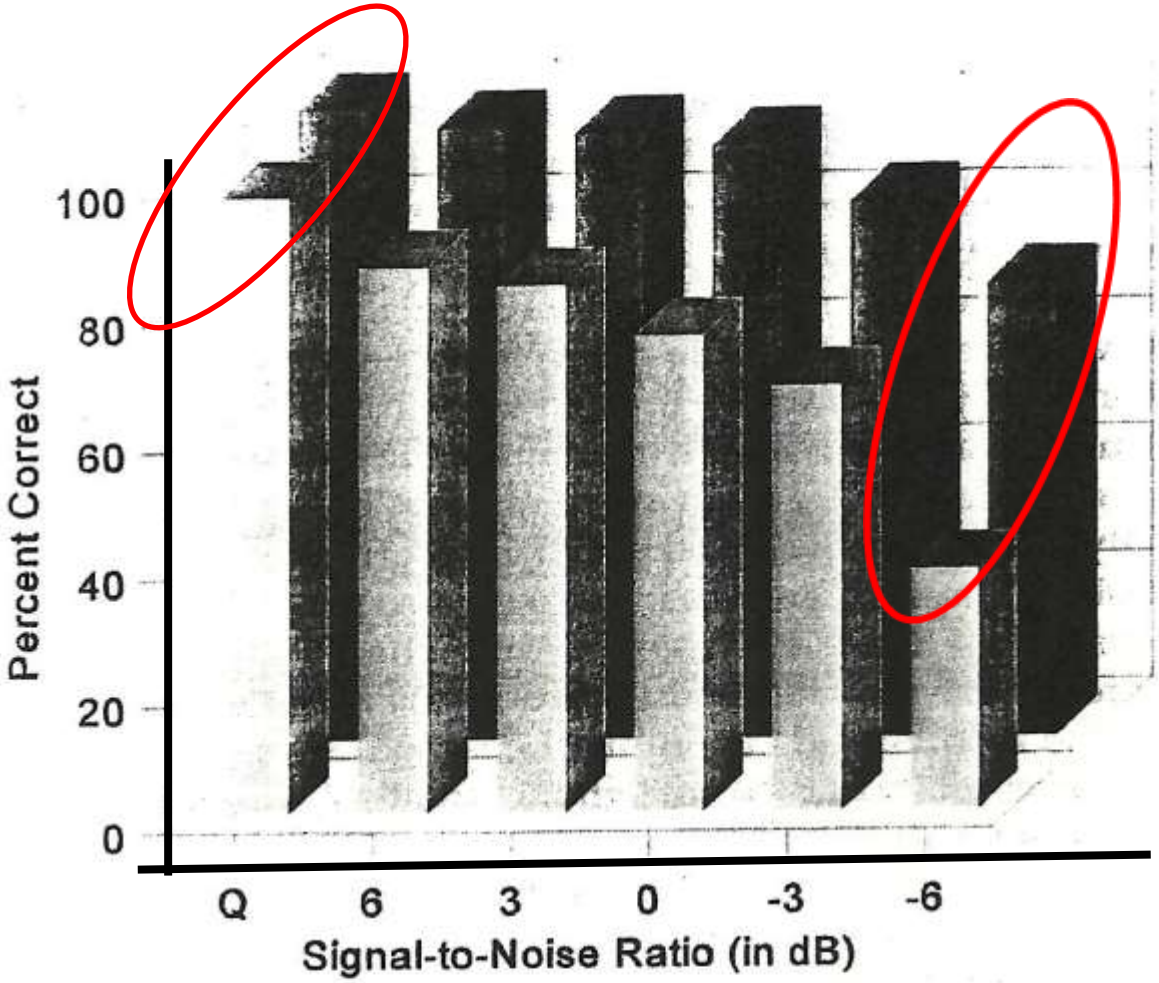


Figure 20–2 Mean speech recognition scores (in % correct) of children with normal-hearing (*dark shaded bars*) and children with minimal degrees of SNHL (*light shaded bars*) in quiet and at various SNRs. (Adapted from Crandell et al [1995].)

Interaction of :

- audibility (incl. the effects of noise)
- Speech-recognition
- Cognitive/linguistic processing

Speech Perception in Noise (SPIN) test

Low-predictability sentences:

He didn't know about the spoon.

John was aware of the crib.

The man had not discussed the oath.

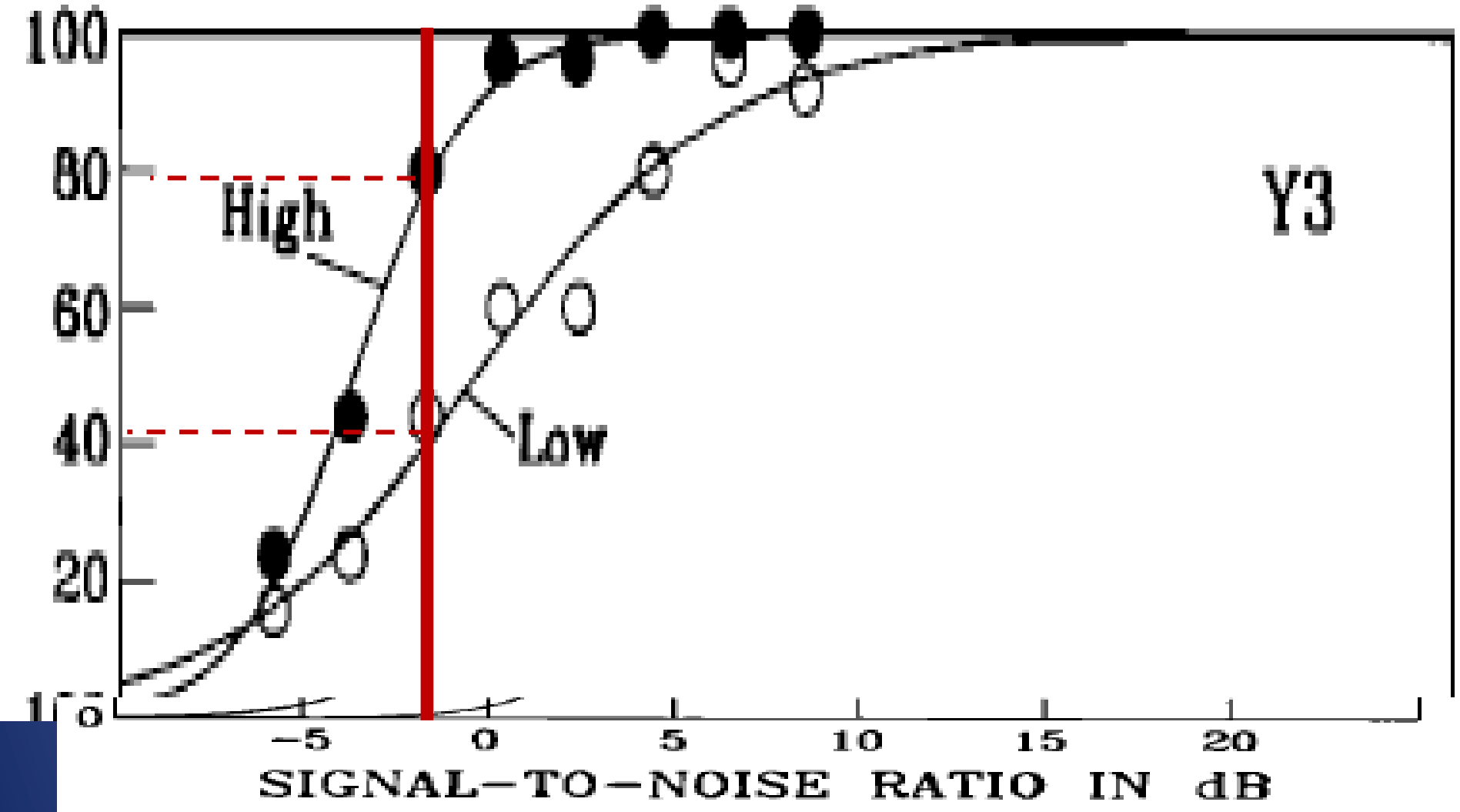
High-predictability sentences:

Stir you coffee with a spoon.

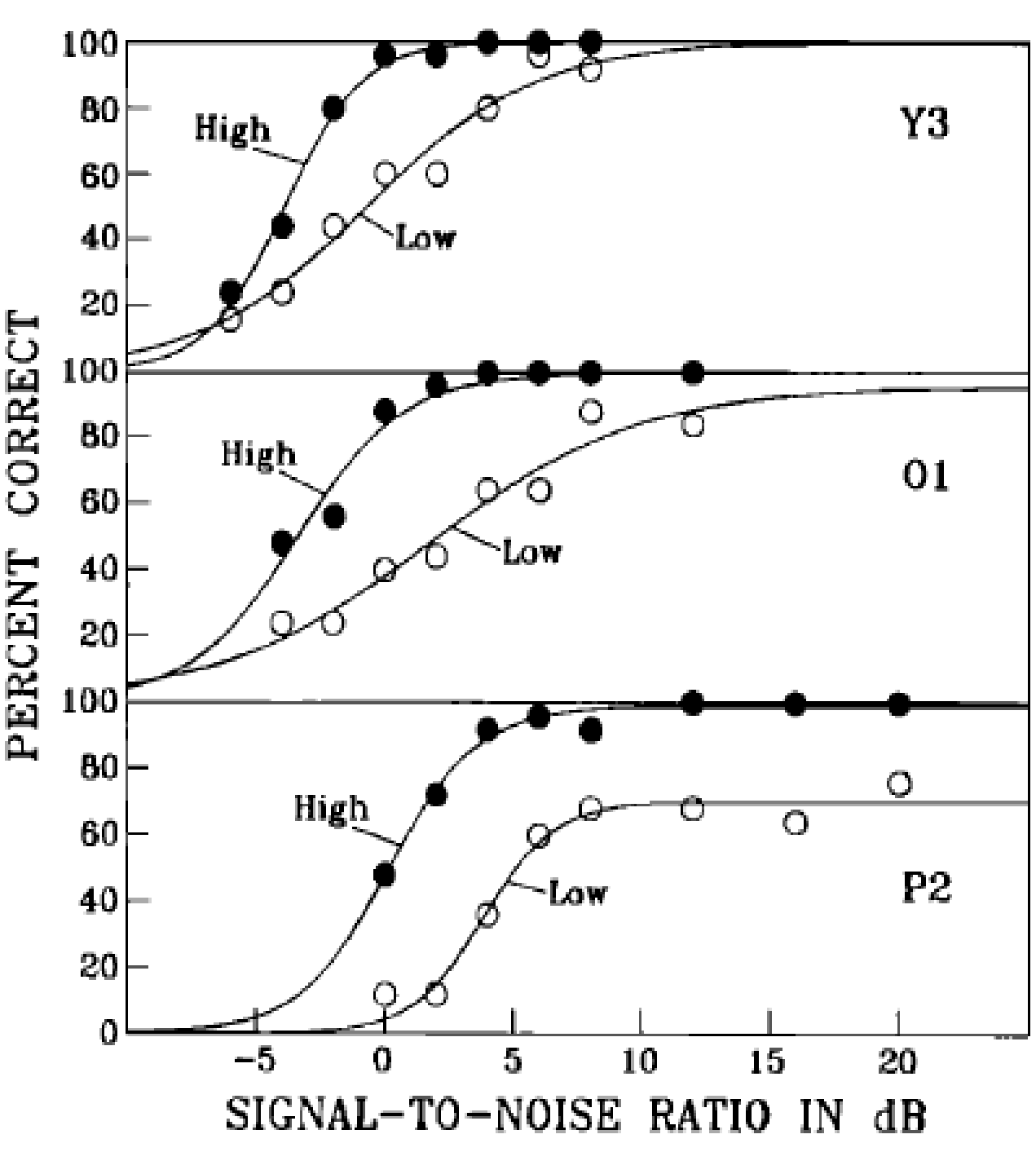
The baby slept in his crib.

The witness took a solemn oath.

