

The Robustness of Linguistic Communication

Robustness as a Design Feature of Language



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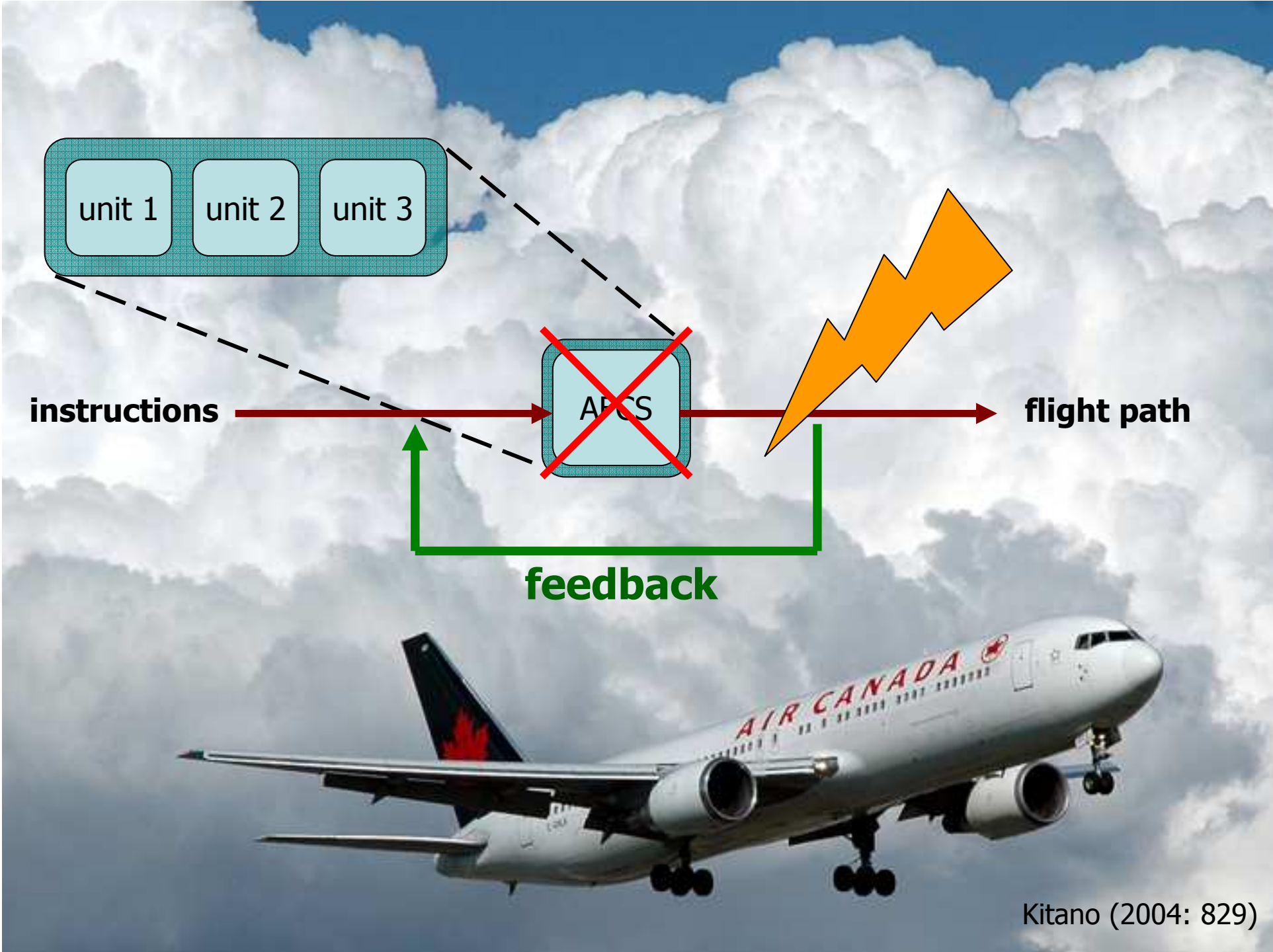
Overview

1. Airplanes, fruit flies

2. Why we need robustness

3. What constitutes robustness

4. What we can do with robustness



Robustness

- = “the property of a system that assures a system’s function despite internal and external perturbations” (Kitano, 2004)
- = “the ability to maintain performance in the face of perturbations and uncertainty” (Stelling et al., 2004)

Robustness in Biology



"Examples of robust biological systems are found at many scales, from biochemical to ecological."

(Lenski et al., 2006)

"robustness is pervasive on different levels of biological organization"

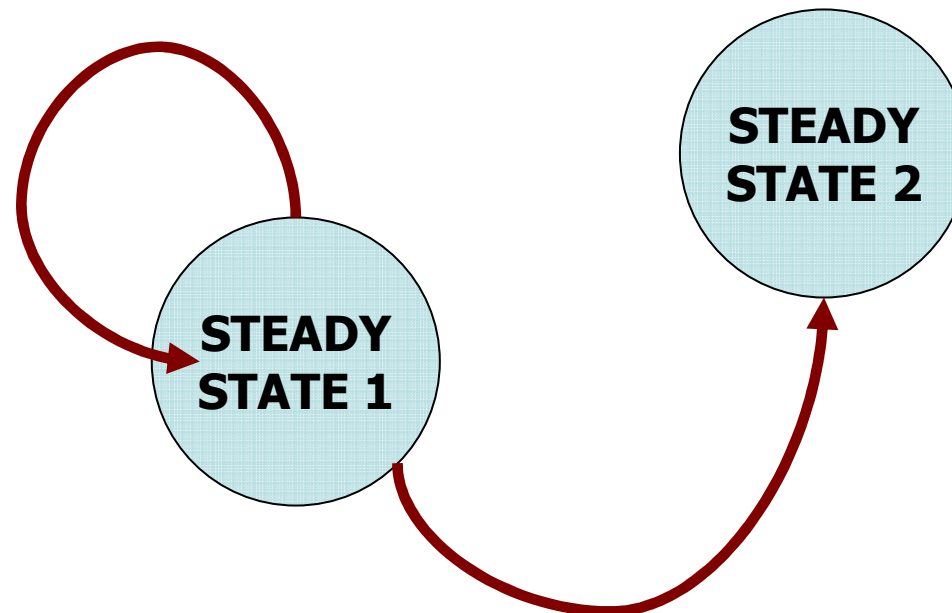
(Wagner, 2005)

