On the perception of voicing in whisper: A cross-modal semantic priming study

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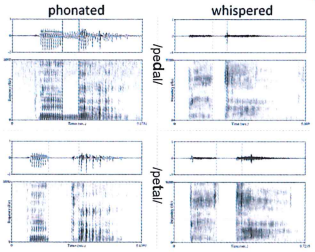
This work addresses the question of the one-line pre-lexical processing and the role of the fine phonetic details in the recognition of the voicing feature in French whispered words. As produced without vocal fold vibration, the [+voice] obstruents are not immediatly recognised. But if few more time is left to the listener, they are well recognized. It suggests that this time may be used by the listener to extract from the acoustical signal the phonetic details necessary to reconstruct voicing during word recognition process.

Background & Questionning

Whisper: voiceless speech

- Open glottis > no vocal f. vibration
- ambiguity : [+voice] phonemes becomes voiceless
- not a linguistic or phonological process (vs. assimilation rules)
- a communication requirement to reduce the distance perceptibility



Phonetic traces of voicing

- Production: C or V durations, intra-oral pressure, glottal opening...
- Perception: few studies, difficult comparisons, off-line tasks
  > variable levels of recognition, often better than chance
  > a bias towards [-voice].

Phonetic details in word recognition and lexical representation

- **Real-time process of phonetic details** in spoken word recognition
  > on-line processing with time pressure
- **Granularity of the phonological representation** of word
  > exemplar vs. abstract

Cross-modal semantic priming experiments

audio prime — *time delay* — visual target — *reaction time* (ms) — *yes/ no response*

C voicing	word prime	*2 delays*	word target	*Semantic relationship*	*Voicing matching*
[+voice]	/pedal/ *'pedal'*	0 ms vs. 50 ms	VÉLO *'bike'*	*related*	***congruent***
	/pedal/ *'pedal'*		FLEUR *'flower'*	*related*	*incongruent*
	/kitãs/ *'receipt'*			***control***	
[-voice]	/petal/ *'petal'*		FLEUR *'flower'*	*related*	***congruent***
	/petal/ *'petal'*		VÉLO *'bike'*	*related*	*incongruent*

Lexical task: " *Is the letter sequence on the screen a French word?* "
Phonated vs. whispered speech (as at the ear of a close listener)

Material and subjects

6 minimal contrasts of voicing : /p t k f s ʃ/ vs. /b d g v z ʒ/

Primes 20 minimal pairs *(pédale-pétale)*

Targets the most frequent semantical associate of the prime > 20% from a free association task by 38 subjets *(pédale–VELO; pétale–FLEUR)*

Controls prime not semantically related to the target *(quittance–VELO/FLEUR)*

Non-word Targets = 50% (for the task)
- 40%: pseudo semantically unrelated *('bottle' bouteille–FUDUR from 'futur')*
- 10%: pseudo semantically related *('lettuce' laitue–VALADE from salade)*

Related prime-target stimuli = 20% (tested items)

17 French listeners per test list (N=408)
8 test lists in whisper + 4 in phonated
x2 prime-target delays

> **each prime or target presented only once to the same listener**

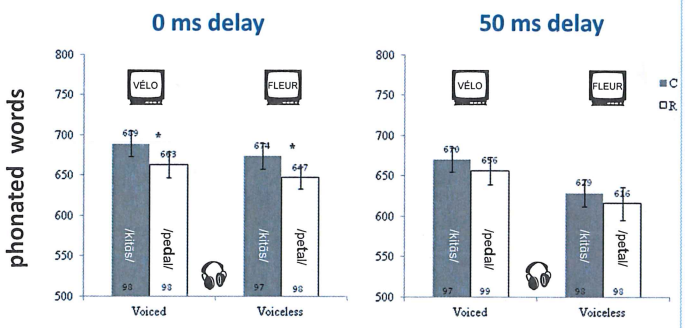
Neutralised properties of the primes and targets	Lexical Frequency (per million)	Number of syllables	Number of phonemes/ graphemes	Auditory uniqueness point	% of association
Voiced consonants					
Target words (VELO)	44	1.75	5.55	-	41.22
Related primes (/pedal/)	21	2.20	4.35	4.95	41.22
Control primes (/kitãs/)	16	2.20	4.35	4.85	-
Voiceless consonants					
Target words (FLEUR)	106	1.80	5.90	-	40.30
Related primes (/petal/)	14	2.20	4.35	4.80	40.30
Control primes (/kitãs/)	16	2.20	4.35	4.85	-

Significant differences acoustical duration (ms)	Consonants		Pre-C vowels	
	[-voice]	[+voice]	[-voice]	[+voice]
Phonated words	141	92	114	145
Whispered words	149	88	138	170

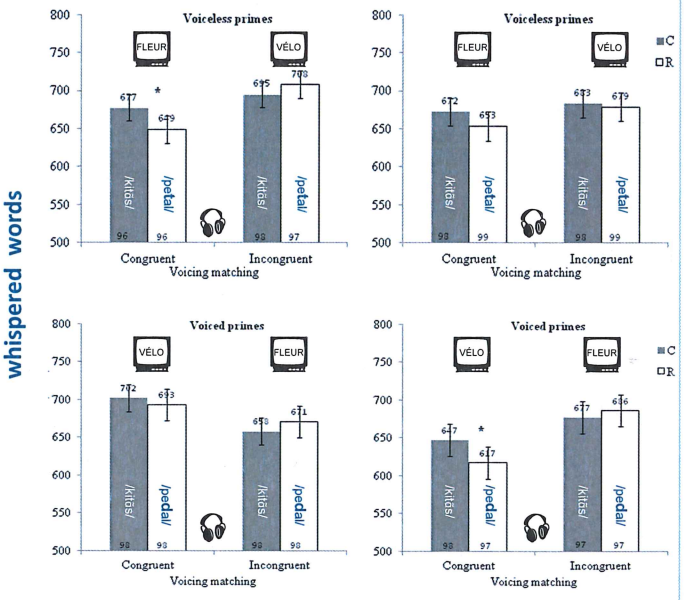
- for each phonation separately, the intensity level of all each stimulus was normalized to the intensity level averaged over all stimuli.
- Listeners were exposed to the 'natural' sound volume characterizing each phonation: no amplification of whisper.

Results

Mean Reaction Times (in ms) and Standard Errors for the control (C) and related (R) primes. Percentages of correct responses inside the bar and significant priming effects (* p < .05)



[+voice] as [-voice] obstruent primes show priming effect
> immediate recognition of voicing
> priming disappears with 50-ms longer delay



[-voice] obstruent words show **only immediate priming**
[+voice] obstruent words show **only late priming**
No voicing incongruence shows priming effect

Conclusion

- For **whispered [+voice]** obstruents
  - the recognition takes time
  - **but** never confounded with voiceless (ambiguity)

> the voicing processing seems to start as soon as the whispered word is heard, but **more time is needed to identify the [+voice]** feature.

- A **reconstruction process** takes place that suggests
  - not exemplar lexical representation
  - but an **extraction of phonetic details** from the signal

> the phonetic knowledge (i.e. of C/V durations) is used in a **pre-lexical recontruction process of more abstract units** : phonological feature or phoneme.