Speech Perception in Noise test (Spin: Bilger et al., 1988) sentences (Kalikow, Stevens, & Elliott, 1977)



Pichora-Fuller, Schneider, Daneman, JASA: 1995



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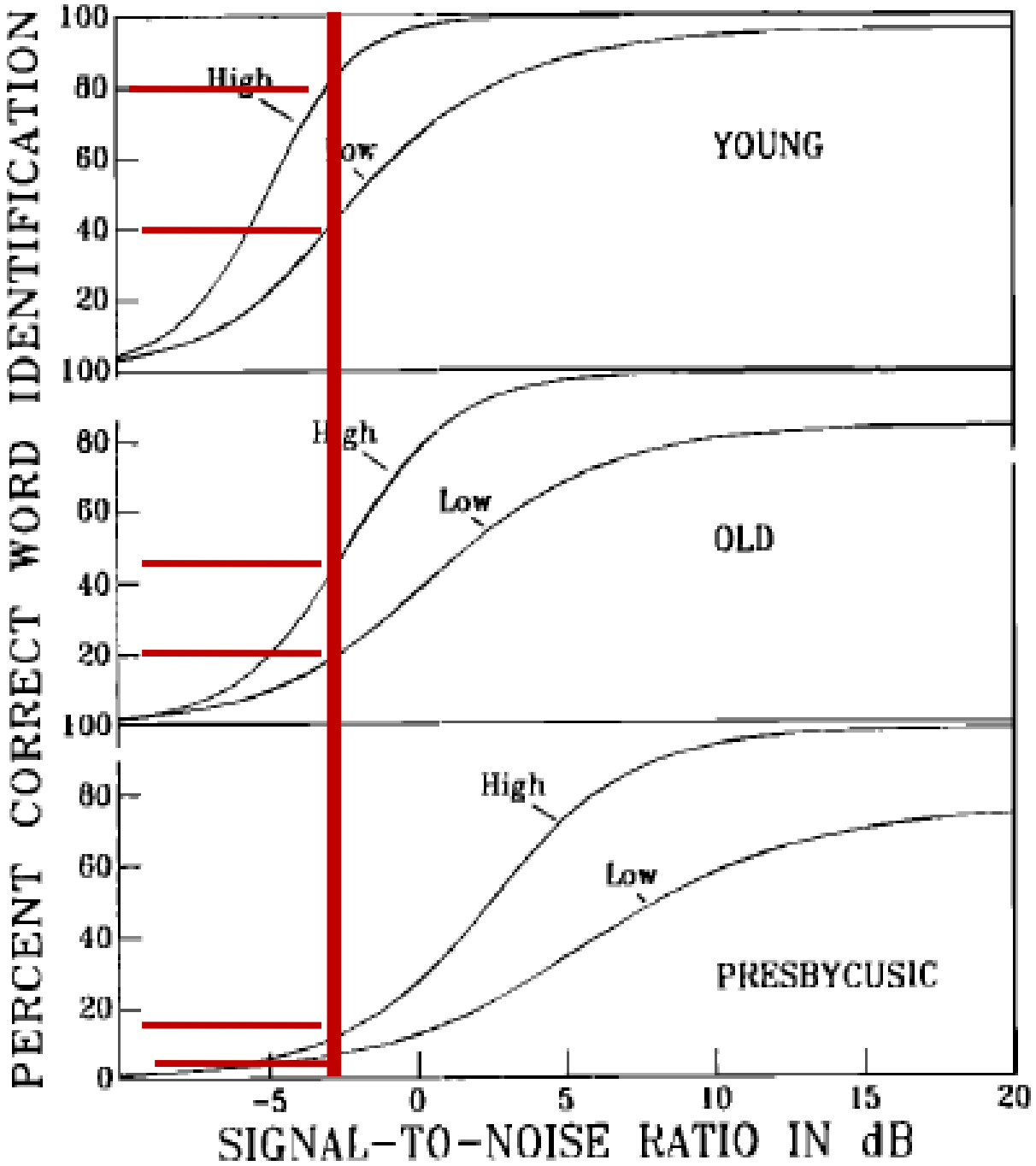
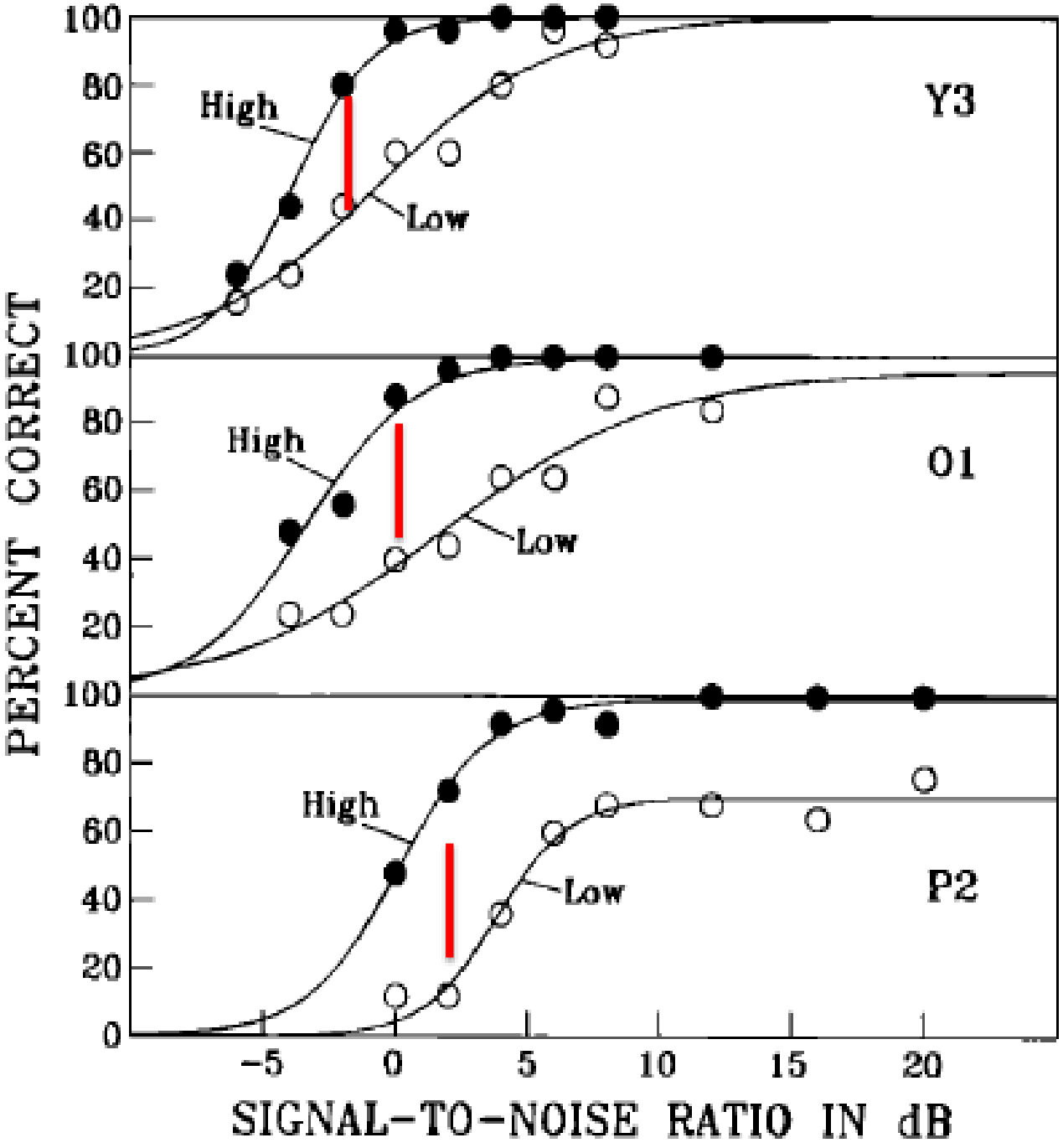


Pichora-Fuller, Schneider, Daneman, JASA: 1995



Pichora-Fuller, Schneider, Daneman, JASA: 1995

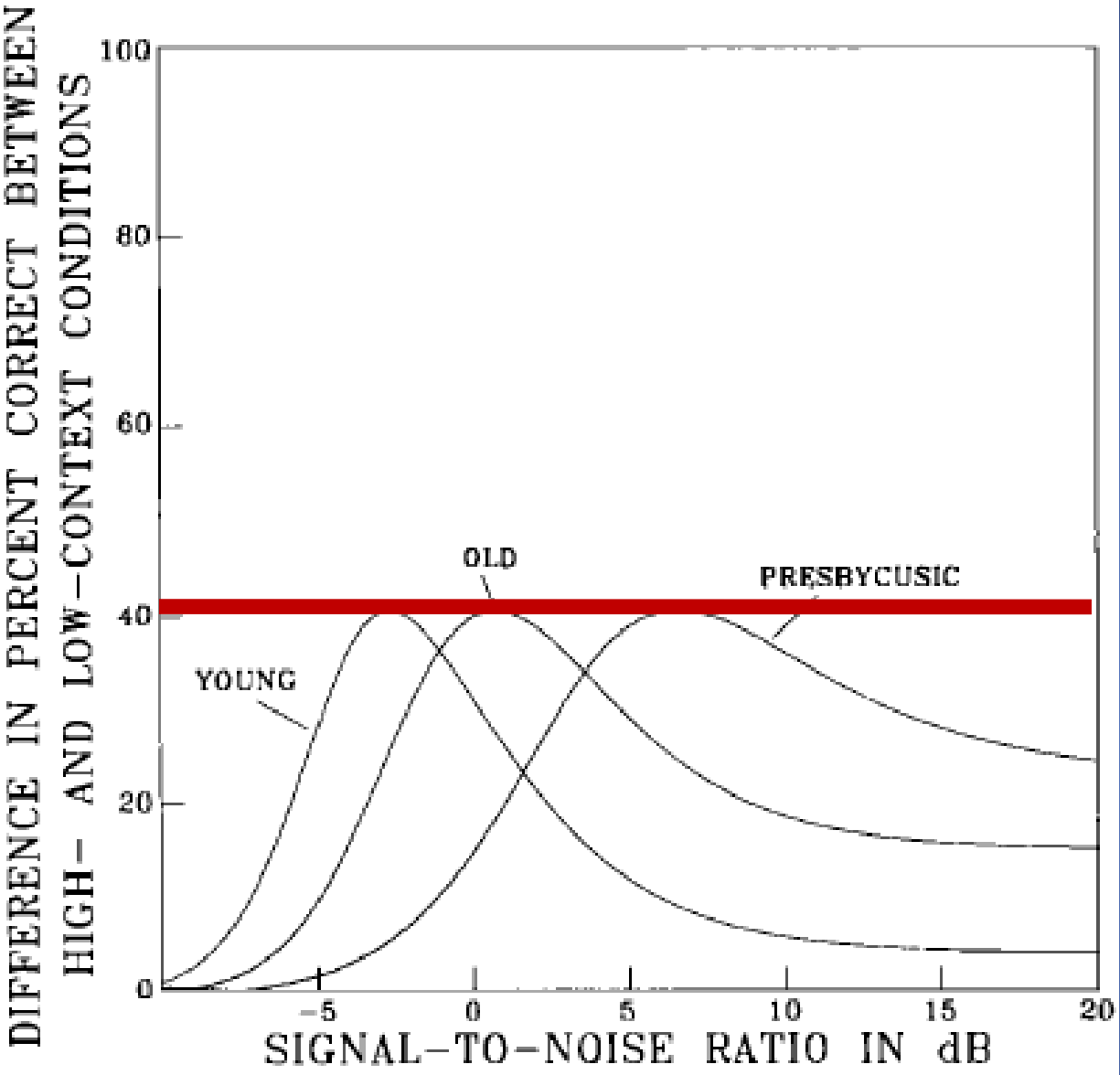
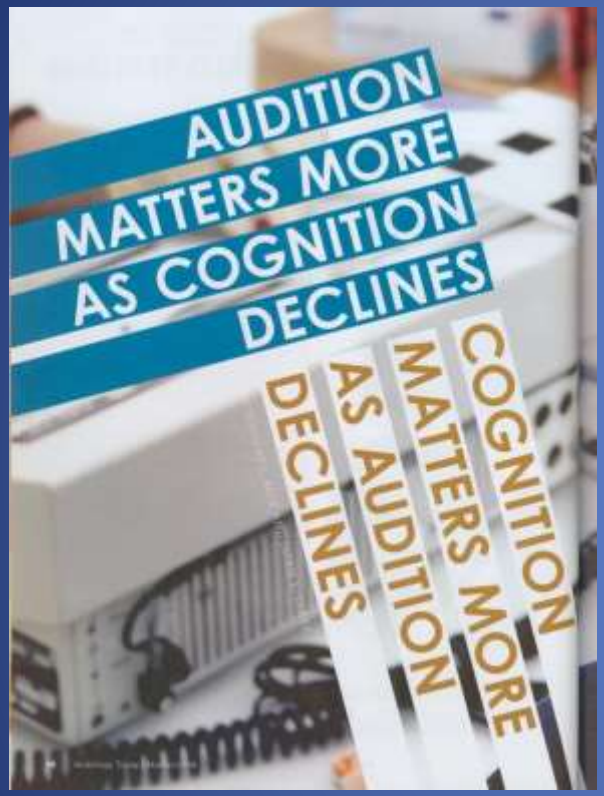


FIG. 2. A plot of the difference between high- and low-context conditions for the three hypothetical subject groups (young, old, presbycusics) portrayed in Fig. 1.

Pichora-Fuller, Schneider, Daneman, JASA: 1995

Audition and cognition



Hearing and cognition are not the same but they are interrelated in many ways

Especially when speech is presented under difficult conditions

Beck, D. L., & Clark, J. L. (2009). Audition matters more as cognition declines: Cognition matters more as audition declines. Audiology Today, 21(2), 48-59.