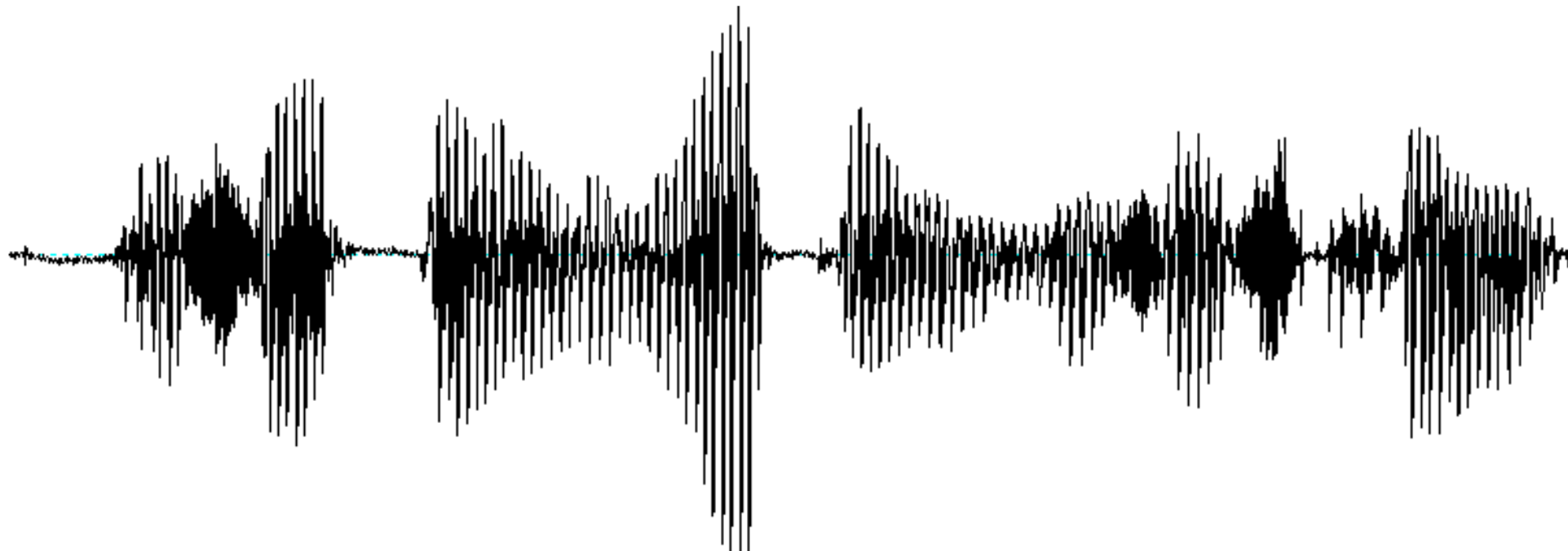
Robustness vs. Stability

Jen (2002)

