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LANGUAGE, SPEECH, AND HEARING SERVICES IN SCHOOLS • Vol. 42 • 273-285 • July 2011

## Peeling the Onion of Auditory Processing Disorder: A Language/Curricular-Based Perspective

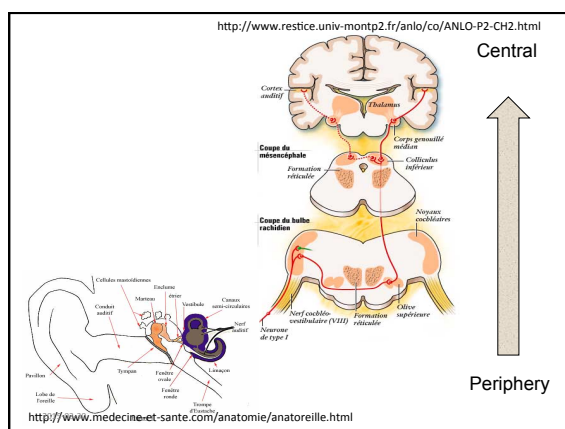
Geraldine P. Wallach\*

The “onion” metaphor in the article’s title was inspired by a statement made by the famous actress, Joanne Woodward, during an interview several years ago. She indicated (para- phrased here) that “acting is like an onion. You have to keep peeling its layers to get to the core of your character.

Keep a simple idea in mind: We do not process auditory, we process language, so keep peeling the onion to get to its core.



<http://drdandsdailydose.com/?p=514>

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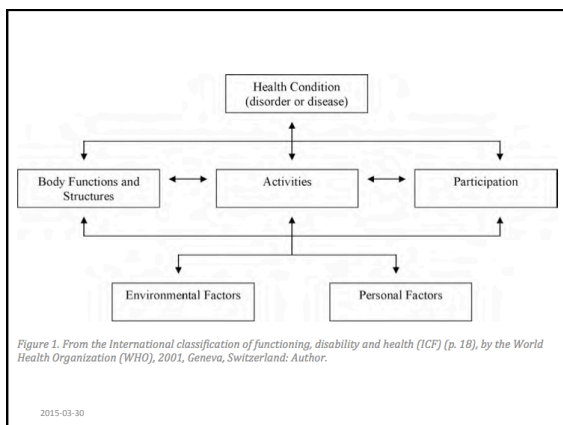
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**2.6. Definition of auditory processing disorder**

With reference to the ICF, auditory processing disorder is presumed to originate in the auditory system (body functions and structures) and is characterized by a persistent limitation in the performance of auditory activities and significant consequences on participation. In the ICF model, *capacity* is defined as executing tasks in the standardized environment (e.g., in an audiological sound room); *performance* is defined as executing tasks in the everyday environment (in the individual's daily life). These auditory activity limitations may be evident in assessing capacities (e.g., speech discrimination in noise, temporal resolution via gap detection, pitch perception, binaural processing as in masking level differences). Importantly, they also affect performance, such as conversing at a cocktail party, localizing a siren on the street, understanding a multistep instruction in the classroom or appreciating music. Such problems will undermine participation of

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learners in educational settings, of workers in occupational settings and of individuals in a wide range of community roles. For practical purposes, functional problems which are explained adequately in terms of loss of auditory acuity (e.g., speech perception problems explainable in terms of loss of audibility given audiometric threshold elevations) are not dealt with in this discussion. Furthermore problems that are adequately explained by non-auditory deficits (e.g., language comprehension problems explainable in terms of delays or disorders in language development, attention, memory or cognition) are also excluded. However, the current report will include auditory communication problems for which it is clinically relevant to consider auditory processing problems that may involve multiple levels of the auditory system or multiple deficits. Note that our inclusion criteria are defined in terms of functional problems rather than in terms of site of lesion being central versus peripheral.

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### Prevalence

Estimation: 2 to 3 % in children

Chermak, G.D. & Musiek, F.E. (1997). Central auditory processing disorders: New perspectives. San Diego: Singular Publishing Group, Inc.

### Categories

There are three categories of APD:

1. Developmental APD: Cases presenting in childhood with normal hearing (i.e. normal audiometry) and no other known aetiology or potential risk factors. Some of these people may retain their APD into adulthood
2. Acquired APD: Cases associated with a known post-natal event (e.g. neurological trauma) that could plausibly explain the APD
3. Secondary APD: Cases where APD occurs in the presence, or as a result, of peripheral hearing impairment. This includes transient hearing impairment after its resolution (e.g. glue ear or surgically corrected otosclerosis).

British Society of Audiology (2011). *Position statement : Auditory processing disorder (APD)*.

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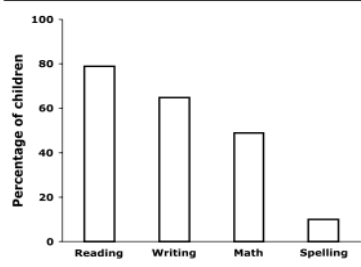
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### Who are children with CAPD

Figure 2. Percentage of children with (C)APD-only (n = 48) as a function of reported academic difficulties.



Jutras, B., Dumont, V., Marcoux, C., Loubert, M., Dupuis, J.-L. & Baril, M. (2007). Applicability of central auditory processing disorder models. *American Journal of Audiology*, 16, 100-106.