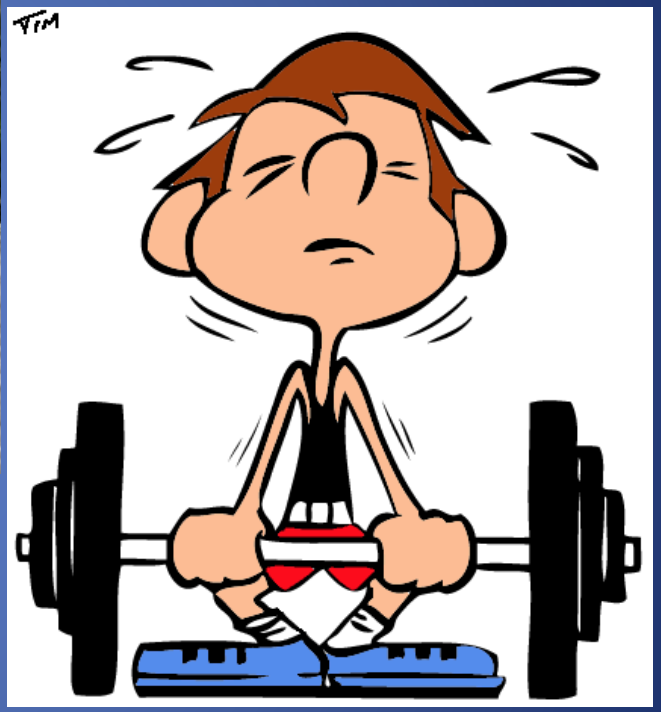
Listening in noise

- Older adults say …
  - "Listening in noise is a challenging and exhausting experience"
- From the literature
  - Even with normal hearing sensitivity, older adults perform more poorly than young adults on speech recognition tasks presented with background noise (CHABA, 1988).

Point: Beyond audibility/perception and language knowledge and cognitive factors are essential for speech understanding.

EFFORT

What is it?



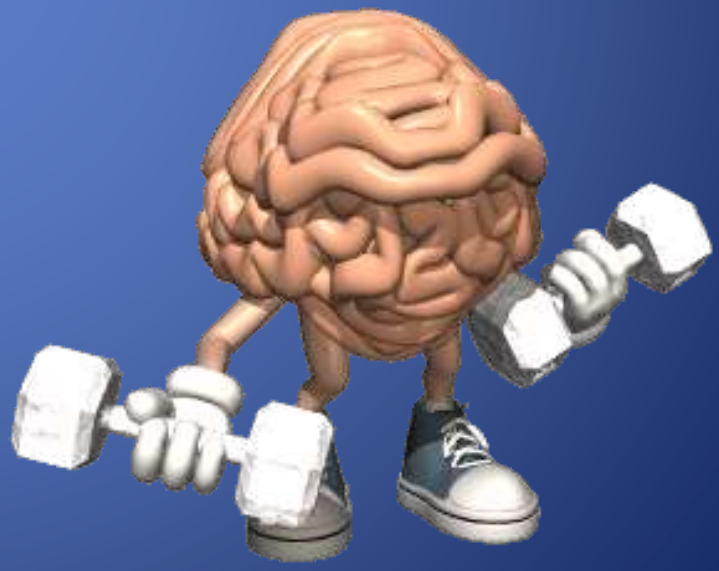
What is listening effort?

Effort is not the same as performance

Listening effort

Definition:

Attentional and cognitive resources required to understand speech (Downs, 1982)



Why measure listening effort?

- Further elucidate the relationship between sensory(hearing) and perceptual/cognitive processing
- To explain individual differences in speech perception tasks among people with similar predicaments
- Outcome measure: the effects of a given rehab. treatment on cognitive processing of speech (e.g., signal processing in hearing aids; speechreading and AV speech recognition)

How to measure listening effort

- Self-report (rating scales)
- Physiological measures
  - Cortisol level
  - Pupil Dilation
  - EEG
  - fMRI
  - ERP

How to measure listening effort

- Behavioral measures
  - Recall
  - Single task paradigm
    - Reaction time measures
  - Dual task Paradigm
    - Ecological validity

Dual task and multi-task examples

- Driving and cell phone use

Dual task and multi-task examples

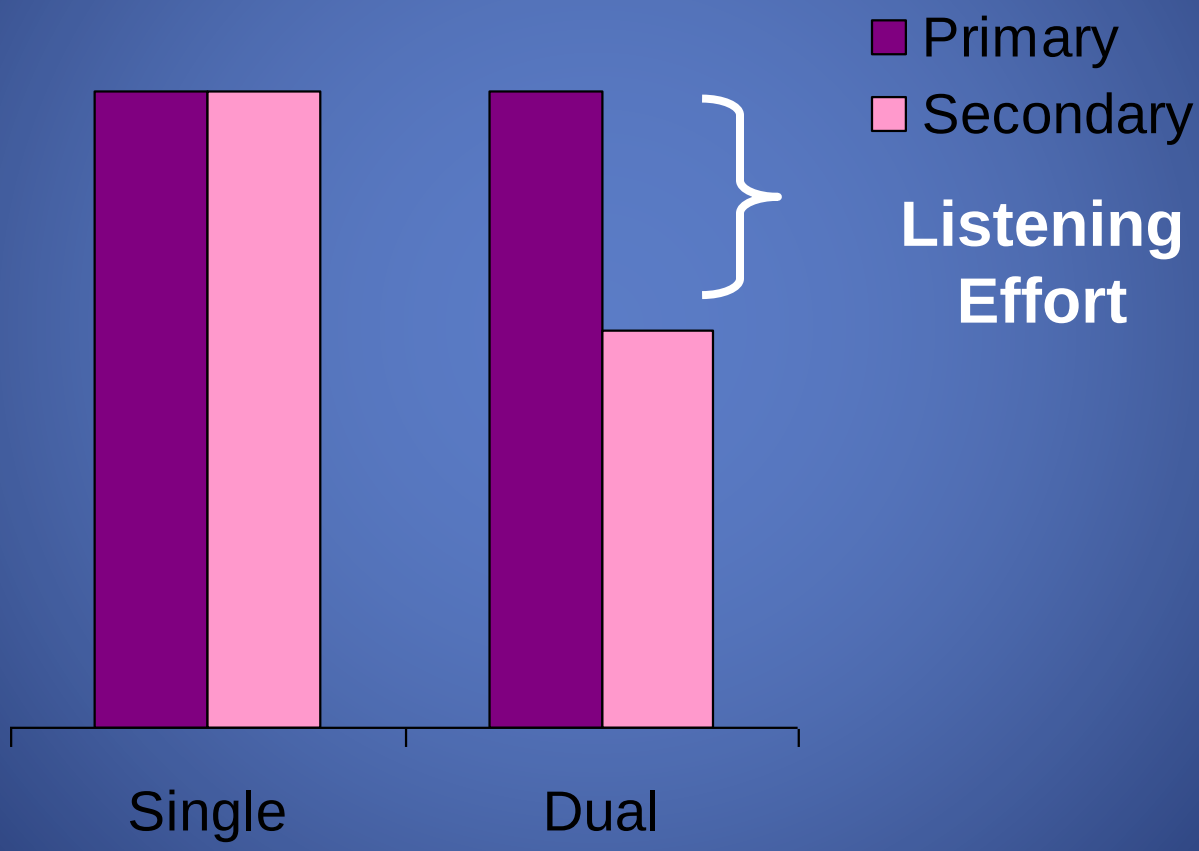
- Extreme driving

Dual task paradigm

- What are the “tasks”?
  - There are 2 tasks
  - Primary task (word recognition task)
  - Secondary task (tactile pattern recognition task)

- What do participants do?
  - Participants complete each task separately and then concurrently

Dual task paradigm theory



Anderson Gosselin, P., & Gagné, J.-P. (2010). Use of a dual-task paradigm to measure listening effort. Journal of Speech-Language Pathology and Audiology, *34(1), 43-51.*

Dual task paradigm theory

- Operational definition of listening effort:
  - Declines in concurrent secondary task performance
- Increasing the effort or load to the primary task (e.g., adding noise to a listening task)

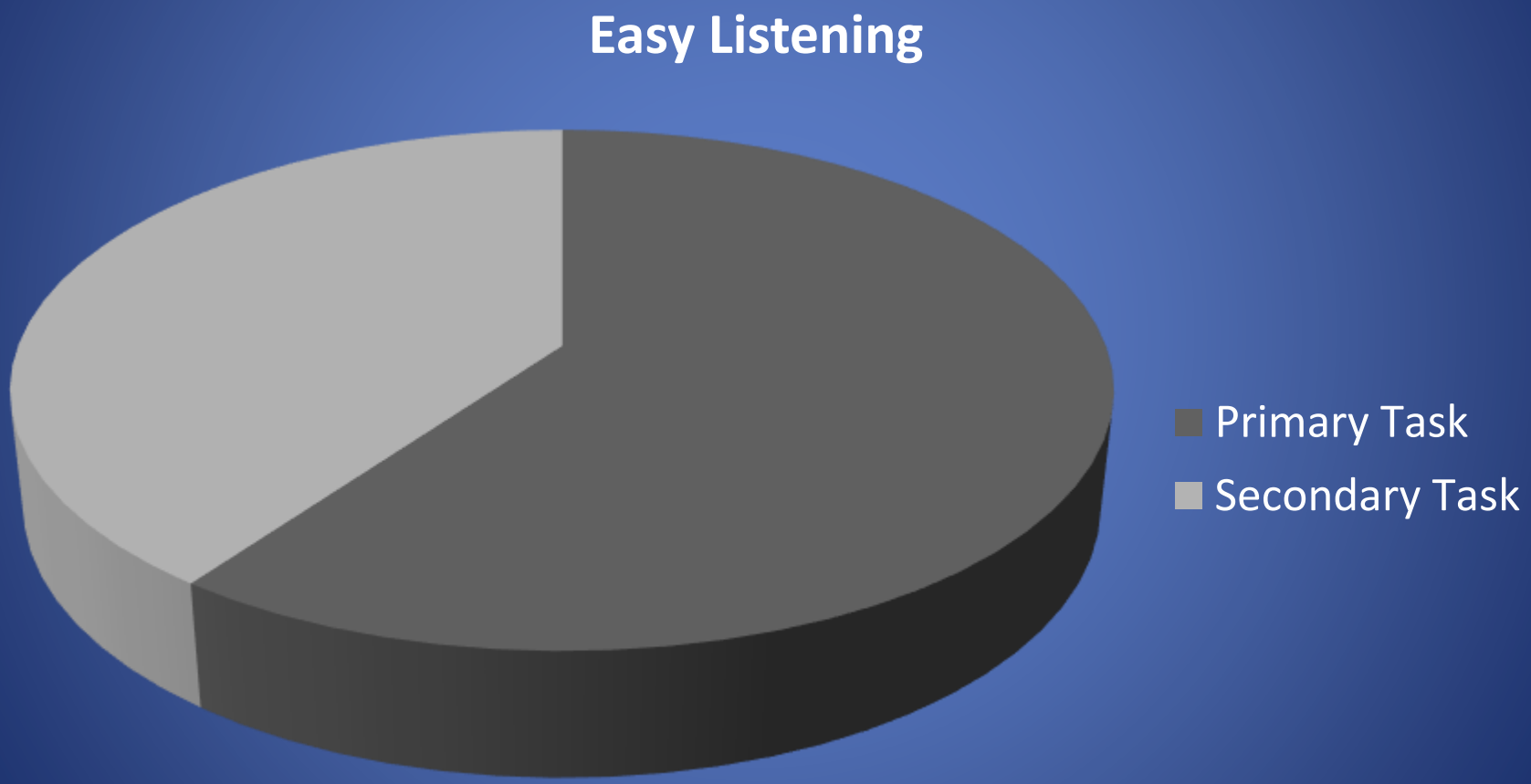
  leads to further decreases in the concurrent secondary task … (Broadbent, 1958)

Dual task paradigm theory

- Models
  - Processing capacity (Broadbent, 1958)
  - Resource capacity (Kahneman, 1973)