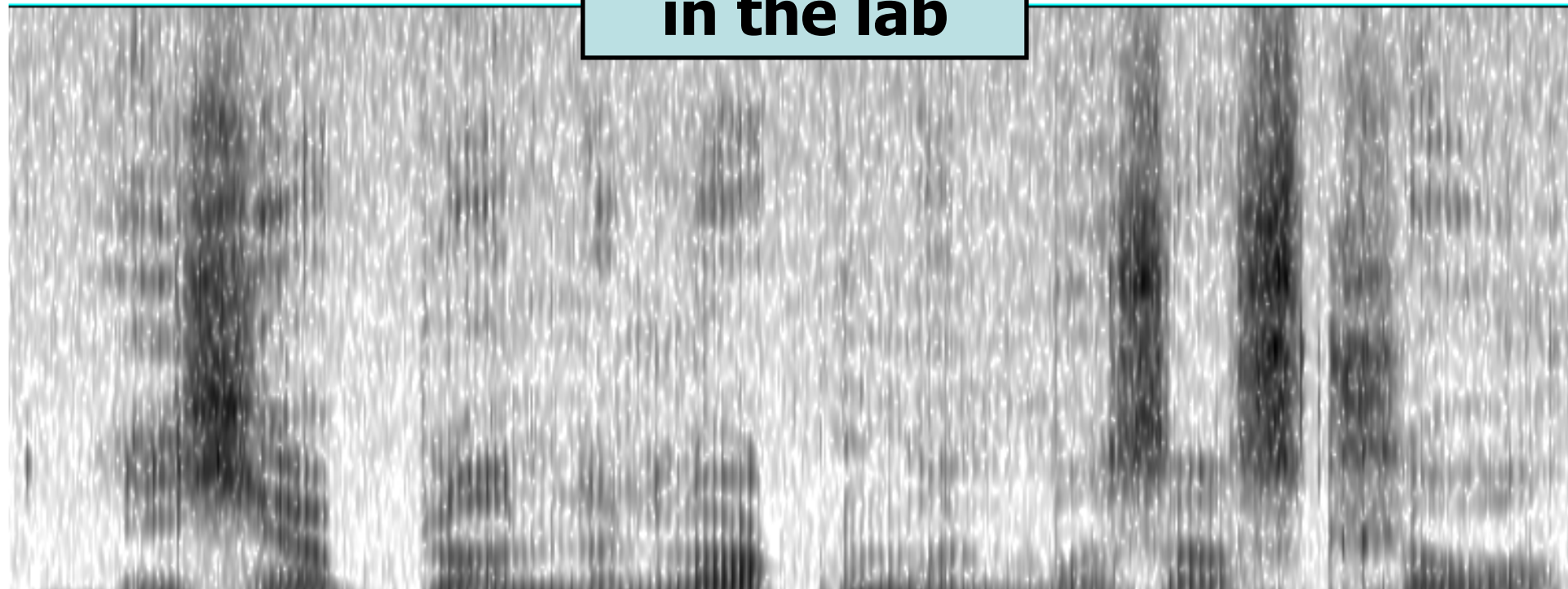
robustness → maintaining functions

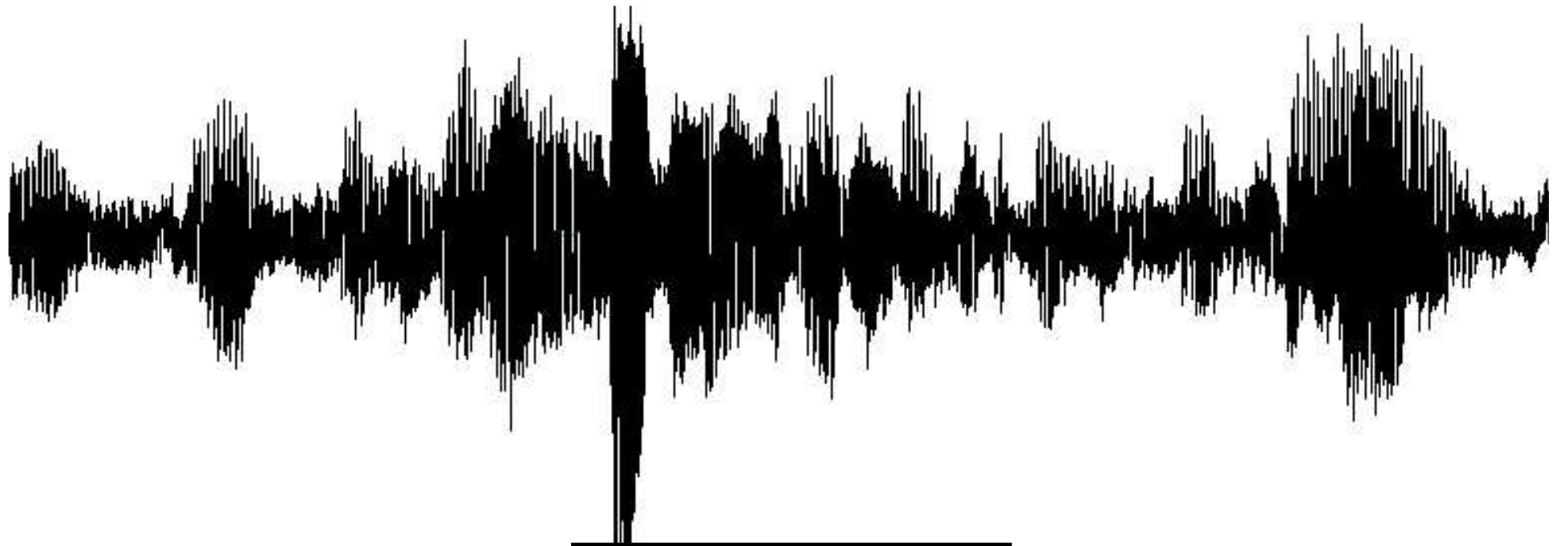
stability → maintaining system states



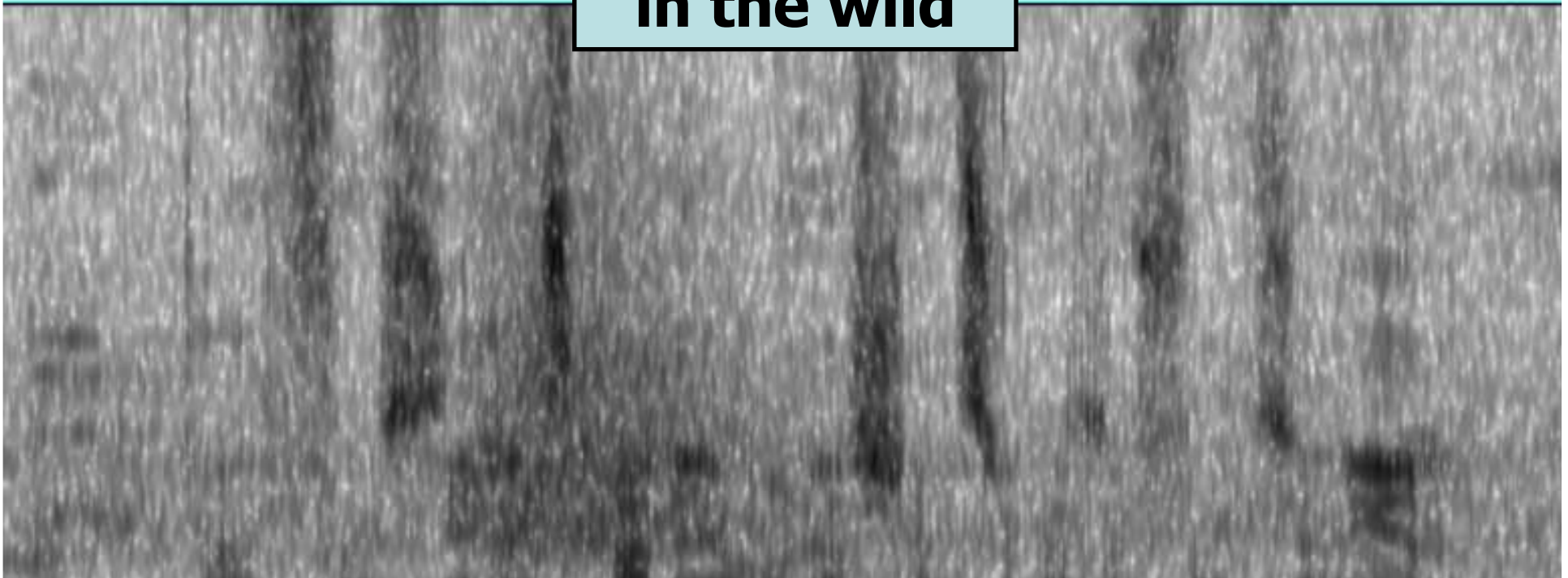


in the lab

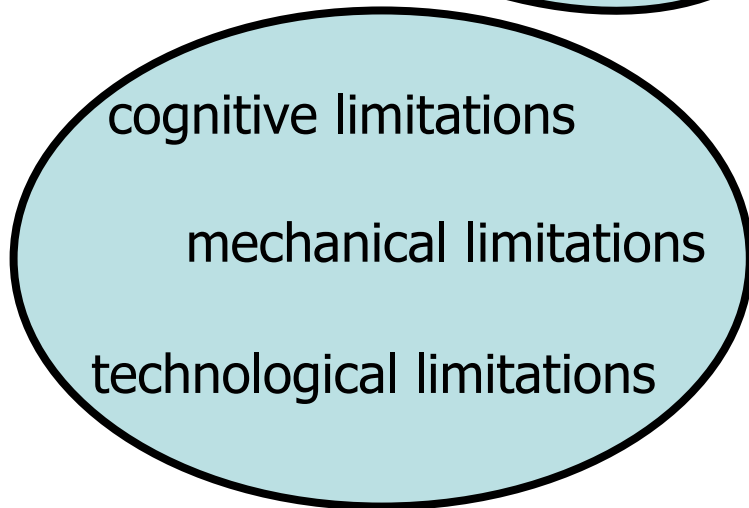
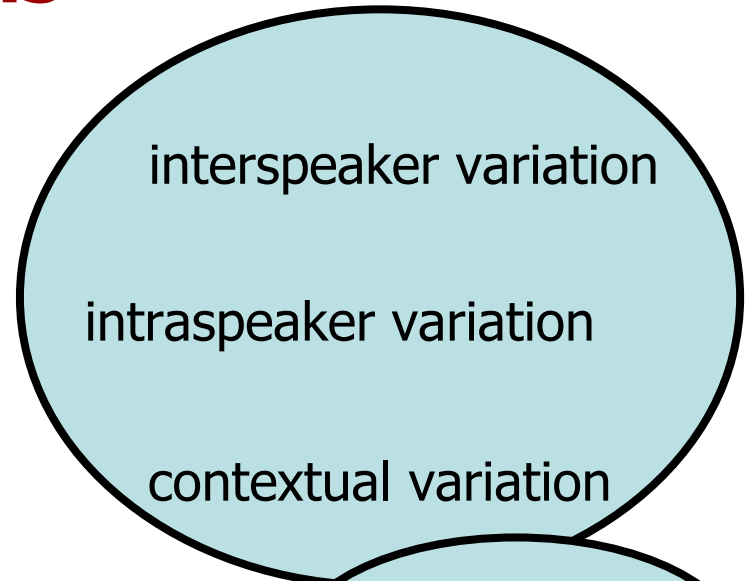
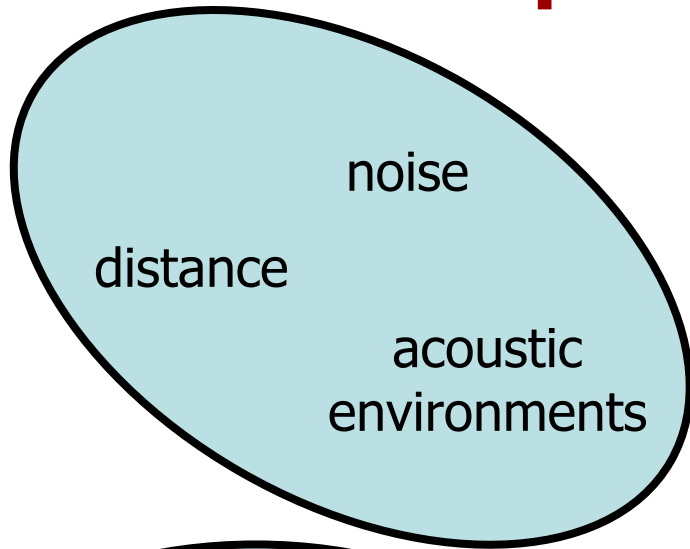




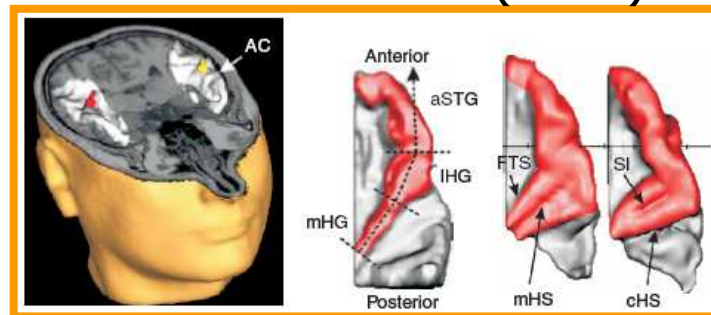
in the wild



An assemblage of perturbations



Schneider et al. (2005)



Robustness enhancers