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### Behavioural signs of CAPD

- Asks for repetition
- Misunderstands when someone speaks to her/him, especially in a noisy environment
- Gives inappropriate responses
- Answers questions with a delay
- Easily distracted in noisy environment

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### CAPD Behavioural Assessment

- Capacities tested
  - Binaural integration or separation
  - Auditory sequential organisation
  - Auditory temporal resolution
  - Auditory signal/noise separation or auditory figure/ground separation (listening in noise)

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### ASHA (2005)

**Diagnosis of (C)APD generally requires performance deficits on the order of at least two standard deviations below the mean on two or more tests in the battery (Chermak & Musiek, 1997).**

American Speech-Language-Hearing Association. (2005). (Central) Auditory Processing Disorders. Available at <http://www.asha.org/members/deskref-journals/deskref/default>

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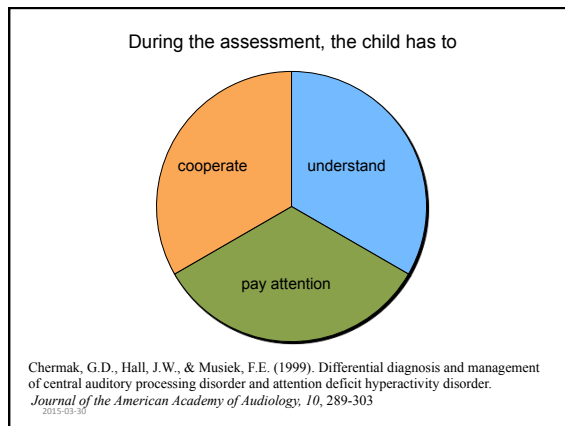
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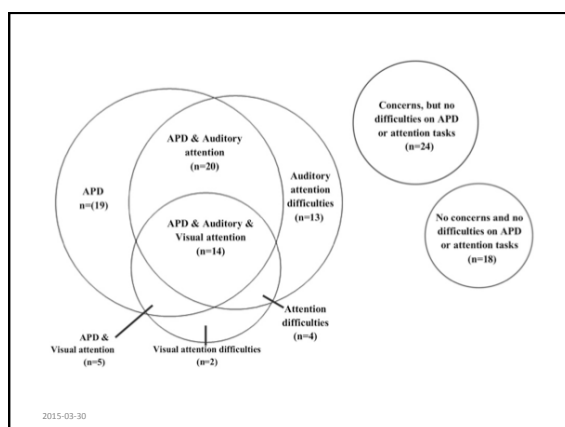
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| Groups            | (n = 119) |
|-------------------|-----------|
| CAPD only         | 16%       |
| AA only           | 11%       |
| VA only           | 2%        |
| CAPD + AA         | 17%       |
| CAPD + VA         | 4%        |
| CAPD + AA + VA    | 12%       |
| AA + VA           | 3%        |
| Normal + Concerns | 20%       |
| Normal            | 15%       |

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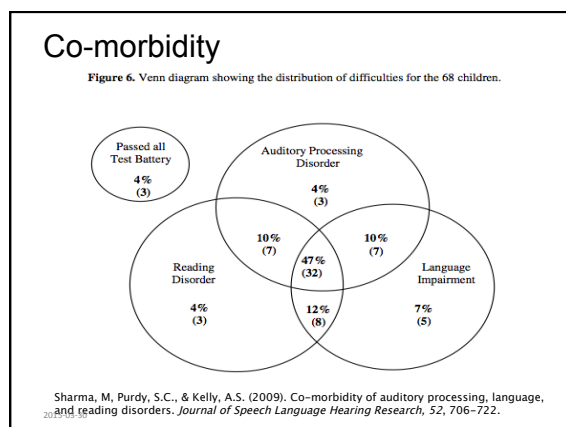
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Ziegler, J.C., Pech-Georgel, C., George, F., F.-Xavier, A. & Lorenzi, C. (2005). Deficits in speech perception predict language learning impairment. *Proceedings of the National Academy of Sciences of the United States of America*, 102, 14110-14115.

Table 1. Characteristics of children with SLI and of A-match and L-match controls

| Group             | Age (range), yr | IQ-P (range)   | Comp.        | Working mem. | Vocab.       | Phonol.     |
|-------------------|-----------------|----------------|--------------|--------------|--------------|-------------|
| SLI               | 10.4 (8.3-12.5) | 99.4 (85-110)  | 84.7         | 28.0         | 50.6         | 77.3        |
| L-match           | 8.6 (7.9-9.6)   | 102.1 (85-129) | 87.8         | 32.0         | 58.8         | 92.0        |
| A-match           | 10.6 (8.6-12.5) | 97.0 (83-110)  | 95.6         | 56.0         | 72.4         | 99.3        |
| Statistical tests |                 |                |              |              |              |             |
| L-match           | $P < 0.01$      | ns             | ns           | ns           | ns           | $P < 0.08$  |
| A-match           | ns              | ns             | $P < 0.0001$ | $P < 0.01$   | $P < 0.0001$ | $P < 0.001$ |

Values for comprehension (Comp.) indicate the percent correct on the ECOSSE picture/word comprehension test (36). Values for working memory (mem.) and vocabulary (Vocab.) indicate percent correct on the L2MA language battery (37). Phonology (Phonol.) values indicate percent correct on a word repetition test taken from the L2MA language battery (37). IQ-P, performance IQ (35); ns, not significant.

10 children in each group

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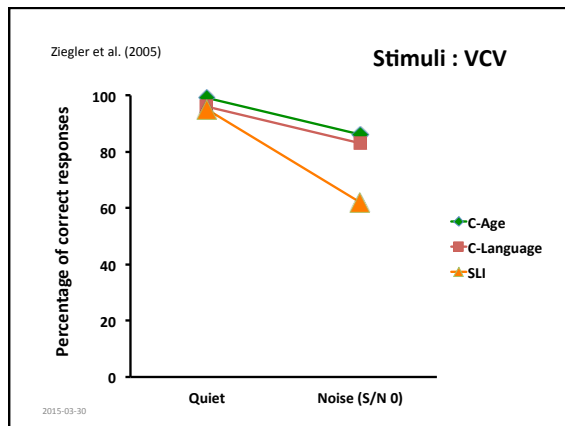
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International Journal of Audiology 2011; 50: 385-395

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Original Article

**Speech perception in noise: Exploring the effect of linguistic context in children with and without auditory processing disorder**