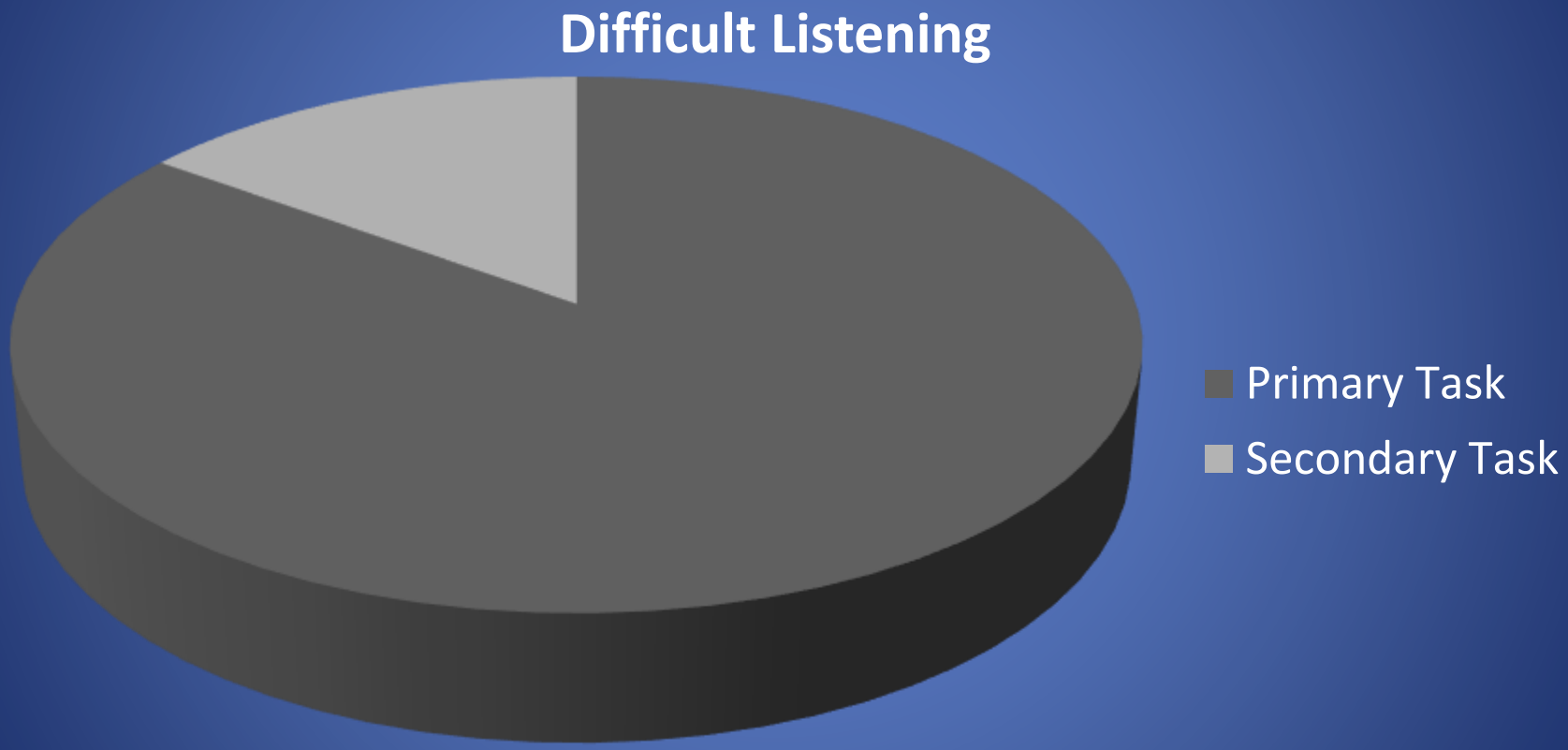
- Underlying assumption:
  - People have a limited capacity to process information

Dual task paradigm theory



Nooraei, N. (2010). Hearing aids and cognition. Expert e-seminar on Audiology Online

Dual task paradigm theory



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Anderson Gosselin and Gagné

JSLHR, 2011; IJA, 2011

Comparison of the effort expended by younger and older adults to recognize speech in noise

Study 1: A-alone

Study 2: AV speech recognition

Study 1

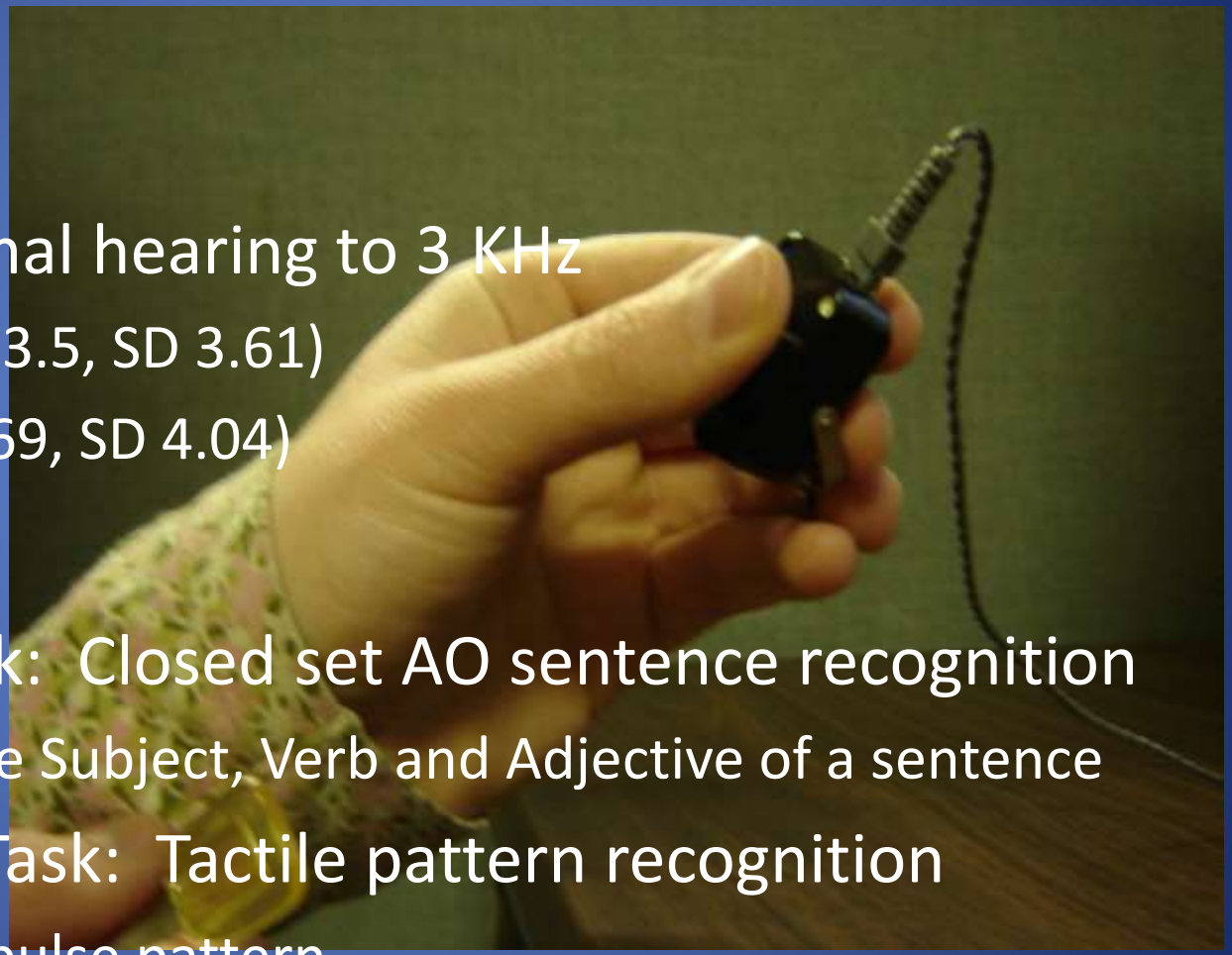
Purpose:

To determine if older adults expend more effort to recognize auditory speech in noise than younger adults

PART 1:

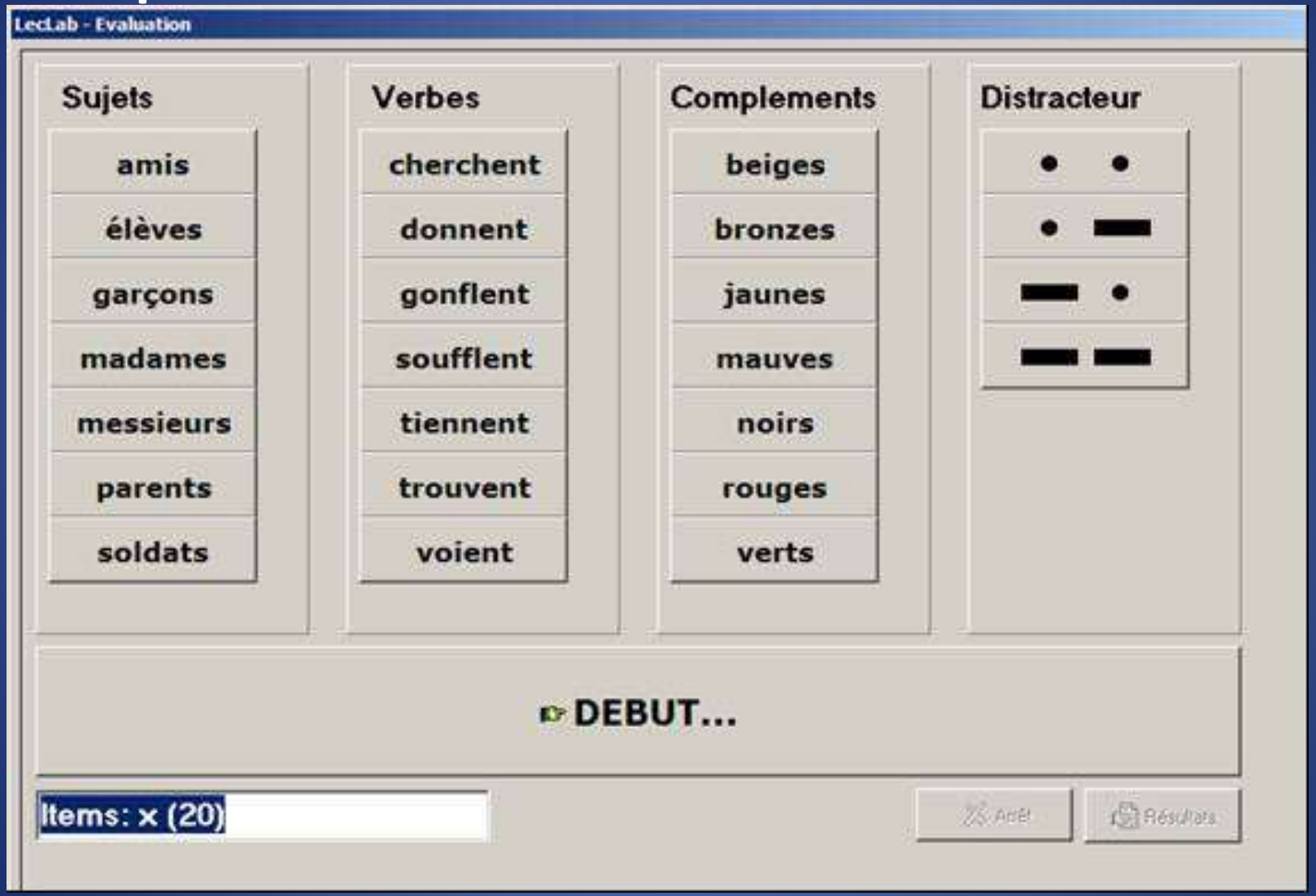
Speech stimuli presented at the SNR that yielded 80% correct responses in YA with normal hearing sensitivity

Methodology



- Participants:
  - all had normal hearing to 3 KHz
    - 25 YA (M 23.5, SD 3.61)
    - 25 OA (M 69, SD 4.04)
- Tasks
  - Primary Task: Closed set AO sentence recognition
    - Identify the Subject, Verb and Adjective of a sentence
  - Secondary Task: Tactile pattern recognition
    - Identify a pulse pattern
      - short-short, long-long, short-long, long-short
      - Short = 250 msec, Long = 500 msec

Response on touch screen monitor



Sentence Recognition: Les parents cherchent les ballons jaunes

Tactile Pattern Recognition: -- long & long --

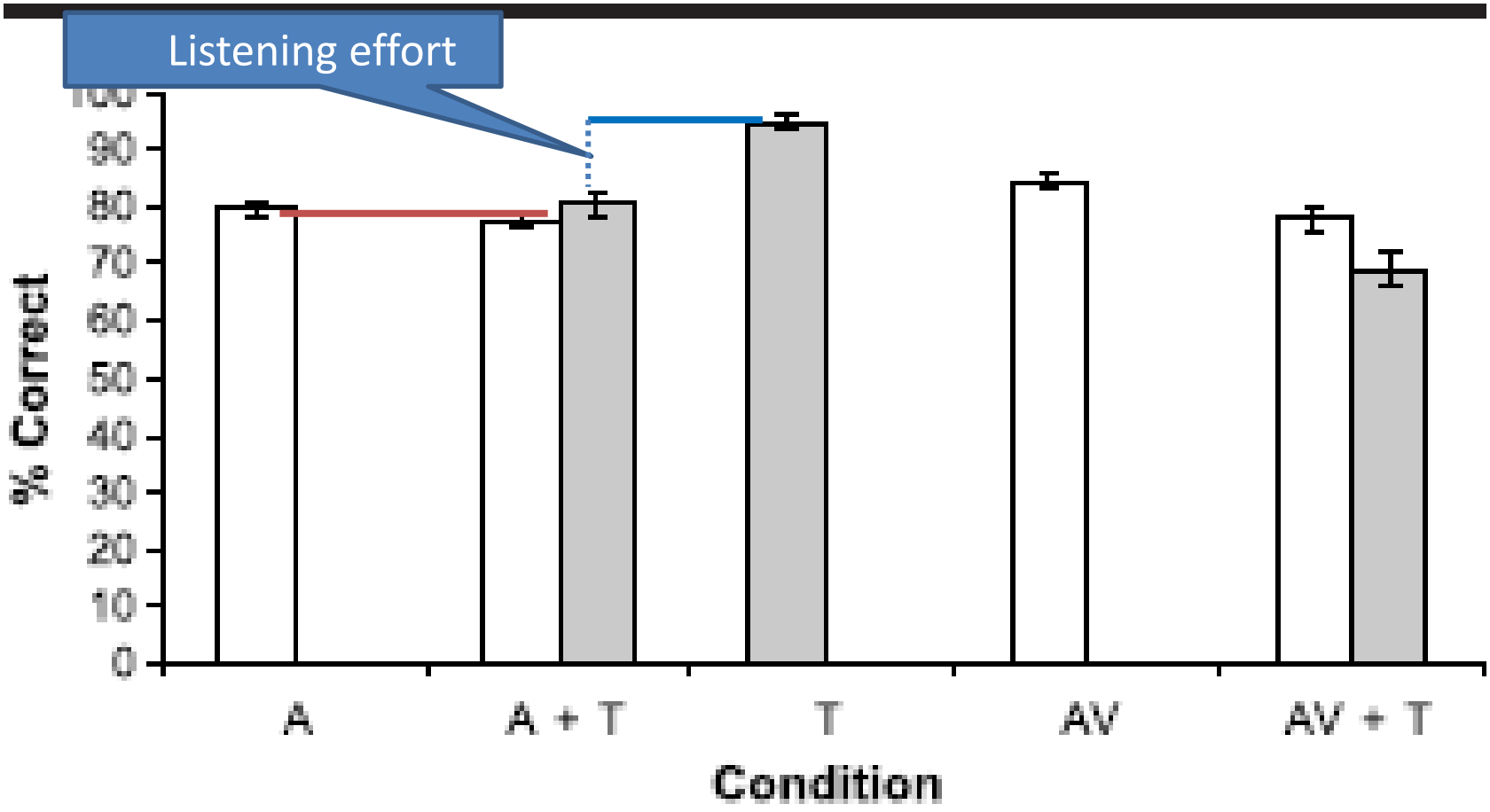
Data collection

-Percent correct responses

-Response time

mean response time for the test items in which a correct response was recorded during a block of trials

Figure 3. Experiment 2: Mean percentage of correct scores (±1 *SE*) for the speech recognition task (unfilled bars) and the tactile pattern recognition task (filled bars).