- 1.** Functional redundancy
- 2.** Feedback and Adaptation
- 3.** Accommodation

Robustness enhancers

1. Functional redundancy

2. Feedback and Adaptation

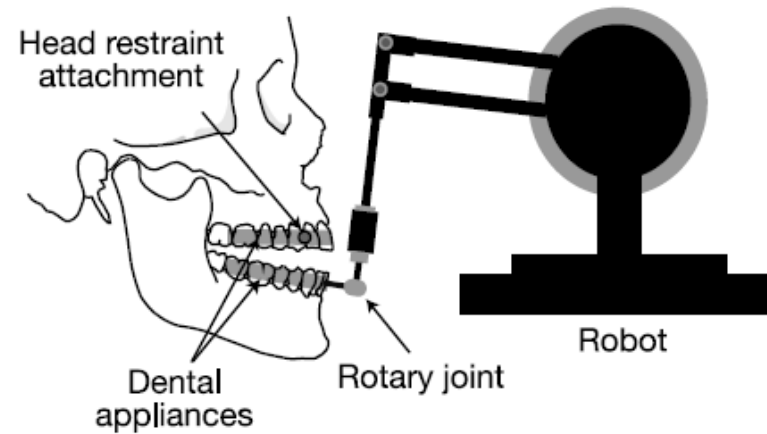
3. Accommodation

Auditory Feedback

- 1. loudness** (Lane & Tranel, 1971)
- 2. pitch** (Kawahara, 1993; Burnett et al., 1998; Jones & Munhall, 2000)
- 3. formant frequencies** (Villacorta et al., 2007; Houde & Jordan, 2002; Max et al., 2003)

Adaptation: a sensorimotor example

Tremblay et al. (2003)



