Temporal Modified Speech Perception in Dyslexia

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Framework

- **Auditory hypothesis** (Tallal, 1980).
- General auditory deficit in temporal processing (Tallal et al., 1993).
- Training of language impaired children with **temporally stretched speech** (Merzenich et al., 1996; Tallal et al., 1996).
- Accelerated Speech Intelligibility and Perception?
- The temporal organisation of spoken language may become more critical to comprehension, the more the speech rate is increased (Foulke, 1971).

➢ Artificially time-compressed speech was easier to process than naturally produced fast speech (Janse, 2003). **Hypothesis**: an acceleration of the speech signal rate would change the speech perception of dyslexic adults. Dyslexics would have more difficulties to process artificially time-compressed speech than controls.

➢ Rapid transition and brief sound of the speech signal: acoustic cues are essential in speech perception, the Voice Onset Time (VOT) and the transition of the formant 2 (FT2). **Hypothesis**: dyslexics would show more or less specific impairment for each acoustic cue compared to controls.

Method

Participants

- Maternal language : French.
- Normal hearing.
- Dyslexic adults *vs.* Control adults.
- Dyslexia **diagnosed** + French dyslexia detection test (ODEDYS created by Jacquier-Roux, Valdois, & Zorman, 2002) and Alouette test (Lefavrais, 1965).

Table 1. Participant groups in experiment 1 and 2.

		Experiment 1		*Experiment 2*	
		Control adults (N = 32)	*Dyslexic adults (N = 32)*	*Control adults (N = 32)*	*Dyslexic adults (N = 32)*
Mean Age (yrs)		22.6	23.3	22.6	23.3
Gender	**male**	10	10	10	10
	female	22	22	22	22

Stimuli

- Male French speaker
- 64 disyllabic non-words $C_1V_1C_2V_2$
- 16 fillers $V_1C_1V_2$

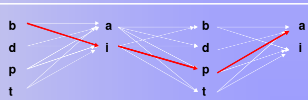

Figure 1. Schematic illustration of non-words structure.

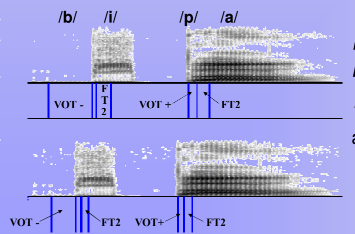

Figure 2. Spectrogram of non-word [bipa], time-compression 50%.

Subjects' Task

Non-words binaural auditory identification.

- Control group: transcription task
- Dyslexic group: repetition task

Method

Manual segmentation VOT and FT2

Time-Compression for each acoustic cue according to 4 conditions :

- 100% = original duration
- 50% = 50% of original duration left
- 25% = 25% of original duration left
- 0% = totally deleted

Experiment 1: VOT time-compression

Results

➢ Vowels are better identified than consonants.

➢ *3-way ANOVA*

- ➢ ***Group effect*** *(p < .001).*
- ➢ ***Position effect*** *(p < .001).*
- ➢ ***Time-compression effect*** *(p < .001).*
- ➢ **Group x Position Interaction** *(p < .05).*
- ➢ **Position x Time-Compression Interaction** *(p < .01).*

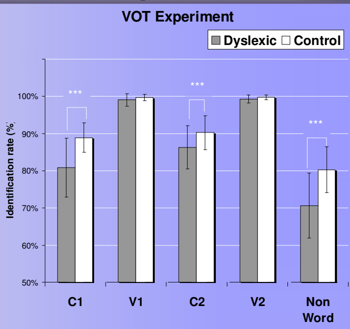

Figure 3. Histograms of the identification rate (%) of each phoneme (C and V) and the non word.