Fraser et al., JSHR, 2010

Analyses

- To take into account any differences in the single task performances between age groups, proportional dual task costs (pDTC) were calculated for each measure:
  - Word task accuracy and response time
  - Tactile task accuracy and response time

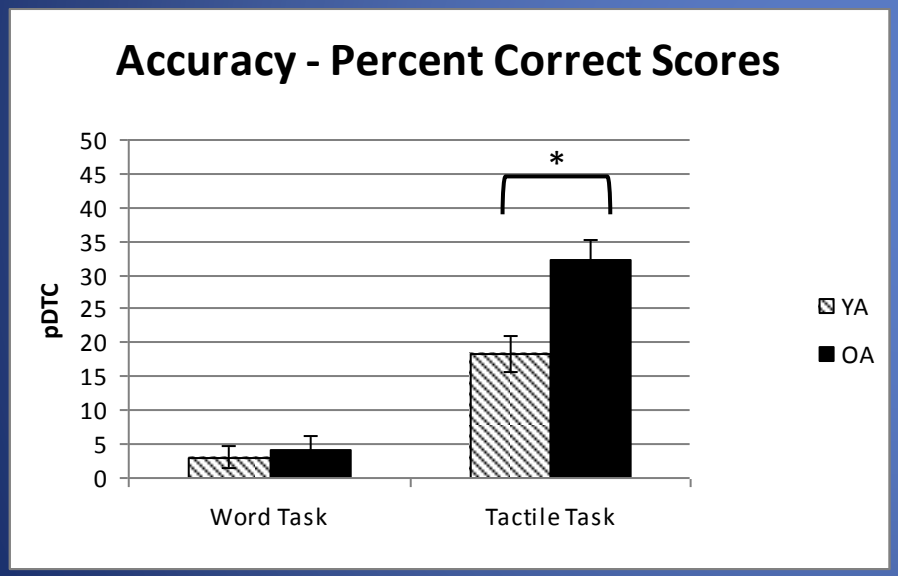
- **In our studies the pDTC is essentially the difference score (single task – dual task)**

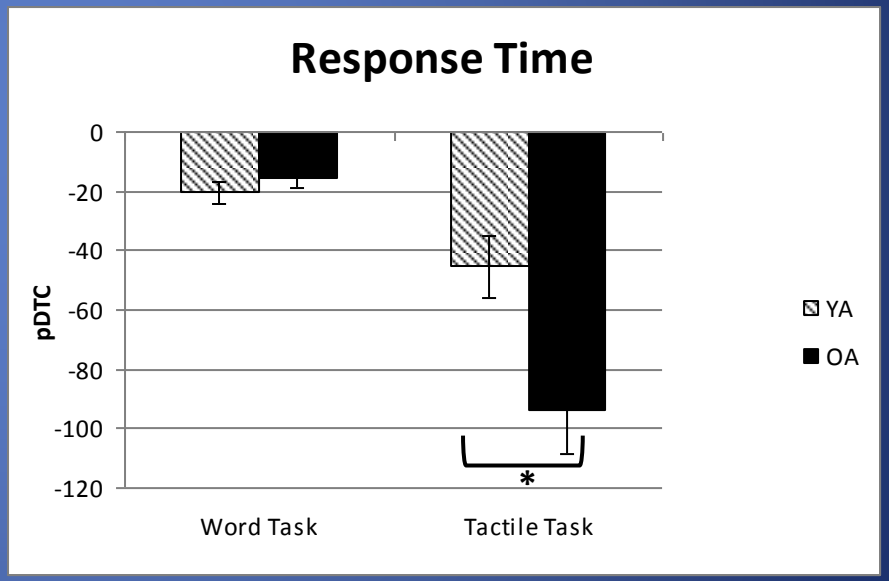
Analyses

In Graphs

- The larger the data points (the pDTC),
- The larger the Difference score (ST-DT)
- The more the effort deployed on that task

Equated Level Condition: (Speech at 60 dBA, Noise at 72 dBA)





N.B: performance level was poorer for OA

So, Question:
Is ‘cost’ simply directly related to difference in performance level

Equated Level Condition
(the SNR is the same)

		Young Adults (n=25)		Older Adults (n=25)	
		Mean	SD	Mean	SD
Single Task	Word - Accuracy (%)	83,00	6,90	71,30	10,41
	Tactile - Accuracy (%)	95,80	3,80	90,10	8,76
	Word - Response Time (sec)	3,08	0,44	4,38	0,82
	Tactile - Response Time (sec)	2,23	0,21	2,65	0,38
Dual Task	Word - Accuracy (%)	80,30	7,85	67,83	9,23
	Tactile - Accuracy (%)	78,40	14,01	60,60	13,27
	Word - Response Time (sec)	3,71	0,83	5,03	1,01
	Tactile - Response Time (sec)	3,21	1,06	5,11	2,15

Part 2

Purpose:

To determine if older adults expend more effort to recognize speech in noise than younger adults

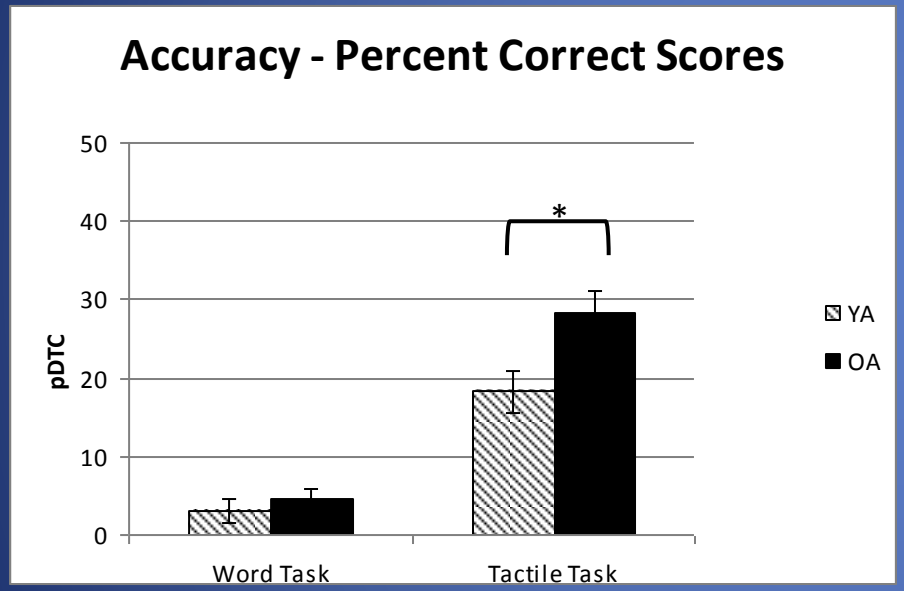
- Equated performance (where SNR was adjusted to produce same baseline word recognition scores)

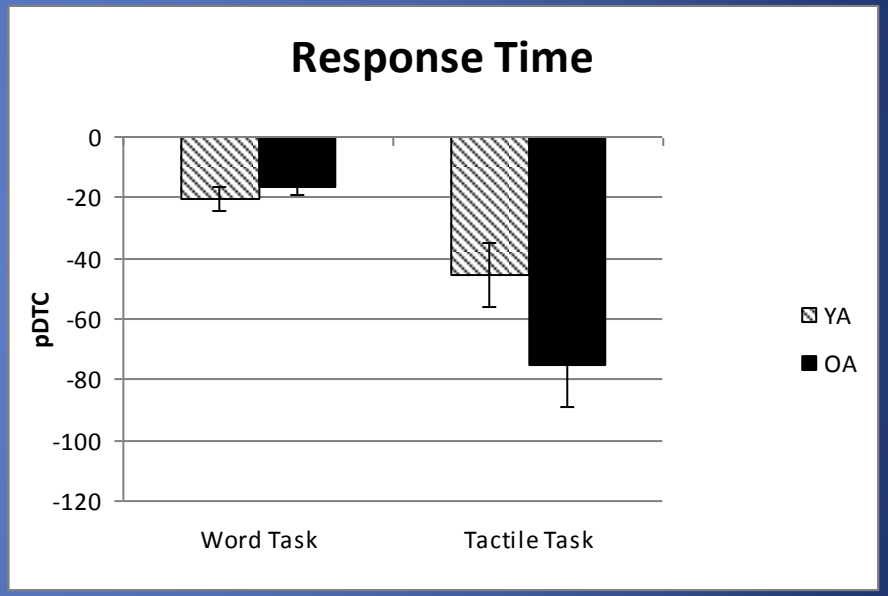
Equated performance condition

- How was performance equated?
  - the noise level was individually adjusted (***we turned it down***) for older adults as needed to ensure that word recognition (performed singly) was equivalent to young adults – 80% correct
- How much adjustment was needed?
  - On average about ***3 dB less noise overall***
  - The noise level ranged from 66-71 dBA

  (i.e., Mean 69.31 dBA, SD 1.65).

Equated Performance:
(Speech at 60 dBA; noise varied for OAs)





So, even when noise adjusted to produce same performance level, OA expend more effort than YA to recognize speech in noise.

Subjective Evaluation

- Accuracy rating scale: (0-100%)
  - When you did the two tasks together:
    - “What percentage of sentences do you think you identified correctly?”
    - “What percentage of the vibrations in your hand do you think you identified correctly?”

- Effort rating scale: (0 - no effort, 100 – very difficult)
  - When you did the two tasks together:
    - “How much effort was required for you to identify the components of the sentence?”
    - “How much effort was required for you to identify the vibrations in your hand?”

Subjective Evaluation Results Correlation Results

- Ratings of task accuracy correlated with the relevant percent correct dual-task measures
  - Word Accuracy Rating & DT Word % Correct **(r=.680, p<.0001)**
  - Tactile Accuracy Rating & DT Tactile % Correct
  - **(r=.597, p<.0001)**.

- Effort estimates did not correlate with any of the dual task measures

What are we measuring when we use a dual task procedure measure?

Experiment 2: Audiovisual Speech

(Anderson Gosselin & Gagné, IJA,2011)

Similar procedure as in Experiment 1

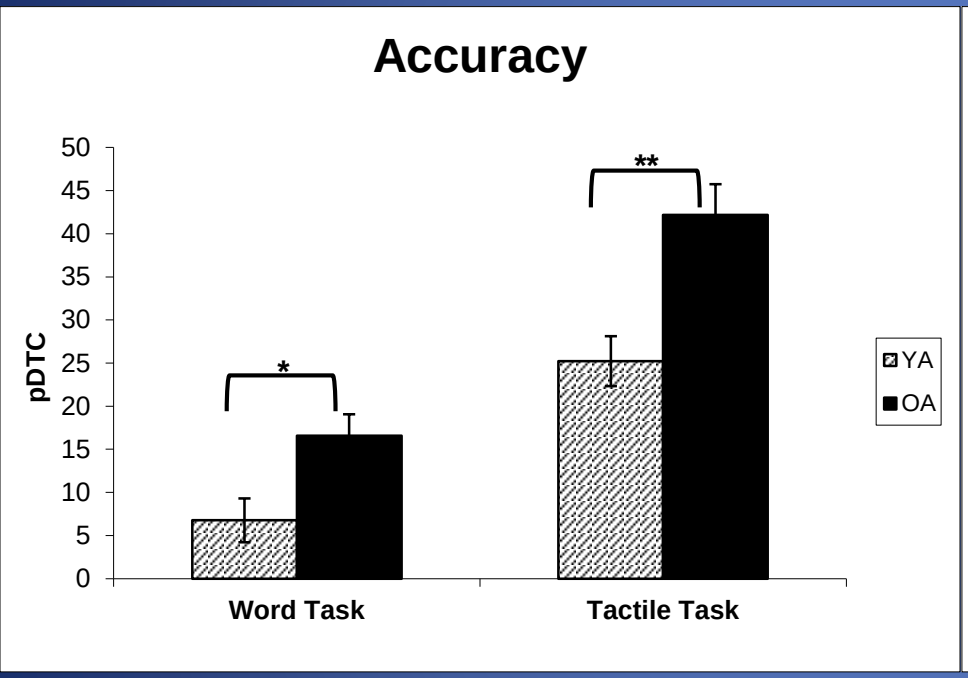
Difference?
Speech task was administered AV.