Adaptation as increasing robustness



split tongue

Bressmann (2006)



braces

Robustness enhancers

1. Functional redundancy

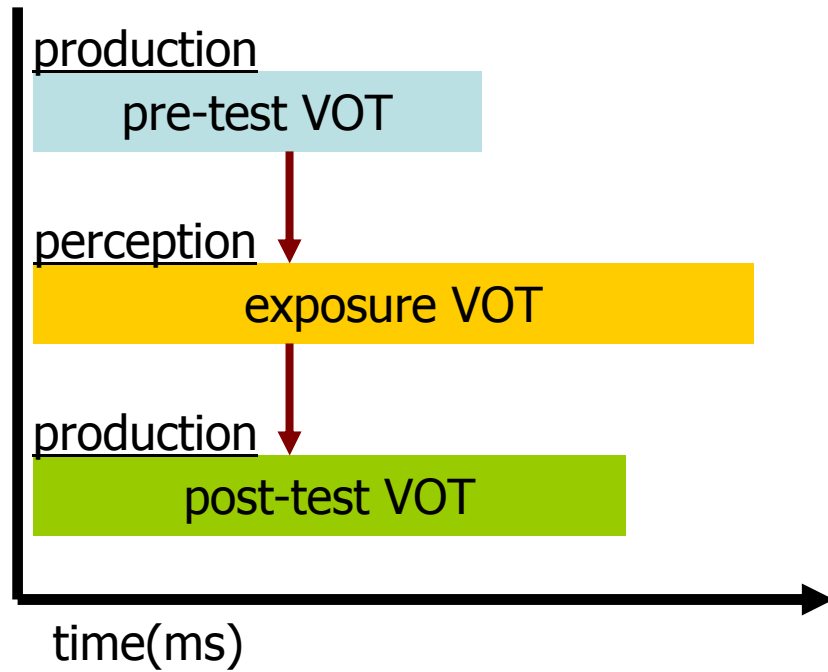
2. Feedback and Adaptation

3. Accommodation

Robustness enhancers

1. Functional redundancy
2. Feedback and Adaptation
3. Accommodation

Accommodation



Nielsen (2005)



Casasanto et al. (2010)

Robustness enhancers

1. Functional redundancy
2. Feedback and Adaptation
3. Accommodation

Robustness enhancers

1. Functional redundancy

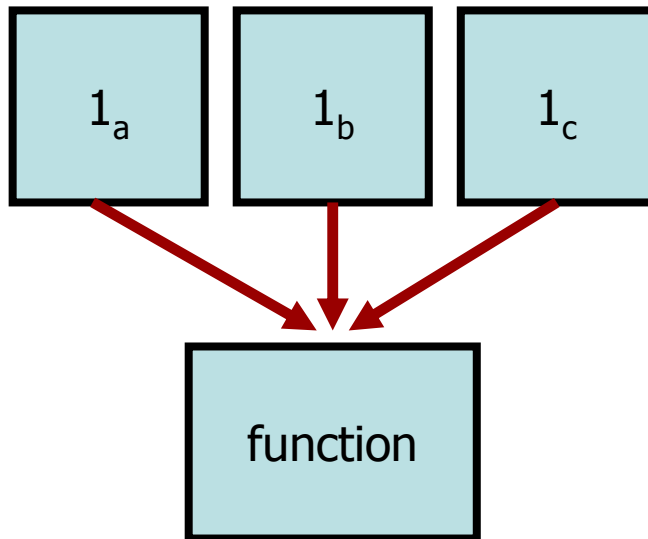
2. Feedback and Adaptation

3. Accommodation

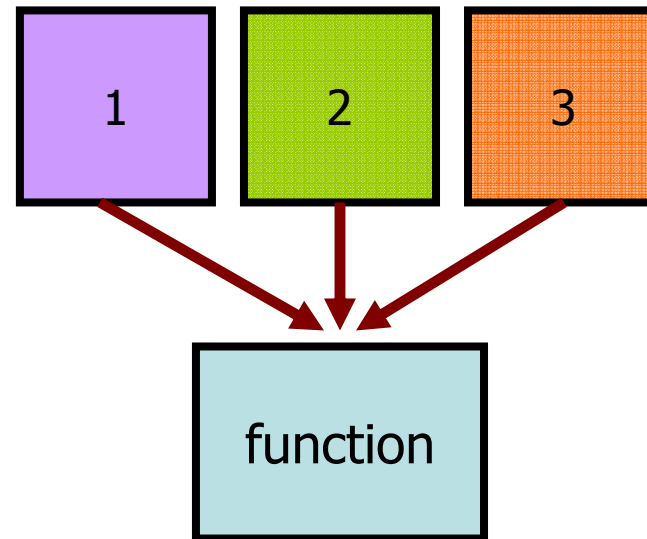
What is redundancy?

Wagner (2005)

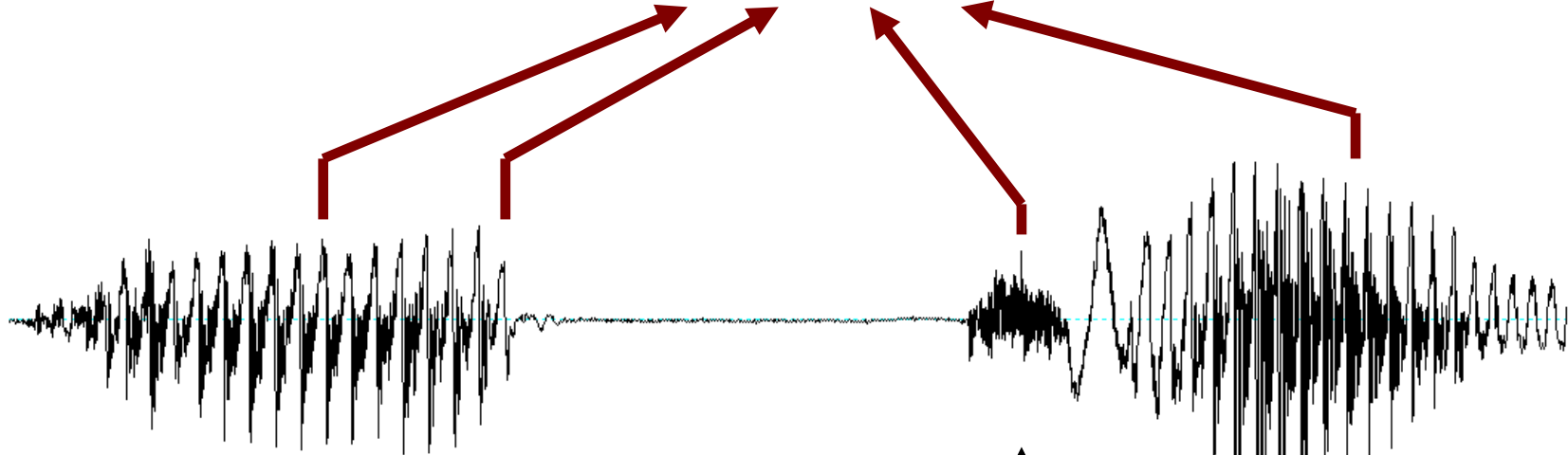
"ordinary" redundancy



functional redundancy



"I am a /t/"



