Early Preparation of Experimentally Elicited Minimal Responses

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6th SIGdial Workshop on Discourse and Dialogue

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Outline

Introduction: Transition Relevance Place

Transition Relevance Place (TRP)

- a point of possible completion of the current utterance
- where the next speaker may potentially take the turn
- as either a full utterance or a minimal response;
- projected before actual end of utterence.

minimal response: e.g. 'hmm', 'yes', 'ah'

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- syntactic / semantic completion
- pragmatic function
- visual information (gaze direction, gestures)
- prosodic information (loudness, duration, tempo, pauses, pitch)

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Caspers 2005:

- Main factor in turn-taking is syntactic completion
- **End tones** play a supporting/constraining role:
  - where pauses coincide with syntactic completion, *low or high* boundary tones are used to signal completion
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To provide **quantitative** data on:

- importance of information for the projection of TRPs
- the integration of various sources of information
- the time course of TRP projection

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Questions adressed in this talk:

- Is intonation enough for TRP projection?
- How is the use of intonation integrated with other sources of information?
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Introduction: Task

Minimal Response Task:

Identification of TRP's in Dialogue

- Reaction Time (RT) task
- Identify when to start speaking
- by saying 'AH'
- more 'natural' task than pushing button

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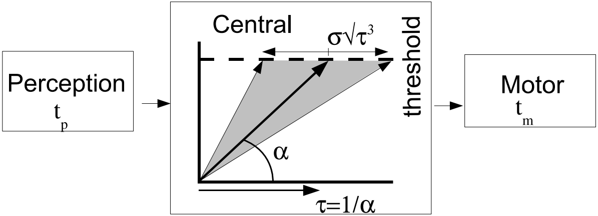

Three temporal stages in Reactions to Stimuli:

- Perceptual component (P) and
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- Central **decision making component** (C)
  characterized by a random walk to a decision threshold

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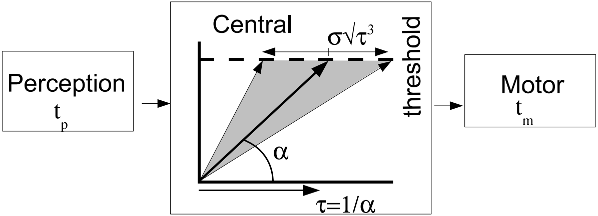

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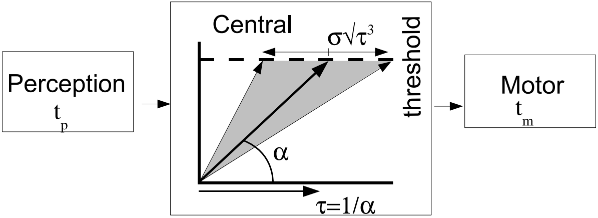

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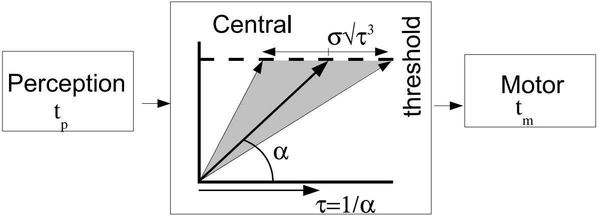

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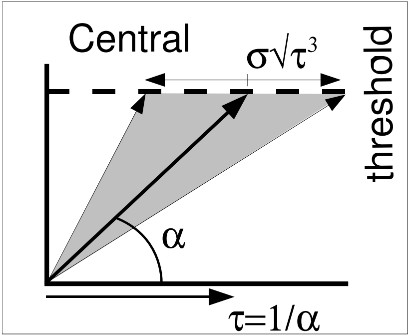
Introduction: Timing in PCM-model



Relative integration time to decision, τ, can be determined from the relative **variances** of the Reaction Times

$$\frac{\tau_1}{\tau_2} = \sqrt[3]{\frac{S_1^2}{S_2^2}} \quad \text{with } (S^2 = \text{variance})$$