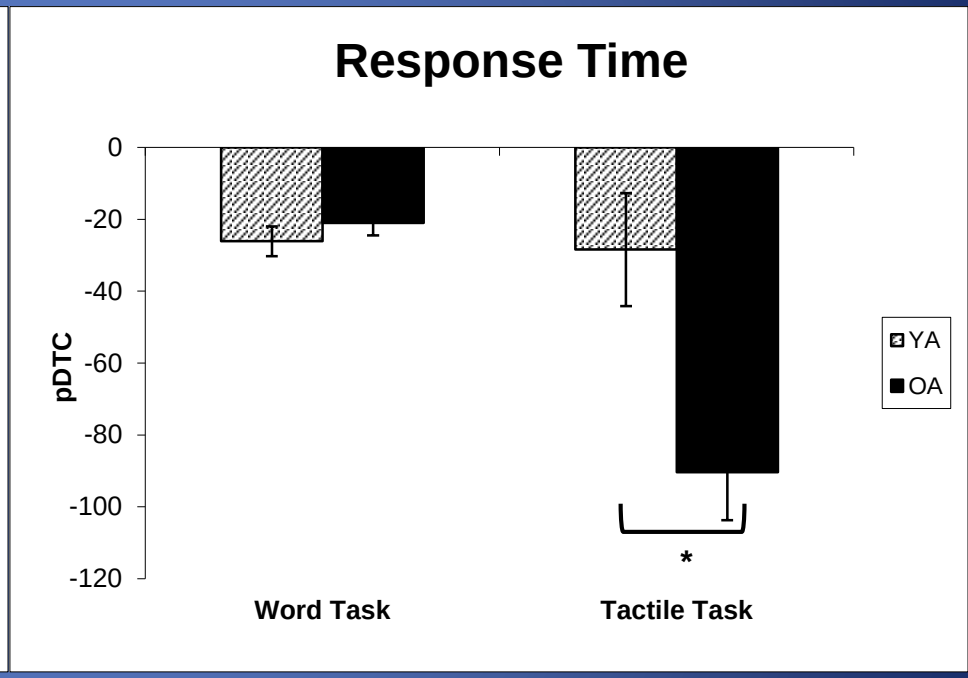
Experiments
- Same SNR
- Same level of performance

Methodology

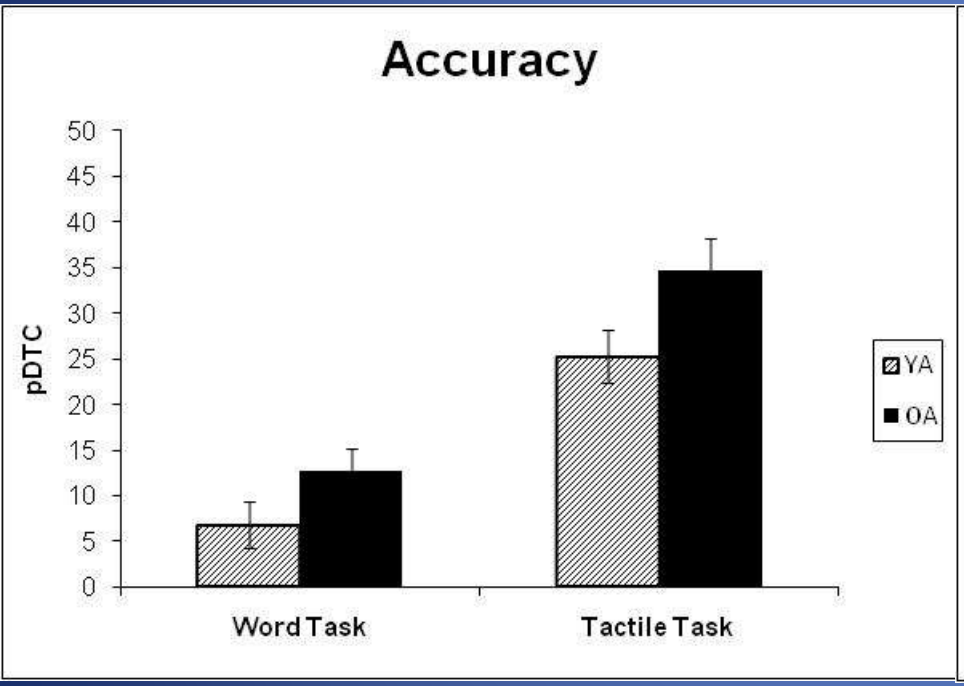
- Participants:
  - Normal or corrected normal visual acuity
  - all had normal hearing to 3 KHz
    - 25 YA (M 24.9, SD 5.63)
    - 25 OA (M 69.4, SD 3.53)
- Tasks
  - Primary Task: Closed set AV sentence recognition
    - Identify the Subject, Verb and Adjective of a sentence
  - Secondary Task: Tactile pattern recognition
    - Identify a pulse pattern
      - short-short, long-long, short-long, long-short
      - Short = 250 msec, Long = 500 msec

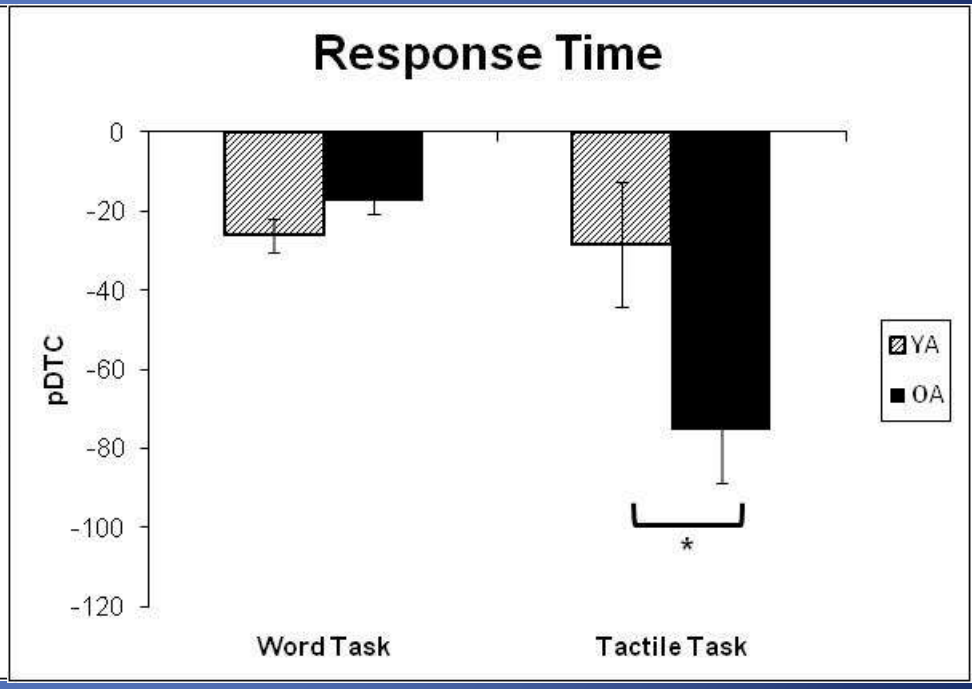
Equated Level Condition: (Speech at 52 dBA, Noise at 72 dBA)





Equated Performance:
(Speech at 52 dBA, noise varied for OAs)





Equated Performance Condition

Even when the level of noise was reduced (as required) older adults still exerted more listening effort than young adults.

This suggests that older adults deploy more processing resources to recognize speech in noise.

Important:

Equal percent correct scores on a speech task do not necessarily mean that an equivalent amount of listening effort was expended.

Summary: 1&2

- Significant dual task findings:
  - Older adults expend more effort than young adults to recognize speech in noise under both experimental conditions regardless of modality (audio or audiovisual speech)
  - Dual task measures are sensitive to age-related differences ('cost') in listening effort
  - OAs require more processing resources than YA to understand speech in noise

Dual task paradigm can be applied to other populations– other research questions

Thank You
for your attention
and …
your interest

I look forward to
the discussion ☺

L'effort associé à la reconnaissance de la parole présentée en langue seconde: une étude exploratoire

Effort deployed to process speech in L2: A pilot investigation

Telefoglou, Fraser, Laniel, L'Heureux, Wright & Gagné (2012)

Institut universitaire de gériatrie de Montréal

École d'orthophonie et d'audiologie

Université de Montréal

Processing speech in L 2

In many ways processing speech in one L2 (depending on one's level of proficiency in L2) is like having a hearing loss

Can result in:

poorer performance in quiet
Poorer performance in noise
Require more processing resources

The effects of processing speech in one's L2 on speech under-standing in noise

(Crandell et al., 1995)

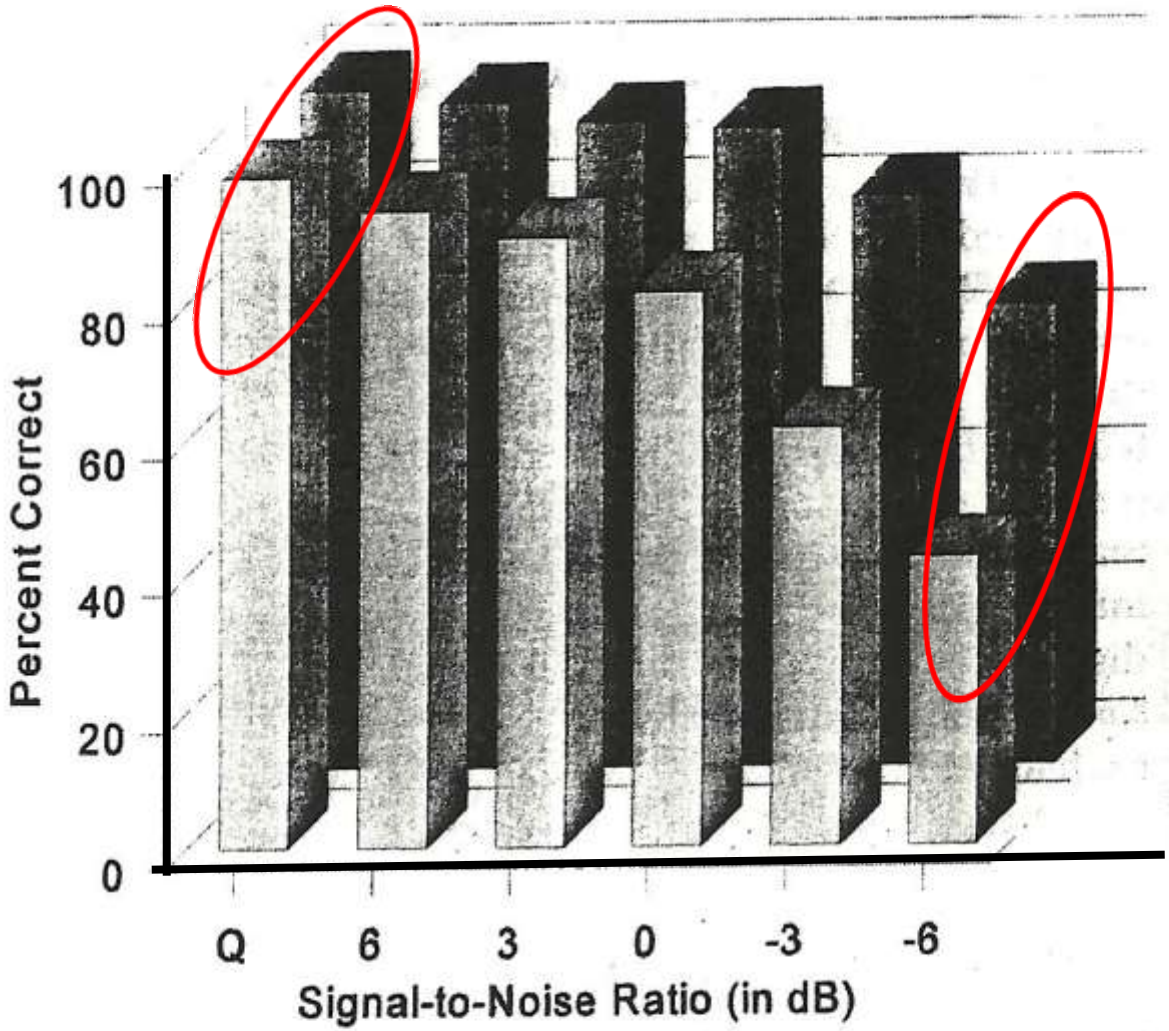


Figure 20–3 Mean speech recognition scores (in % correct) of native English children (*dark shaded bars*) and nonnative English children (*light shaded bars*) in quiet and at various SNRs. (Adapted from Crandell et al [1995].)