←
Hawkins & Nguyen
(2001), Hawkins
(2010)

- 1. length
- 2. F1
- 3. F2

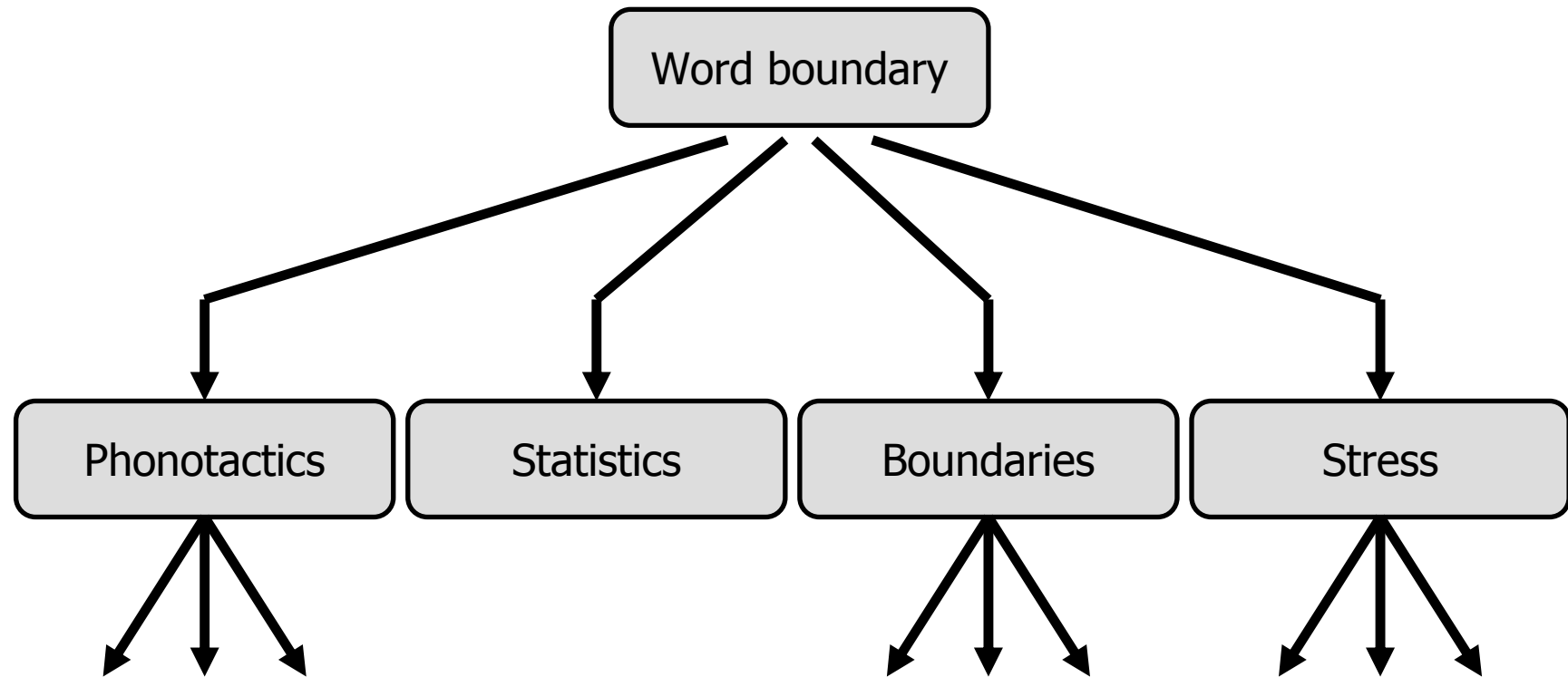
4. VOT

5. pitch

Cue layering is ubiquitous

- Utterance endings
- FOCUS (e.g. House et al., 2001)
- Nasals
- Stress (e.g. Sluiter, 1995)
- Length contrasts (Vainio et al., 2010)