Josée Lagacé<sup>a,\*</sup>, Benoît Jutras<sup>a,†</sup>, Christian Giguère<sup>b</sup> & Jean-Pierre Gagné<sup>a,§</sup>

<sup>a</sup>École d'orthophonie et d'audiologie, University of Montreal, Canada; <sup>b</sup>Research Center of the Sainte-Justine Hospital, Montreal, Canada; <sup>c</sup>Audiology and Speech-Language Pathology Program, University of Ottawa, Canada; and <sup>d</sup>Research Center of the University Geriatric Institute of Montreal, Canada

**Objective of the study**

To explore the underlying nature of the speech perception problems in noise in the case of APD using the Test de Phrases dans le Bruit (TPB), adapted version of the SPIN test

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CAPD Assessment

SPIN test

- The original version of the SPIN test (Kalikow, Stevens & Elliott, 1977) has 10 lists of 50 sentences and a babble noise.
- Each list includes:
  - 25 highly predictable (HP) sentences  
Ex.: She made the bed with clean .....
  - 25 low predictable (LP) sentences  
Ex.: I should have considered the .....

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**CAPD** **Assessment** **SPIN test**

- The original version of the SPIN test (Kalikow, Stevens & Elliott, 1977) has 10 lists of 50 sentences and a babble noise.
- Each list includes:
  - 25 highly predictable (HP) sentences  
Ex.: *She made the bed with clean sheets.*
  - 25 low predictable (LP) sentences  
Ex.: *I should have considered the sheets.*

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**CAPD** **Assessment** **SPIN test**

| HP sentences  | LP sentences  | Difference  |
|---|---|---|
| <div style="border: 1px solid black; padding: 2px;">Auditory processing</div> <div style="border: 1px solid black; padding: 2px;">Language-based processing</div> | <div style="border: 1px solid black; padding: 2px;">Auditory processing</div> | <div style="border: 1px solid black; padding: 2px;">Language-based processing</div> <div style="border: 1px solid black; border-radius: 50%; padding: 5px; margin-top: 5px;">Use of contextual linguistic information</div> |

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**CAPD** **Assessment** **The TPB**

- developed for speakers of Canadian French and it is composed of 5 lists of 40 sentences and a babble noise (recorded with 8 French speaking adults).
- Each list includes:
  - 20 highly predictable (HP) sentences
  - 20 low predictable (LP) sentences

Tested in adults and in children

**Participants**  
 10 children with CAPD from 9 yrs 4 mths to 12 yrs 10 mths (average: 10 yrs 6 mths)  
 10 children for control from 8 yrs 11 mths to 12 yrs 5 mths (average: 10 yrs 3 mths)

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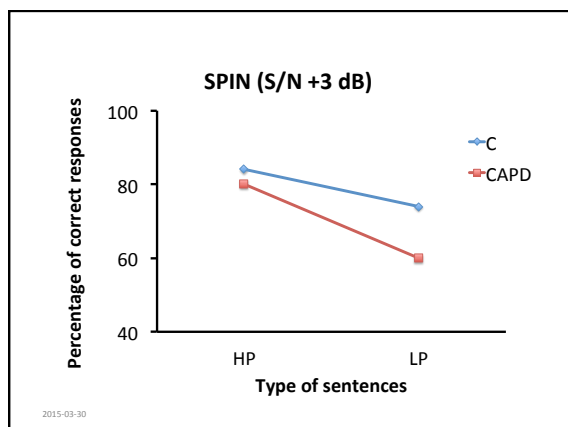
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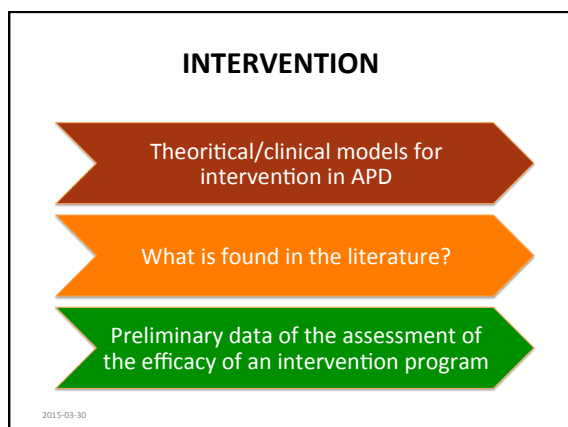
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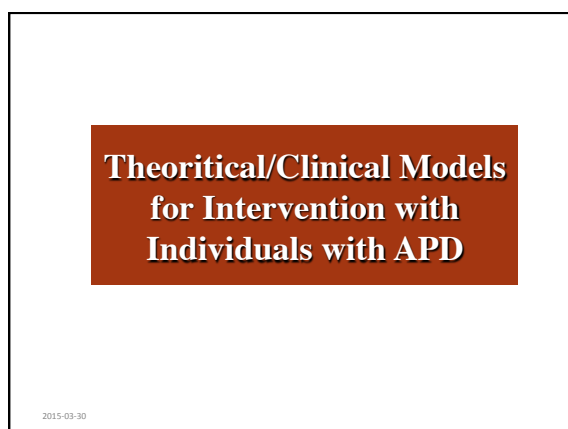
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**Models**

**Buffalo Model**

- (Katz, 1992)

**Bellis/Ferre Model**

- Bellis (2003)/Ferre (1997)