Experiment 2: FT2 time-compression

Results

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➢ *3-way ANOVA*

- ➢ ***Group effect*** *(p < .01).*
- ➢ ***Position effect*** *(p < .001).*
- ➢ ***Time-compression effect*** *(p < .001).*
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- ➢ **Position x Time-Compression Interaction** *(p < .001).*

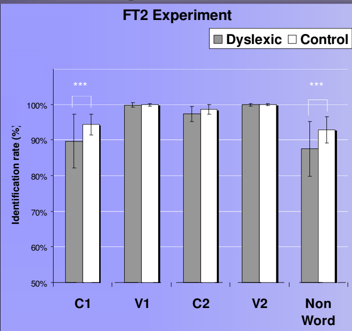

Figure 4. Histograms of the identification rate (%) of each phoneme (C and V) and the non word.

➢ **Inter-individual variability.**

Table 2. Identification rates (%) for VOT and FT2 compression experiments for Control *vs.* Dyslexic groups.

		VOT compression				***FT2 compression***			
		Control adults	***SD***	***Dyslexic adults***	***SD***	***Control adults***	***SD***	***Dyslexic adults***	***SD***
C_1	**100%**	97.3	*0.04*	91.2	*0.09*	97.5	*0.04*	93.9	*0.09*
	50%	95.5	*0.04*	87.9	*0.09*	98.2	*0.04*	92.4	*0.09*
	25%	92.8	*0.06*	85.2	*0.10*	96.5	*0.04*	92	*0.10*
	0%	70.1	*0.10*	59.2	*0.13*	85.2	*0.08*	80.5	*0.11*
C_2	**100%**	99.6	*0.02*	97.5	*0.05*	99.6	*0.02*	98.2	*0.03*
	50%	99	*0.02*	97.7	*0.03*	99.4	*0.02*	98.4	*0.03*
	25%	94.7	*0.06*	87.3	*0.09*	99.6	*0.02*	97.3	*0.04*
	0%	67.8	*0.14*	62.9	*0.17*	95.7	*0.04*	95.3	*0.04*

Confusion Matrix (Experiment 1)

- Attack consonant: confounded with the unvoiced corresponding consonant (/b/->/p/ or /d/->/t/) even at 100% (control condition) for dyslexics.
- Intervocalic consonant: Voiced consonants (/b/ and /d/) confounded with the approximant liquid consonant /l/.

Confusion Matrix (Experiment 2)

- A main type of confusion: a place of articulation error for voiced consonants (/b/->/d/) in both consonant positions for both groups but appears as from the control condition (100%) for dyslexics.
- It is noteworthy that dyslexic adults present **significant auditory non-words identification deficit in the control condition in which the speech signal is intact.**

Discussion

Group effect. **Dyslexic adults exhibit more difficulties to identify the temporal modified speech for both phonetic features (voicing and place of articulation).** In addition, our results revealed a large inter-individual variability in each group. This variability was also observed in a previous study using reversed speech stimuli (Meunier et al., 2002). Degraded speech identification may differ according subject's cognitive abilities.

Phonetic features. **Stronger deficit of integration for the VOT** than for the second formant transition. In Experiment 1, the attack and the intervocalic consonants were affected whereas in Experiment 2, only the attack consonant was sensible to a group effect. In accordance with the strongly effect of voicing observed in Ziegler et al.'s study (2005).

Auditory theory. Time-compressed non-word auditory identification deficit for dyslexic adults compared to control adults. Dyslexics may show an **auditory deficit in temporal processing and particularly in time-compressed speech**. In repetition task for dyslexics: they only have to decode stimuli at the first acoustic stage (acoustic features extraction). In opposition with Rosen's opinion (2003): the rapid auditory processing would be impaired with dyslexia.

To conclude. Specific identification deficit on consonant even at normal rate for dyslexics and it is worst and worst with the speech degradation. The temporal organisation seems to play an important role for dyslexics.

In addition of this temporal processing deficit, we assume that cognitive restoration capacities of dyslexics are also deficient. The descendant auditory pathway might be a cognitive feedback to modulate the temporal resolution. Further hearing tests in order to evaluate the central auditory system of dyslexic adults would inform us on their central auditory abilities.

Literature

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