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Introduction

Experiment

Results

Discussion

Conclusions

Experiment: Materials

Full Set

- 61 dialogues from the Spoken Dutch Corpus (CGN)
- informal and spontaneous Dutch dialogues
- telephone & face-to-face
- transcription:
  - orthography, hand aligned on word level
  - turn switches, minimal responses

Stimulus Set

- 7 telephone & 11 face-to-face dialogues
- 165 minutes of speech
- for each utterance: boundary tones are estimated

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Boundary Tone of Utterance i

$$Boundary\ Tone\ Z_i = \frac{Mean_i F_0 - End_i F_0}{Sd(F_0)}$$

$Z_i > 0.2$ $\longrightarrow$ high boundary tone

$-0.5 \leq Z_i \leq 0.2$ $\longrightarrow$ mid boundary tone

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1. **FS** Full Speech
2. **IO** Intonation Only: nothing but intonation and pause structure

Intonation Only speech: Dialogs resynthesized as reiterated 'UH' sequences with the original pitch contour

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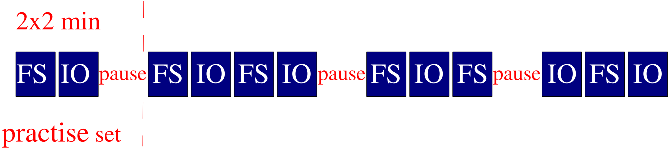

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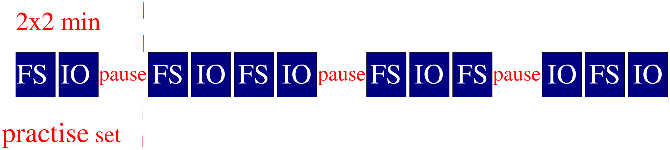

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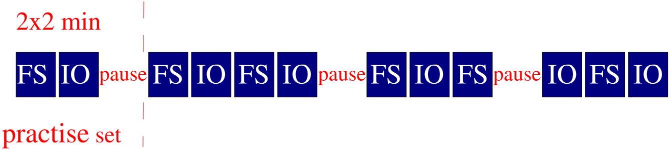

- 2 x 2 minutes practise set
- 10 x 6 minute stimulus files, randomized for presentation

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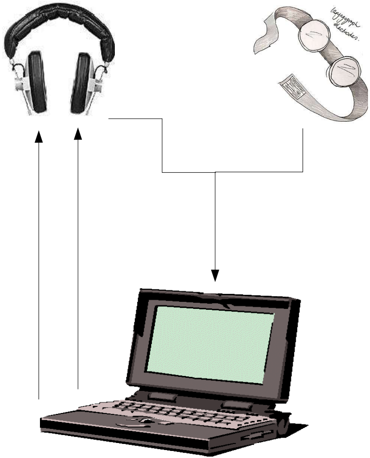
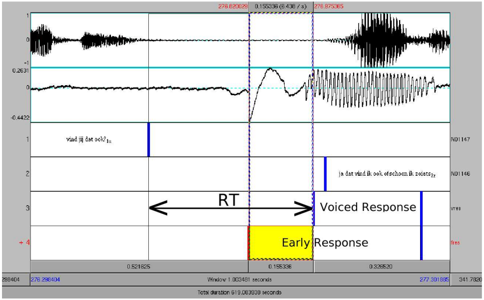
Experiment: Recording Setup



Experiment: Recordings

Example response waveform and segmentation



- Top: Mono waveform of the stimulus
- Center: Laryngograph signal of a single response
- Bottom: Annotation tiers for the two speakers and the automatic segmentation of a *voiced* and *early response*.
- Intervals: The two classes of response delays and their difference in color

Outline

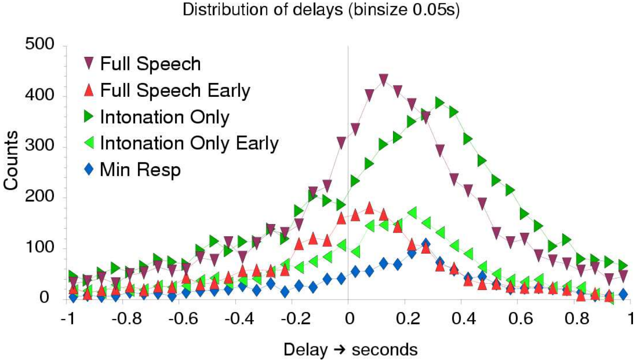
Results: Number of Responses to End-tone Categories