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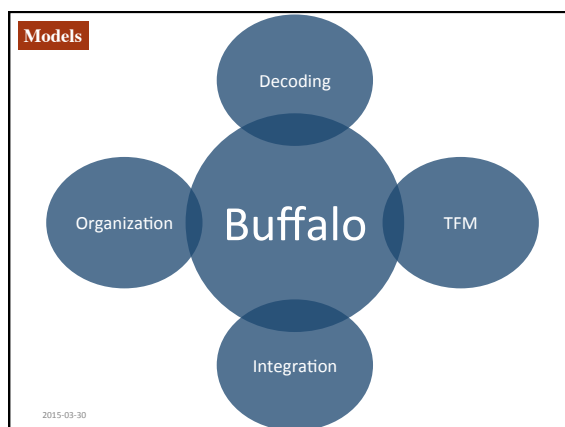
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**Models** **Staggered Spondaic Word (SSW) Test**

| Right First  | R.NC               | R.C      | L.C      | L.NC     |              | L.NC               | L.C      | R.C      | R.NC     |
|--------------|--------------------|----------|----------|----------|--------------|--------------------|----------|----------|----------|
| 1.           | up                 | stairs   | down     | town     | 2.           | out                | side     | in       | law      |
| 3.           | day                | light    | lunch    | time     | 4.           | wash               | tub      | black    | board    |
| 39.          | race               | horse    | street   | car      | 40.          | green              | house    | string   | bean     |
| <b>TOTAL</b> | <b>1</b>           | <b>6</b> | <b>4</b> | <b>2</b> | <b>TOTAL</b> | <b>1</b>           | <b>5</b> | <b>8</b> | <b>2</b> |
|              | (CARDINAL NUMBERS) |          |          |          |              | (CARDINAL NUMBERS) |          |          |          |
| Right First  | (A) R.NC           | (B) R.C  | (C) L.C  | (D) L.NC |              | (E) L.NC           | (F) L.C  | (G) R.C  | (H) R.NC |

**FIG 6-2.**  
Portions of the scoring form, including some of the earlier and later items. Odd-numbered items are REF and even-numbered items LEF. Columns A-D represent REF items starting with the right noncompeting (RNC) condition. Total errors are shown at the bottom for half of the RNC words in column A. Columns E-H show the LEF results, starting with the left noncompeting (LNC) condition. The errors in columns A-H constitute the eight cardinal numbers from which most of the SSW calculations are made.

From Katz, J. (1992). Classification of auditory processing disorders. Dans J. Katz, N. Stecker, & D. Henderson (Eds.), *Central auditory processing: A transdisciplinary view* (pp. 81-92). Chicago: Mosby Yearbook.

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**Models****Staggered Spondaic Word (SSW) Test**

|             |                    |         |         |         |       |                    |         |         |         |
|-------------|--------------------|---------|---------|---------|-------|--------------------|---------|---------|---------|
| 39          | race               | horse   | street  | car     | 40    | green              | house   | string  | bean    |
| TOTAL       | 1                  | 6       | 4       | 2       | TOTAL | 1                  | 5       | 8       | 2       |
|             | (CARDINAL NUMBERS) |         |         |         |       | (CARDINAL NUMBERS) |         |         |         |
| Right First | (A) RNC            | (B) R.C | (C) L.C | (D) LNC |       | (E) LNC            | (F) L.C | (G) R.C | (H) RNC |

**Ear Effect: H/L or L/H**

Total number of errors when the sequences started in the right ear /

Total number of errors when the sequences started in the left ear

**Order Effect: H/L or L/H**

Total number of errors on the two first words/Total number of errors on the two last words

From Katz, J. & Ivey, R.G. (1994). Spondaic procedures in central testing. Dans J. Katz (Ed.), *Handbook of clinical audiology (4e edition)* (239-255). Baltimore : Williams and Wilkins.**Models****Table 1. Buffalo Model classification criteria for central auditory processing disorder ([C]APD) categories.**

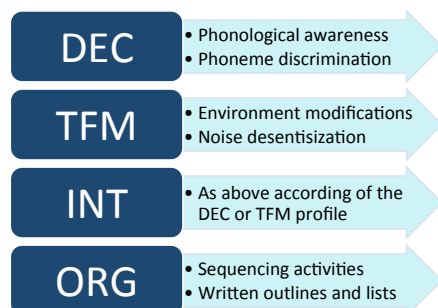
| Category | Listening condition |    |    |     | Response bias |              |     |
|----------|---------------------|----|----|-----|---------------|--------------|-----|
|          | RNC                 | RC | LC | LNC | Ear effect    | Order effect | REV |
| DEC      |                     | A  |    | A   | H/L           | L/H          |     |
| TFM      |                     |    | A  |     | L/H           | H/L          |     |
| ORG      |                     |    |    |     |               |              | A   |

Note. Categories—DEC = Decoding, TFM = Tolerance-Fading Memory, ORG = Organization (ORG)—are based on the Staggered Spondaic Word (SSW) test. RNC = right noncompeting, RC = right competing, LC = left competing, LNC = left noncompeting, H/L = high/low, L/H = low/high, REV = reversal; the letter A indicates abnormal results.

From Jutras, B., Loubert, M., Dupuis, J.-L., Marcoux, C., Dumont, V & Baril, M. (2007). Applicability of central auditory processing disorder models. *American Journal of Audiology*, 16, 100-106.<sup>(29-30)</sup>

**Models****Buffalo Model**

Katz (1992); Stecker (1996)



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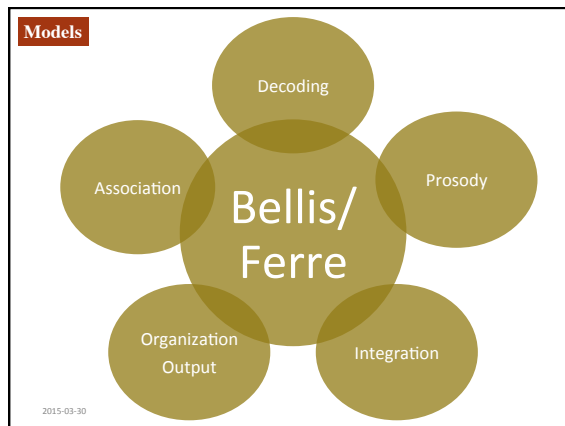
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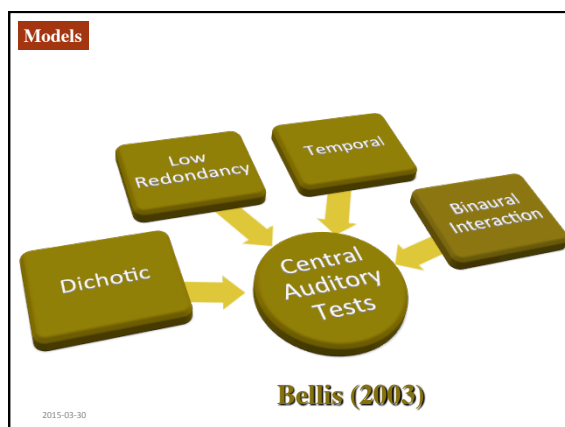
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**Models**