Dual-task paradigm

3 groups of participants:

All YA with normal hearing sensitivity

Grp 1: French as L1

Grp 2: Bilingual Anglos proficient in French

Grp 3: Bilingual Anglos not very proficient in French

Questionnaire on Language Competencies – English version
Adapted from on the LEAP-Q (Marian et al., 2007)

6) For each language that you know, indicate your level of competency for each of the domains of language listed :

Legend

Rating of 0 : no competency

Rating of 1 : very little competency

Ratings in the

Range of 2 to 4: poor to moderately poor

Rating of 5 : moderate level of competency

Ratings in the

Range of 6 to 8: moderate to high level of competency

Rating of 9 : high-level of competency

Rating of 10 : completely master this competency

Questionnaire on Language Competencies – English version
Adapted from on the LEAP-Q (Marian et al., 2007)

Language	Receptive oral (understanding)	Expressive oral (speaking)	Language (reading)	Language (writing)
1)_____	_____	_____	_____	_____
2)_____	_____	_____	_____	_____
3)_____	_____	_____	_____	_____
4)_____	_____	_____	_____	_____

Methods:

Participants :

- ***Groupe Franco*** (n= 18): Jeunes adultes unilingues francophones (cotes de 8/10 ou plus pour chacune des 4 sphères linguistiques du LEAP-Q (oral, compréhension, lecture et écriture) et une cote de 4/10 ou moins pour les 4 sphères linguistiques dans leur L2.
- ***Groupe Anglo1*** (n=21): anglophones bilingues se décrivant comme étant compétent en français (cotes de 8/10 ou plus pour chacune des 4 sphères linguistiques du LEAP-Q.
- ***Groupe Anglo2*** (n= 10) : anglophones bilingues se décrivant comme étant peu compétent en français (cotes de 5/10 ou moins pour chacune des 4 sphères linguistiques du LEAP-Q.

Experimental tasks

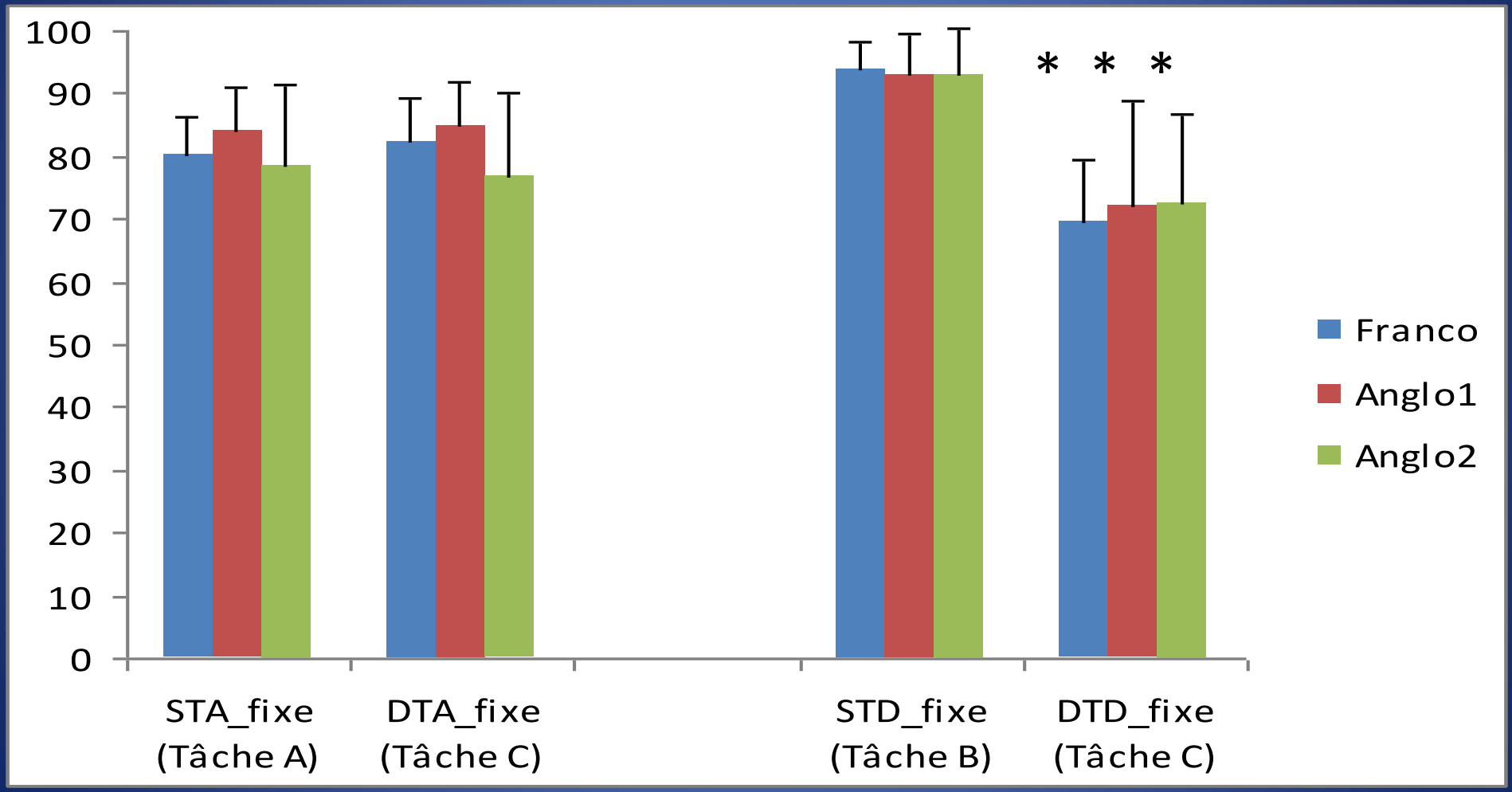
Speech recognition in noise
(same sentences as in previous experiments)

Tactile pattern recognition task
(same tasks as in previous experiments)

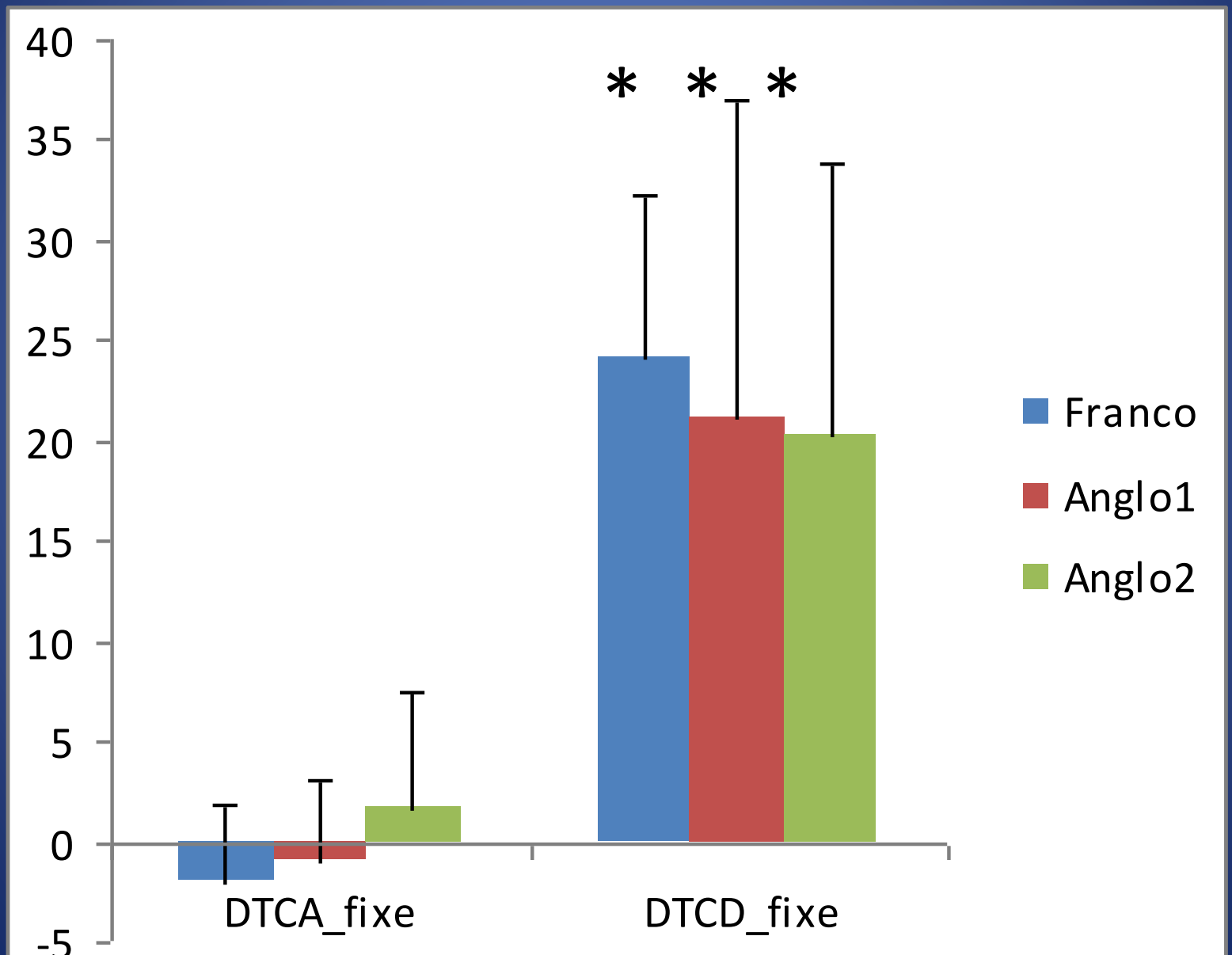
For each task:

- **Percent correct responses**
- **Response time**

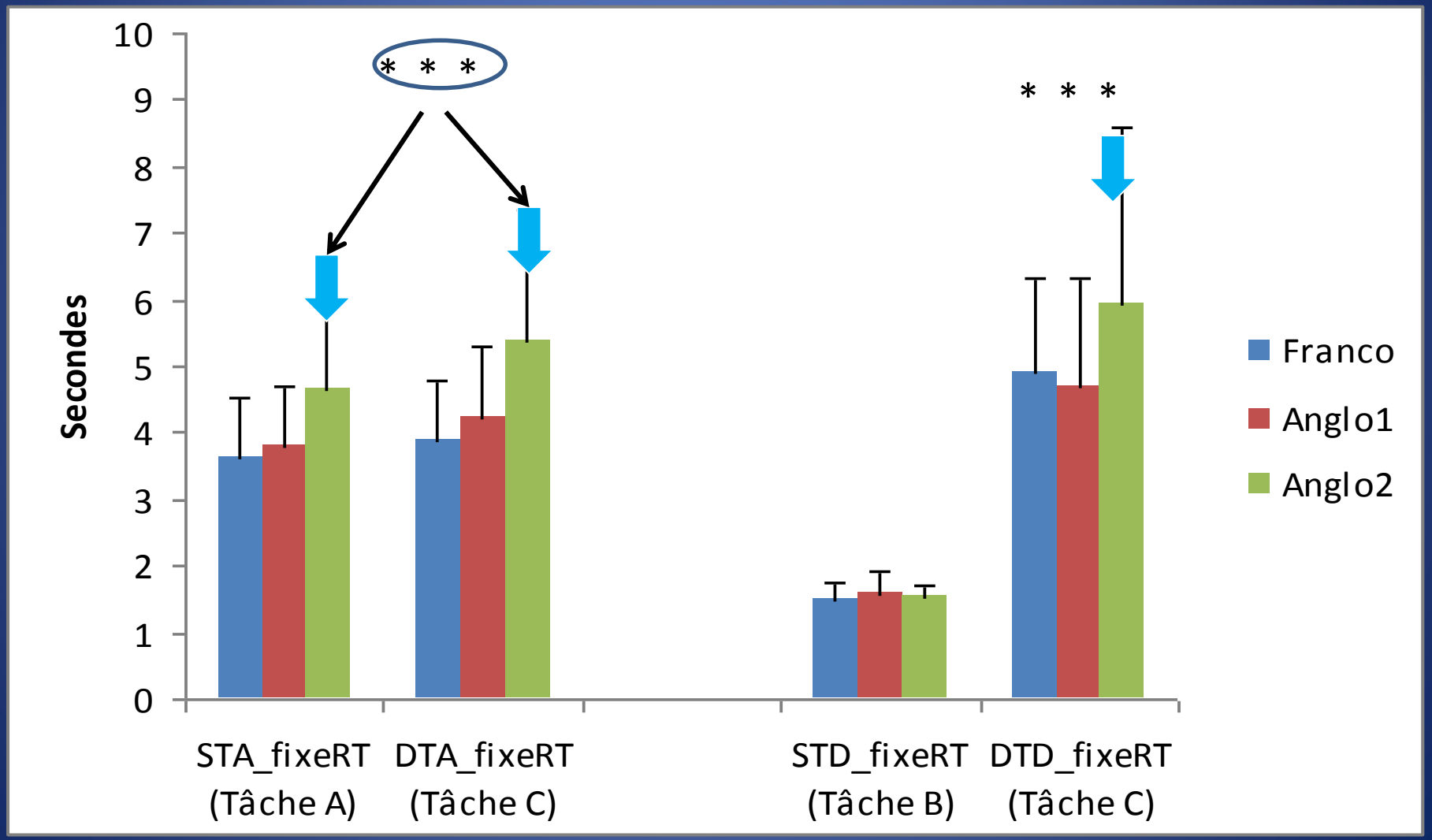
Single task vs. Dual task performances (percent correct) for 3 groups of participants (= noise)