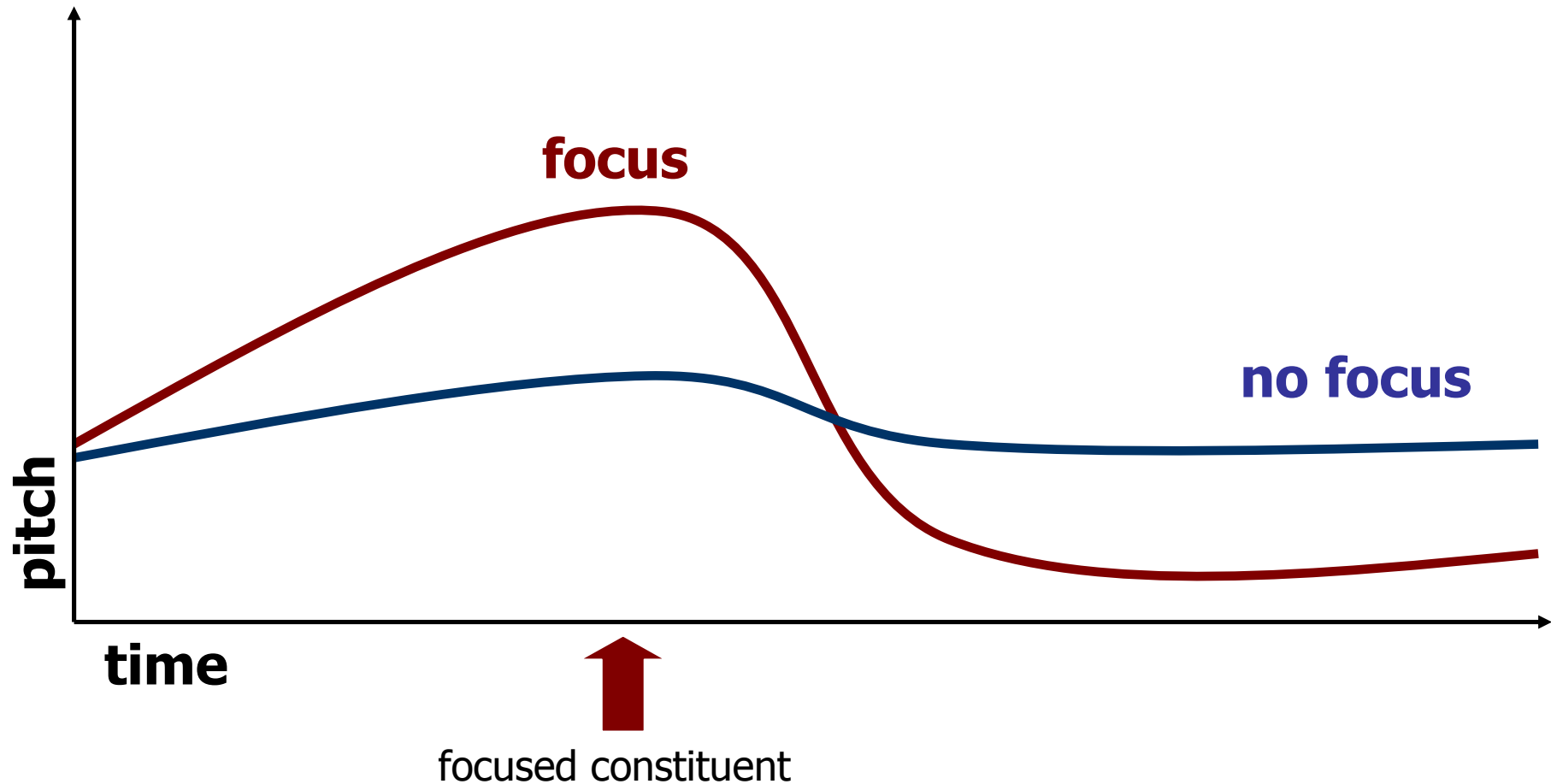
Cue layering for word boundaries



Allen & Christiansen (1996), Christiansen & Allen (1997), Christiansen et al. (1998)

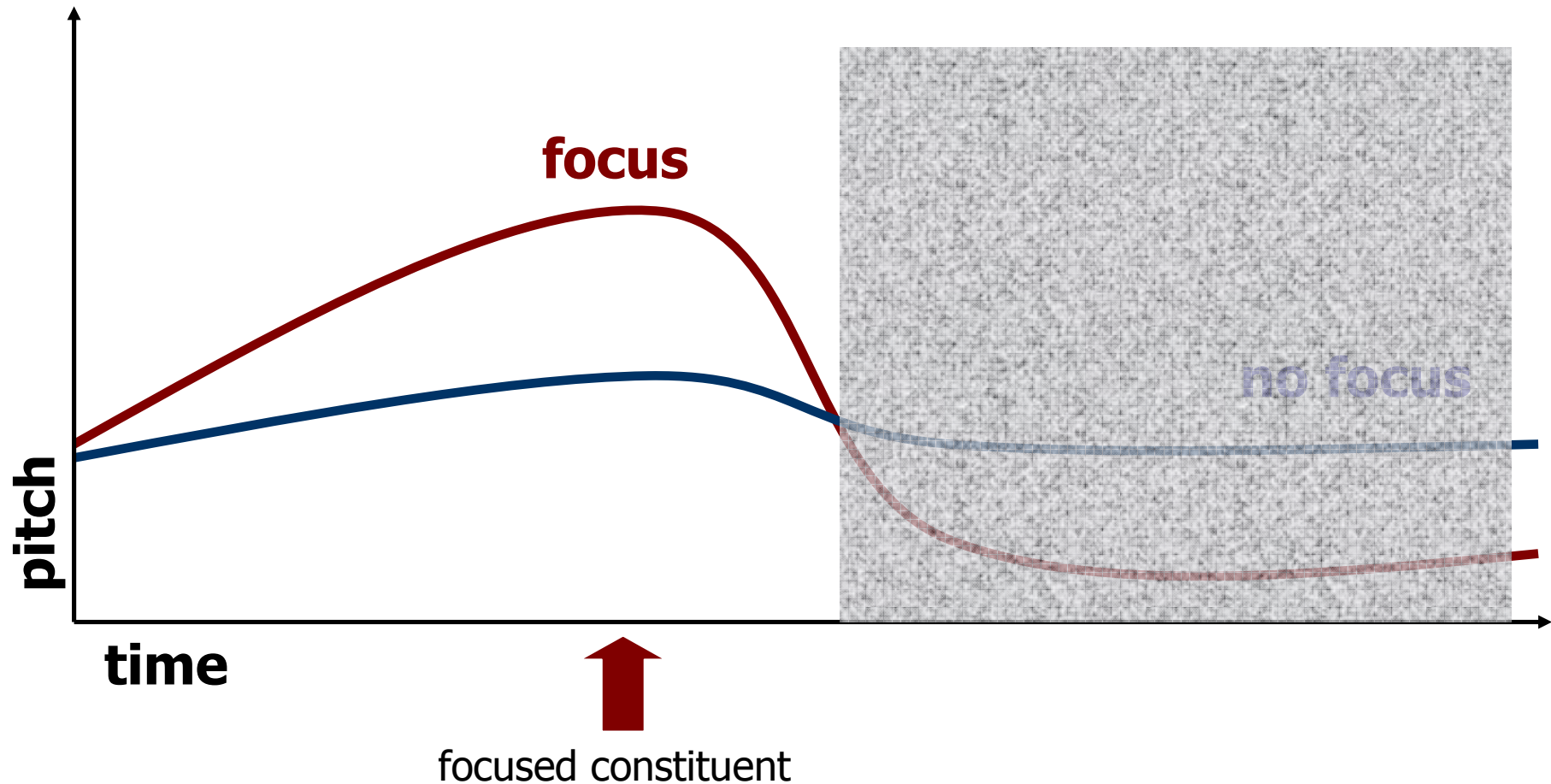
Post-focus compression

Xu et al. (2005)