**Table 2. Bellis/Ferre Model classification criteria for (C)APD categories.**

| Category | SSW        | SSI-ICM | PPST     | Mono/noise |
|----------|------------|---------|----------|------------|
| DEC      | A-RC, A-LC | A       |          | A          |
| PROS     | LE         |         | A-V, A-H |            |
| INT      | LE         |         | A-V      |            |
| ASSOC    | A          |         |          |            |
| O-O      | A          |         | A-V, A-H |            |

**Note.** Categories—DEC = Auditory Decoding, PROS = Prosodic, INT = Integration, ASSOC = Associative, O-O = Output-Organization Deficits—are based on the SSW test, Synthetic Sentence Identification-Ipsilateral Competing Message test (SSI-ICM), Pitch Pattern Sequence Test (PPST), and monosyllable identification under noise (Mono/noise). The letter A indicates abnormal results, independently of test condition or ear tested. A-RC and A-LC indicate abnormal results in the two competing (right competing [RC] and left competing [LC]) conditions. LE indicates abnormal left-ear results, and A-V and A-H indicate abnormal results under verbal or humming condition, respectively.

From Jutras, B., Loubert, M., Dupuis, J.-L., Marcoux, C., Dumont, V & Baril, M. (2007). Applicability of central auditory processing disorder models. *American Journal of Audiology*, 16, 100-106.<sup>33-30</sup>

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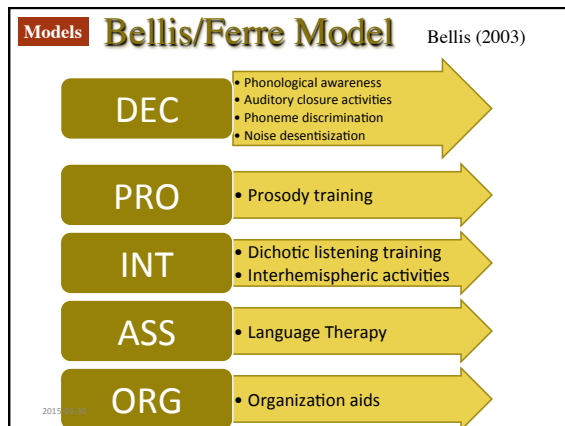
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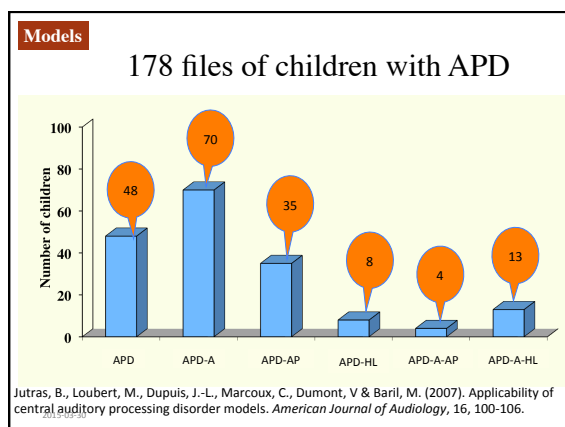
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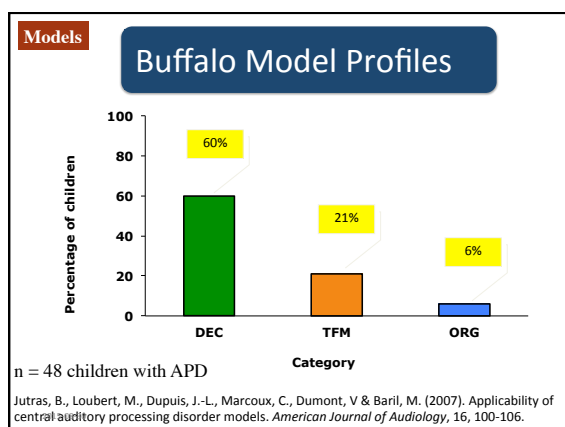
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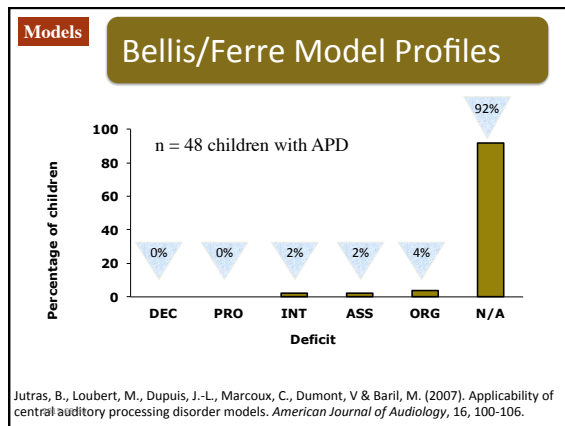
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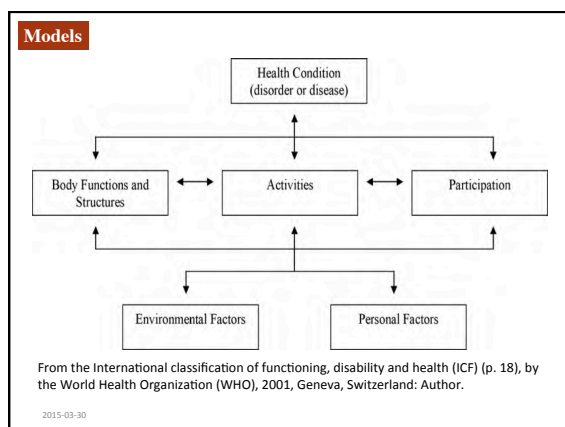
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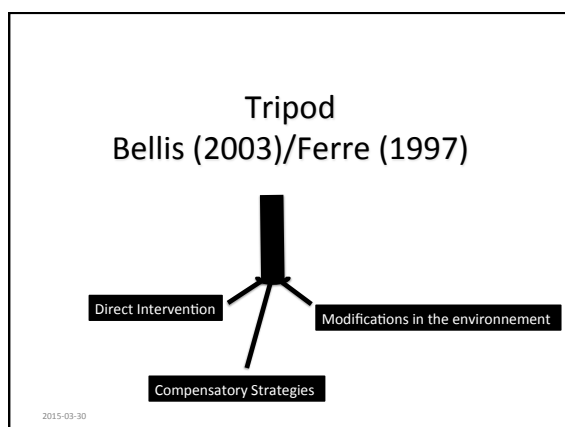
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## Intervention Programs in Scientific Studies and an example from a Clinic