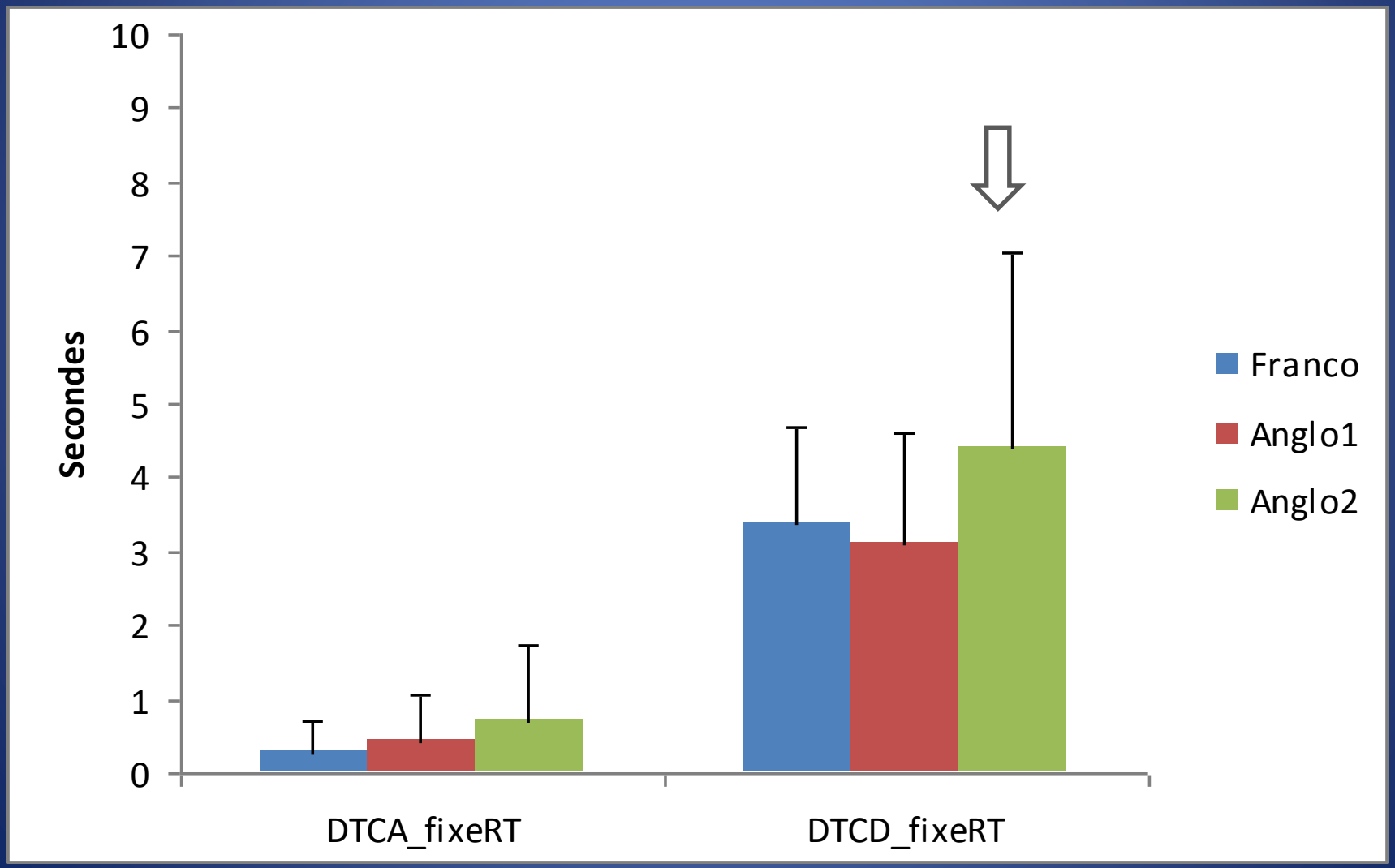
pDTC based on single task and dual task performances (percent correct) for speech and tactile tasks (= noise)



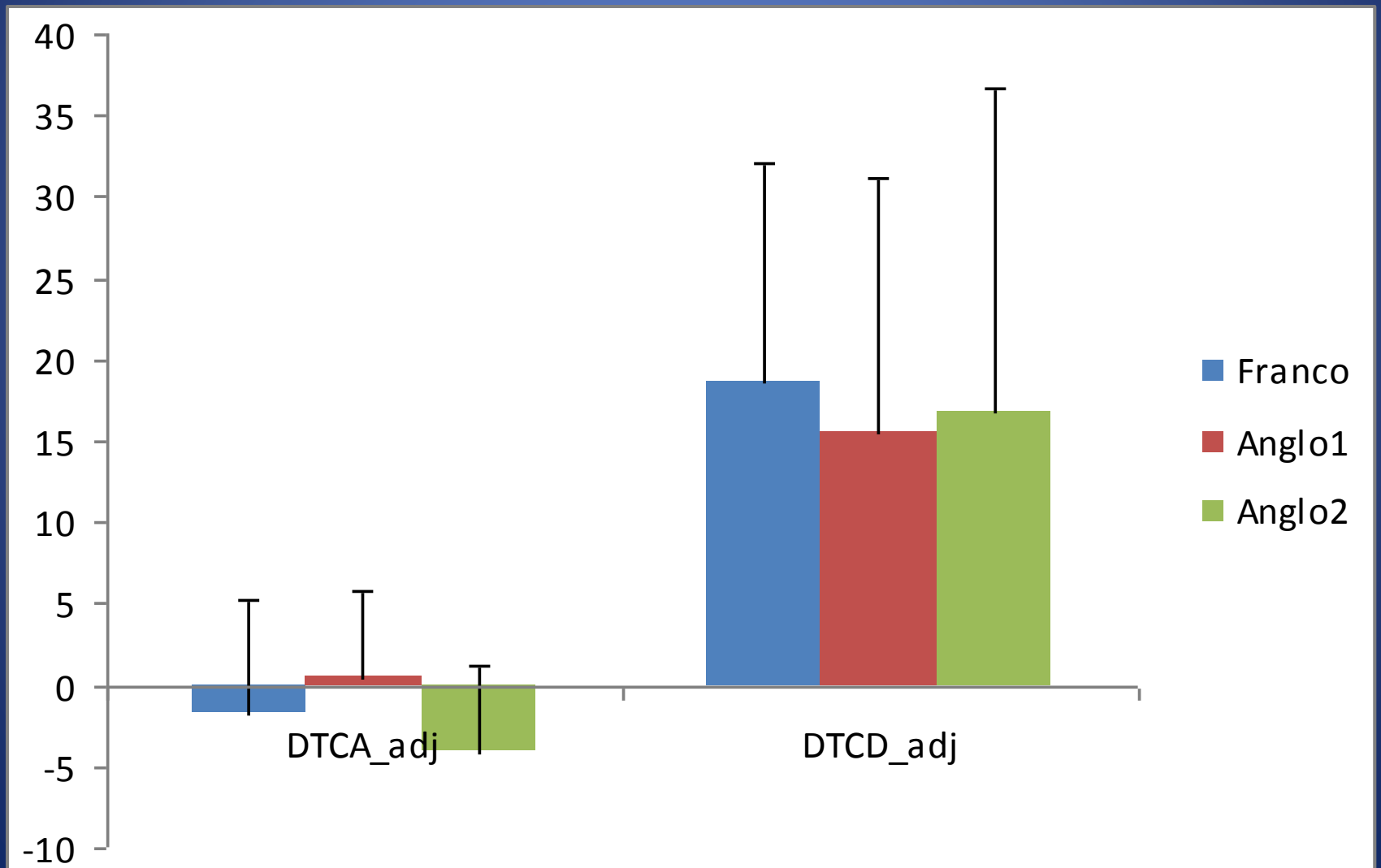
Response times for speech task and tactile task under single and dual task conditions (=noise)



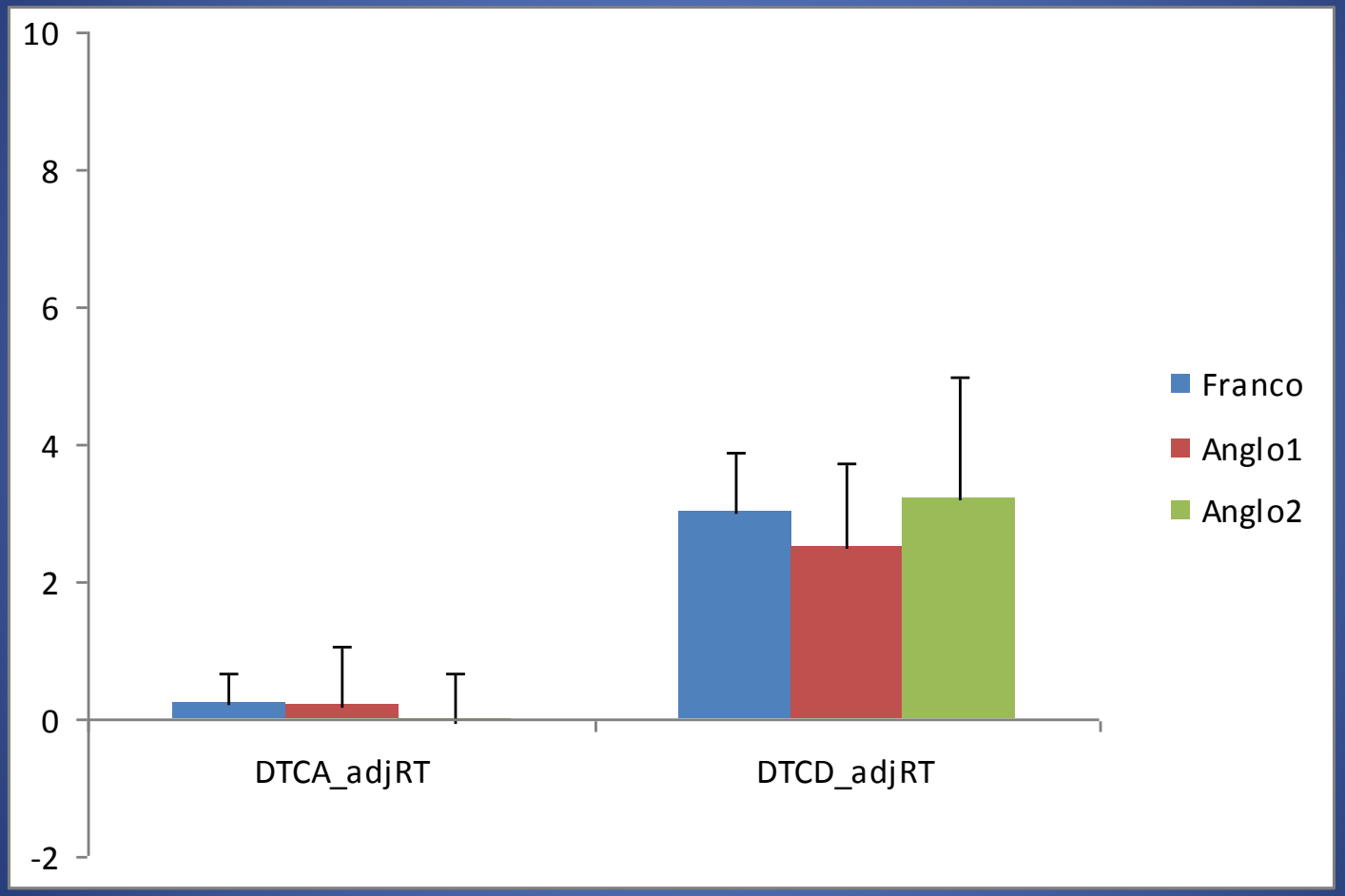
pDTC (response time) for speech and tactile tasks (Speech task performed at the same SNR)



Equal performance (varying SNR) condition (Speech task performed at = performance level



Equal performance (varying SNR) condition (adjusted noise)



Dual task cost (response time) for the primary and secondary tasks
experimental condition = adjusted noise (same performance level)

Results

- For all groups there is a decrease in performance for the tactile task when performed under the dual task condition (Fig. 1 & 2)
- For the speech recognition task, under both the single and the dual tasks conditions, the response times are significantly longer for the A2 group than for the other two groups (Fig.3).
- For all three groups, the response times for the tactile task are significantly longer under the dual task condition than under the single task condition (see Fig. 3).

Results

- For the tactile task, under the dual task condition, there is a tendency (not sig.) for the response times of the A2 group to be longer than the response times obtained for the other two groups (see Figure 3).

- In general, the differences (greater attentional load) observed for the A2 group, are eliminated when the noise level is adjusted in order to yield the same level of performance for the speech recognition task (under single task condition).

Preliminary conclusions

The dual task procedure use may be appropriate (sufficiently sensitive) to capture the increased 'listening effort' (attentional resources) that some bilinguals may be have to deploy to process speech in their L2.

In planning future studies some modifications to may be warranted:

Better tools to characterize competency in L2

More participants per group

Maybe more difficult P and/or S tasks

Thank You
for your attention
and …
your interest

I look forward to
the discussion ☺