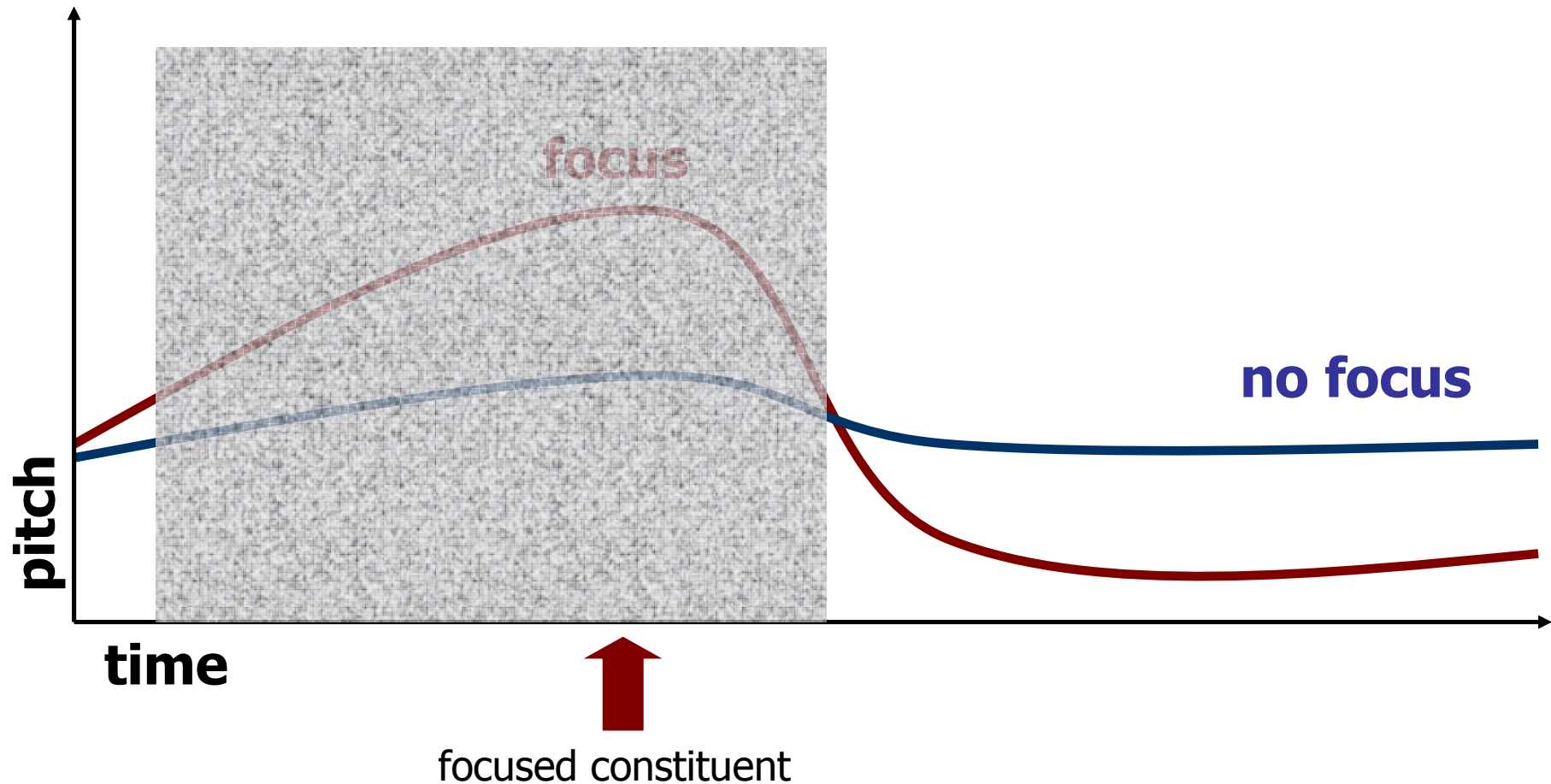
Post-focus compression

Xu et al. (2005)



Post-focus compression

Xu et al. (2005)



How exactly does redundancy increase robustness?

→ Redundancy increases **learnability** and **perceptability** for speakers with slightly different grammars and cognitive make-ups

→ Redundancy increases **learnability** and **perceptability** of contrasts in different types of noise

Robustness enhancers

1. Functional redundancy

2. Feedback and Adaptation

3. Accommodation

Robustness enhancers

- 1.** Functional redundancy
- 2.** Feedback and Adaptation
- 3.** Accommodation

Robustness as a design feature

- **Hockett's design features** (Hockett, 1960; Hockett & Altmann, 1968)
- **Consilience** (Wilson, 1998)

"A theory is said to be consilient if it explains at least two classes of facts"

(Thagard, 1978)

Robustness as a design feature

biology

functional redundancy

adaptation

feedback

e.g. Kitano (2002)



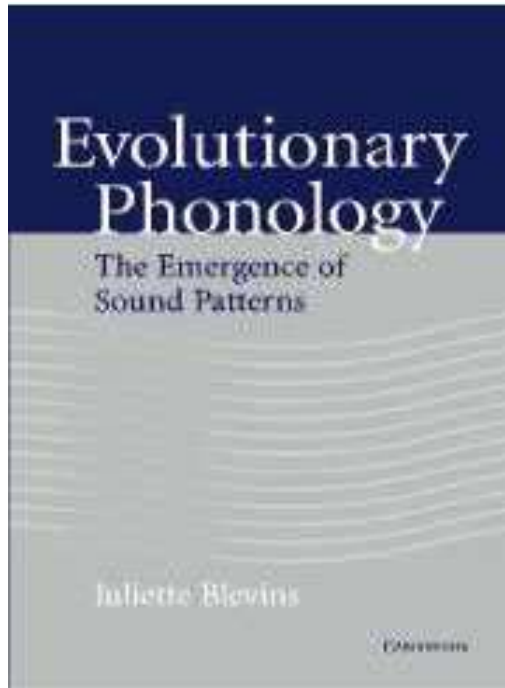
language

SO WHAT?

What we can do with robustness...

- 1. in phonology**
- 2. in experiments**

Robustness and Evolutionary Phonology



Blevins (2004)

Palantla Chinantec

ha vs. hã₁ vs. hã₂
(Merrifield & Edmonson, 1999)

English

<th> versus <f>
(Miller & Nicely, 1955;
Vihman, 1996)

Cue Layering,
Functional Redundancy



"Survival Value"
of a Contrast

Robustness and Experiments

- 1.** Artificial language learning experiments
- 2.** Repeated interaction experiments

Look-out

- 1.** Review article
- 2.** Quantifying redundancy/robustness
- 3.** Experiments & computational simulations

contact me!

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THANK YOU

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