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### Literature

#### Auditory or Phonological Training

| Group Studies<br>Normal   | Case Studies<br>APD                                 | Group Studies<br>APD or Dyslexia  |
|---|---|---|
| Moore et al. (2005)<br>Millward et al. (2011)<br>Halliday et al. (2012) | Musiek & Schochat<br>(1998)<br>Musiek et al. (2004) | Moncrieff et al.<br>(2008)<br>Putter-Katz et al.<br>(2002)<br>Putter-Katz et al.<br>(2008)<br>Muggu et al. (2011) |

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### Literature

Canadian Journal of Speech-Language Pathology and Audiology - Vol. 35, No. 1, spring 2011  
56-65

#### Effect of Noise Desensitization Training on Children with Poor Speech-In-Noise Scores

Akshay Raj Maggu  
Asha Yathiraj

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## Literature

## Maggu et al. (2011)

- **Participants**
  - 10 children 8 to 10 y. o. who failed a screening checklist for APD and had performance lower than 50% on a monosyllable test in noise
    - 5 received the training
    - 5 did not receive the training
- **Training**
  - Short stories presented in noise followed by four questions
    - 20-25 minutes/15 to 20 sessions
- **Pre and post training measures**
  - Monosyllables in noise for each ear
  - Monosyllables in noise through speakers
  - Sentences in noise through speakers

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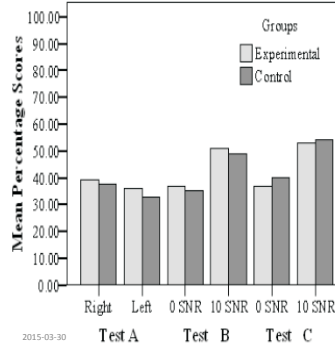
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## Literature

Maggu et al. (2011)



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Figure 3: Mean scores across the experimental and control groups for the baseline evaluation for speech perception in the presence of noise using monosyllables under headphones at 0 dB (A); monosyllables through speakers (B); and sentences through speakers (C).

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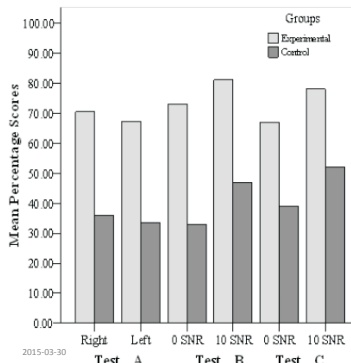
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## Literature

Maggu et al. (2011)



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Figure 4: Mean scores across the experimental and control groups for the final evaluation for speech perception in the presence of noise using monosyllables under headphones at 0 dB (A); monosyllables through speakers (B); and sentences through speakers (C).

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Jirsa, R.E. (1992). The clinical utility of the P3 AERP in children with auditory processing disorders. *Journal of Speech and Hearing Research*, 35, 903-912.

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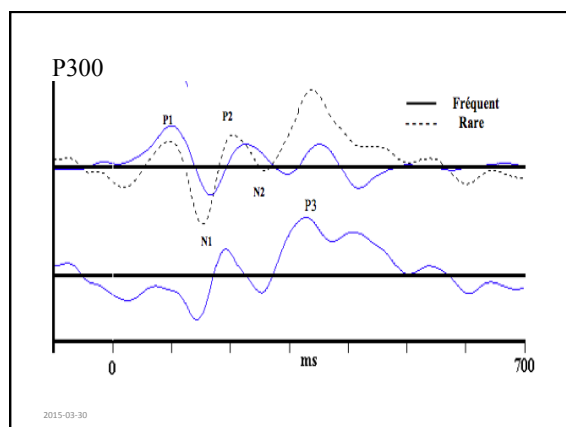
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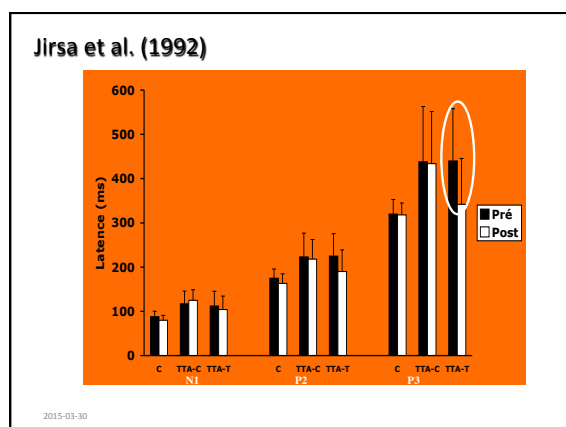
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**CAPD Intervention**

**Auditory training in noise among pupils with central auditory processing disorders: A pilot study**

Benoît Jutras  
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Ministry of Education, Sport and Leisure in Québec