Table: *Total number of articulated (voiced) and early responses to stimuli for each of the 3 end-tone categories and minimal responses for the total conversation set.*

response category	low	mid	high	total
full speech voiced	1860	2850	1374	6084
early	690	1144	515	2349
intonation only voiced	1917	3205	1453	6575
early	663	1180	534	2377
full dialog set (min. resp.)	386	539	281	1206

For roughly $\frac{1}{3}$ of all responses we can measure a so called *Early Response*

Results: Distribution of Reaction-Time Delays



- Response counts are already increasing before end of utterance → Projection of TRPs takes place.
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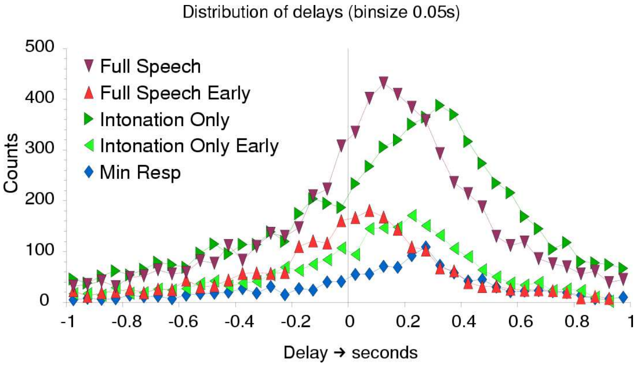

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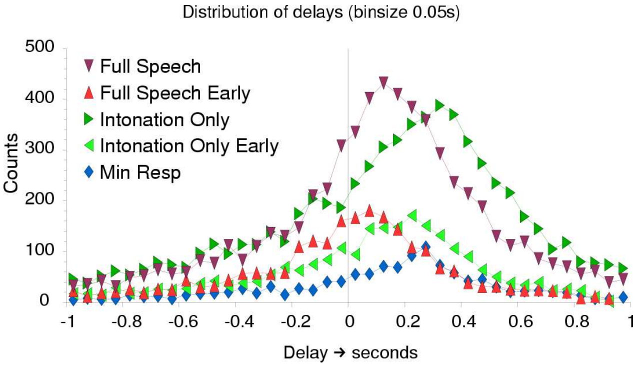

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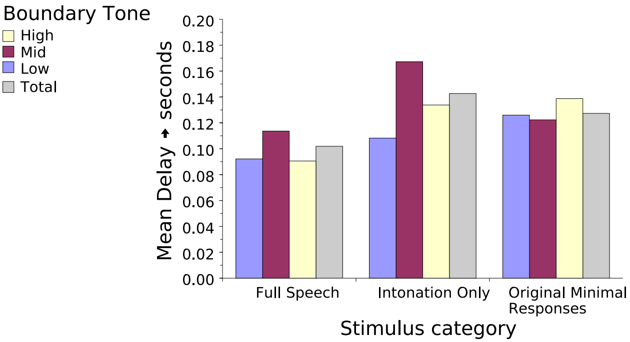
Mean Delays for Three Categories of Boundary Tones.



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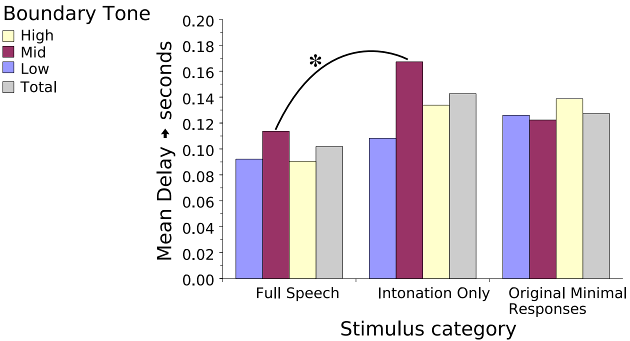