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**CAPD Intervention**

**Aim**


Evaluate the efficacy of an auditory listening program in with a software-based training, called Logiciel d'écoute dans le bruit (LEB)

**Participants**

Ten children with CAPD

- 10 in training therapies using the software
- 6 not expose to training therapies

**LEB**  
Logiciel d'écoute dans le bruit



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**CAPD Intervention**

**Auditory training in noise among pupils with central auditory processing disorders: A pilot study**

- Training 2 x 30 min / week / 13 weeks
  - Babble noise
  - Five main auditory abilities
    - Discrimination of acoustically different and similar words
    - Identification of acoustically different and similar words
    - Identification of sentences
    - Following directions
    - Comprehension of paragraphs and stories

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CAPD
Intervention

Auditory training in noise among pupils with central auditory processing disorders: A pilot study

13 themes

1. sports
2. insects
3. cooking
4. mammals
5. birds
6. occupations

7. music
8. human anatomy
9. transportation
10. energy
11. plants
12. space

13. countries

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CAPD
Intervention

Auditory training in noise among pupils with central auditory processing disorders: A pilot study

19 activities

1 to 4 = Discrimination of words  
5 to 7 = Carrier phrase – identify the last word  
8 to 9 = Identification of words  
10 to 11 = Identification of sentences  
12 to 13 = Following directions  
14 = Brain teasers  
15 to 19 = Listening to stories and answer to questions

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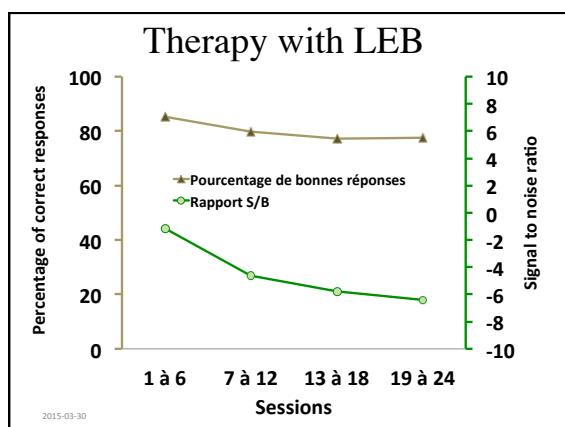
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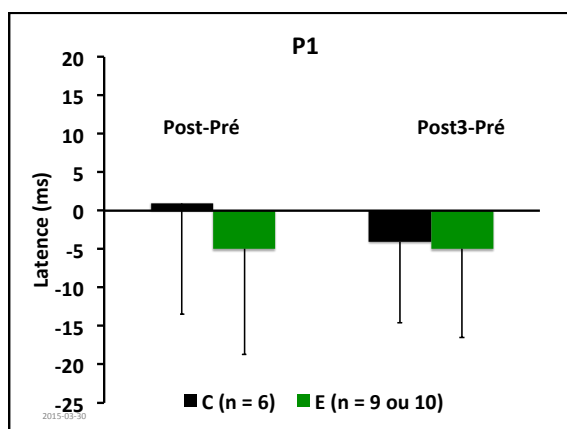
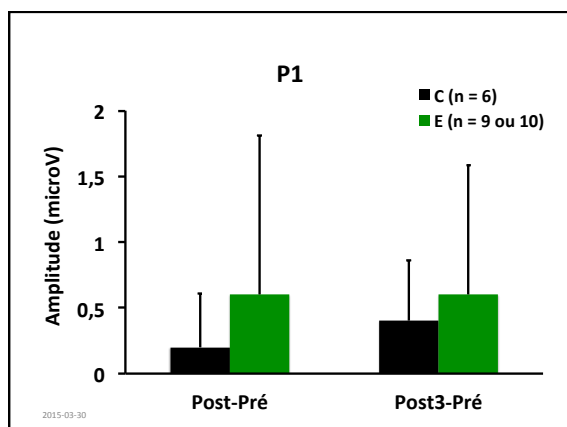
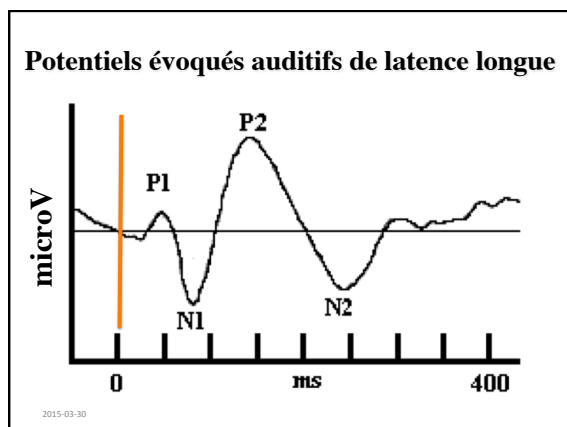
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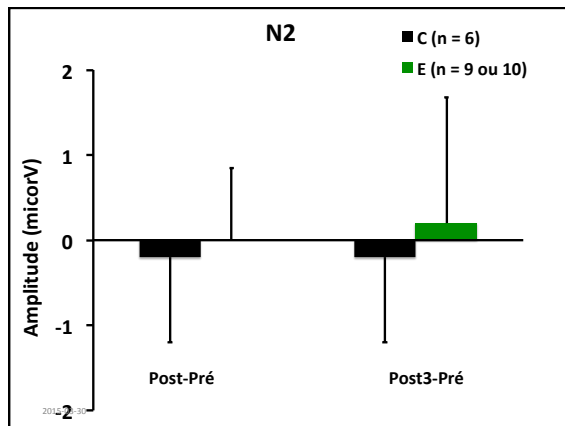
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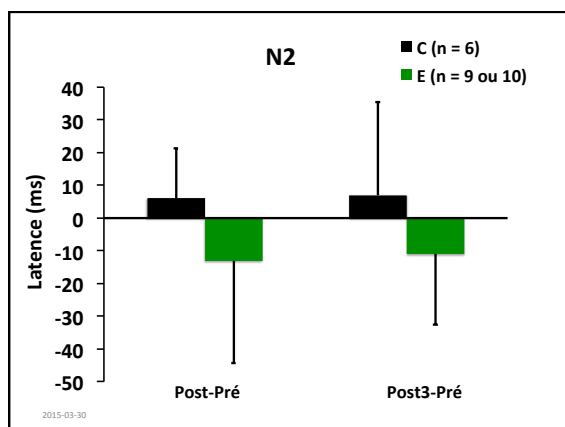
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**Auditory Processing Disorder and Auditory/Language Interventions: An Evidence-Based Systematic Review**