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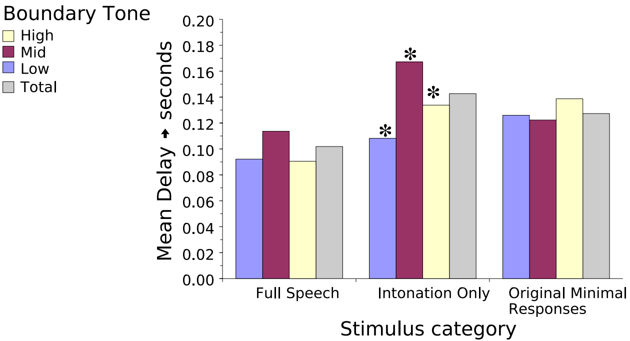

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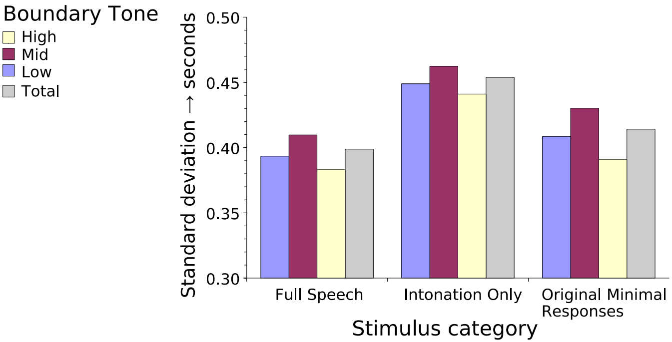

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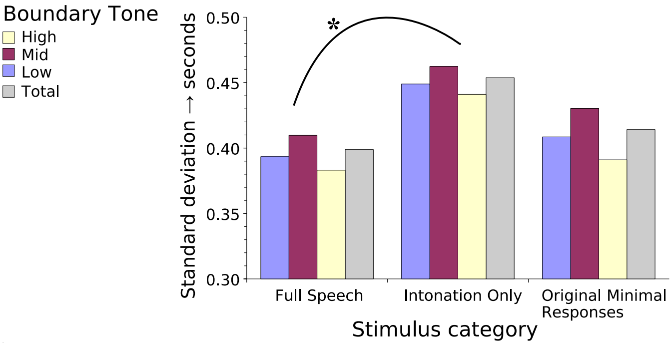

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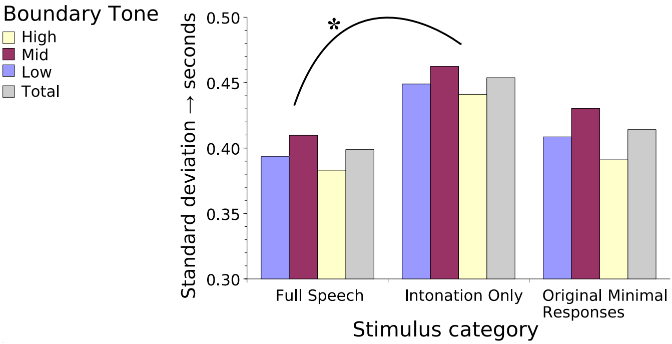

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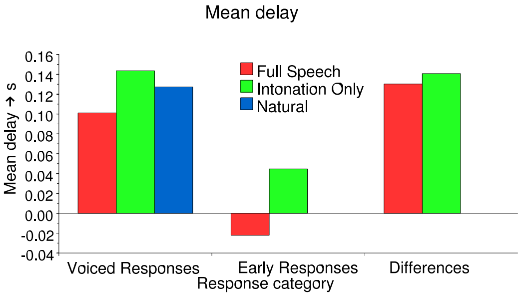
Mean delays for Three Types of Response Delays.



- NB: *Early* and *voiced* responses differ by construction!
- Mean delays for *full speech* are shorter than those for *intonation only* for both *voiced* and *early responses*.
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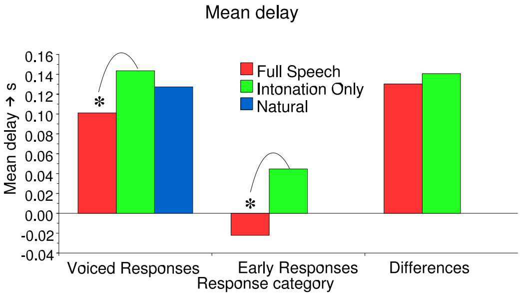

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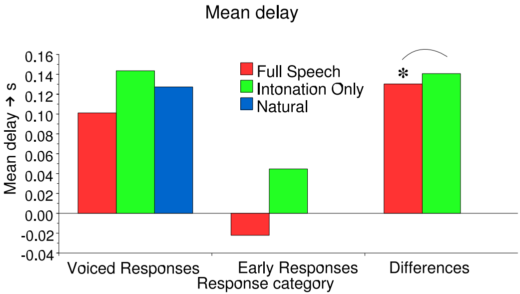

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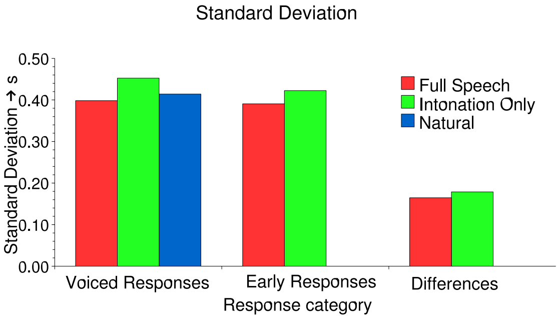

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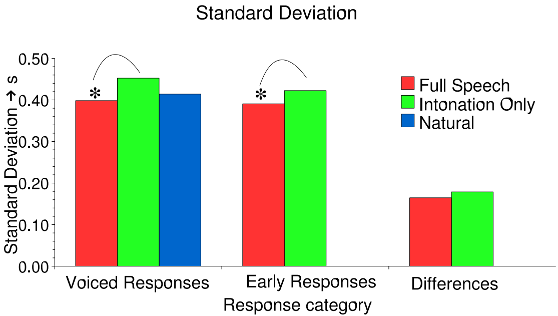

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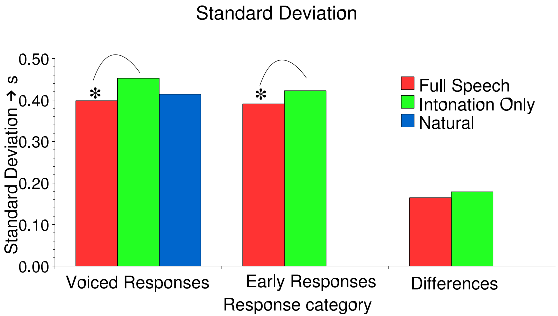

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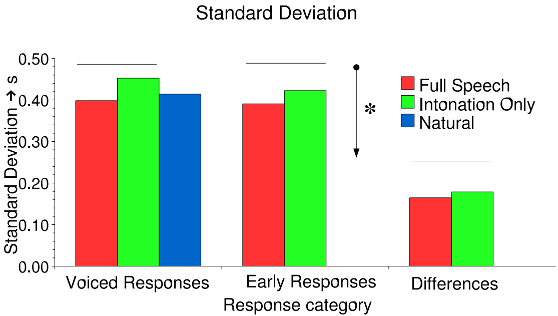

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➜ Intonation into a high or low boundary tone is sufficient to predict an upcoming utterance end, at least some of the time.

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- *Intonation Only* stimuli mostly affect *early* integration-times, not the timing after *early responses*.

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- *Intonation Only* stimuli mostly affect *early* integration-times, not the timing after *early responses*.

➜ There seems to be a perceptual, P, type of delay.

Discussion: Integrationof Intonation

Second question:

- How is the use of intonation integrated with other sources of information?

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➜ There seems to be a perceptual, P, type of delay.
➜ Removing everything but intonation & pauses increases the integration time with around 10 ± 1.3 %

Discussion: Time Course of TRP Projection

Third question:

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  ➜ With a t_0 of $\geq$50 ms under the most favorable circumstances (shadowing tasks) we can conclude that planning (elicited) minimal responses starts more than 300 ms before the actual utterance end (TRP).

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Conclusions: For Further Reading

- Caspers J., "Local speech melody as a limiting factor in the turn-taking system in Dutch", Journal of Phonetics 31: 139-278, 2003.
- Sigman M., Dehaene S., "Parsing a Cognitive Task: A Characterization of the Mind's Bottleneck", PLoS Biology 3, e37, 2005.

Outline

Appendix: Formulas

Probability of a random walk crossing a threshold for the first time at time t:

$$g(t) = \frac{1}{\sigma \cdot \sqrt{2\pi \cdot (t - t_0)^3}} \cdot exp\left(-\frac{(1 - \alpha \cdot (t - t_0))^2}{2 \cdot \sigma^2 (t - t_0)}\right) \tag{1}$$

- $\overline{RT} = t_0 + \tau$
- $var(RT) = \frac{1}{2}\sigma^2\tau^3$
- $\frac{\tau_i}{\tau_j} = \sqrt[3]{\frac{s_i^2}{s_j^2}}$

σ is a task independent,mostly unknown, modeling parameter.

Appendix: Calculations

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- $\rightarrow \tau_{early}$ is about 2 x τ_{diff}
- With a simple model: $\tau_{voiced} = \tau_{early} + \tau_{diff}$
  $\Leftrightarrow \tau_{diff} = RT_{voiced} - RT_{early}$
- For *full speech*, average *difference* RT is 130 ms, integration-time, τ_{early}, is 235 ms and the total effective integration-times τ_{voiced} is 370 ms
- For *intonation only*, the average *difference* RT is 140 ms, τ_{early} is 255 ms and τ_{voiced} is 400 ms.
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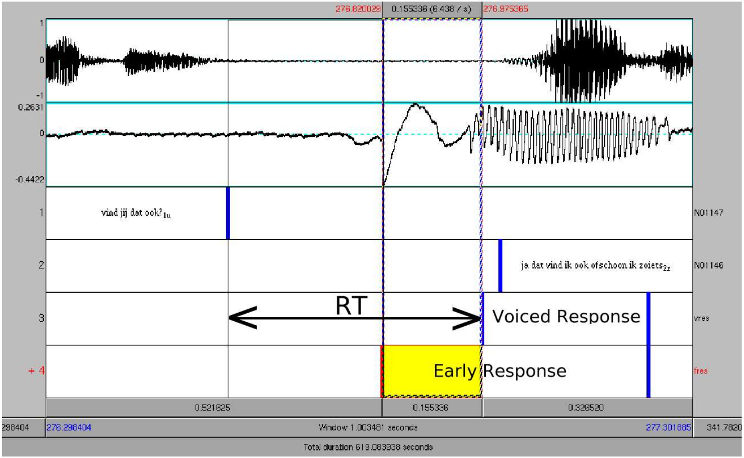
◂ Discussion

Appendix: Recordings



Appendix: Reaction Time Distribution under PCM model

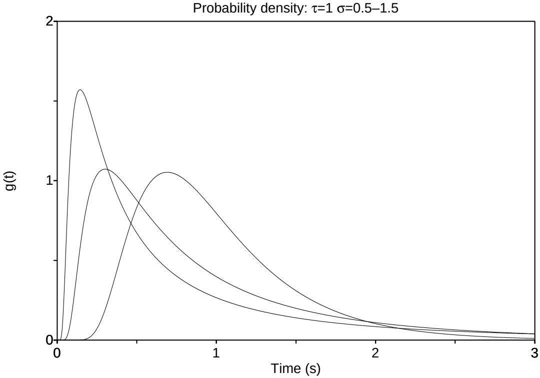


Figure: Distribution of RTs for $\tau = 1$ and $\sigma = [1.5, 1.0, 0.5]$