Marc E. Fey,<sup>a</sup> Gail J. Richard,<sup>b</sup> Donna Geffner,<sup>c</sup> Alan G. Kamhi,<sup>d</sup> Larry Medwetsky,<sup>e</sup> Diane Paul,<sup>f</sup> Deborah Ross-Swain,<sup>g</sup> Geraldine P. Wallach,<sup>h</sup> Tobi Frymark,<sup>i</sup> and Tracy Schooling<sup>j</sup>

The evidence base is too small and weak to provide clear guidance to speech-language pathologists faced with treating children with diagnosed APD, but some cautious skepticism is warranted until the record of evidence is more complete. Clinicians who decide to use auditory interventions should be aware of the limitations in the evidence and take special care to monitor the spoken and written language status of their young clients.

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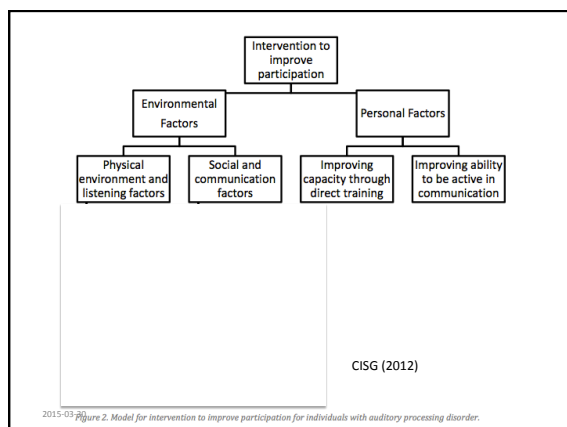
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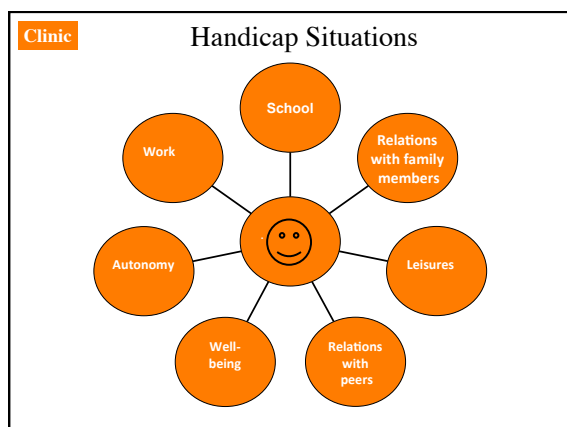
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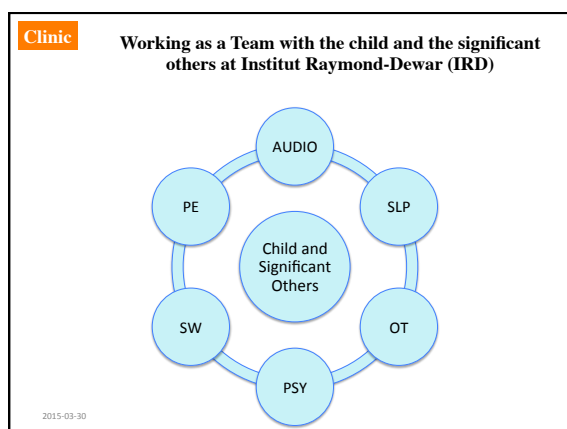
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**Clinic** **Group Interventions at the Rehabilitation Center Institut Raymond-Dewar (IRD)**

-  Hunting and Fishing
-  Top 10
-  Teenager
-  Psychodrama
-  Talking about myself

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**Clinic** **Image Sources**

-  <http://funweb.epfl.ch/sites/fichiers/2010-06-jura/jura43/poissons%20galerie.html>
-  <http://www.appstore-test.fr/22326/2012/02/27/top-10-les-resultats-du-mois-de-fevrier/>
-  <http://www.stopsportsinjuries.org/blog/entryid/23/ask-the-doctor-weight-training-in-youngsters.aspx>
-  [http://abcmecaltourism.com/en/psychoanalytic\\_psychodrama.php](http://abcmecaltourism.com/en/psychoanalytic_psychodrama.php)
-  <http://jecrispourexhorter.over-blog.com/categorie-11961652.html>

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**Conclusions**

- APD exists
- No gold standard test
- Neurophysiological signature in developmental APD?
- Intervention can be beneficial
- Differential conclusion
  - Multidisciplinary approach needed in cases
- Multidisciplinary approach for intervention

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- Bellis, T. J. (2003). *Assessment and management of central auditory processing disorders in the educational setting: From science to practice (2nd edition)*. Toronto : Thomson Delmar Learning.
- Ferre, J.M. (1997). *Processing power: A guide to CAPD assessment and management*. San Antonio, TX: Communication Skills Builders.
- Katz, J. (1992). Classification of auditory processing disorders. Dans J. Katz, N. Stecker, & D. Henderson (Eds.), *Central auditory processing: A transdisciplinary view (pp. 81-92)*. Chicago: Mosby Yearbook.
- Stecker, N. (1998). Overview and update of central auditory processing disorders. Dans M.G. Masters, N.A. Stecker & J. Katz (Eds.), *Central auditory processing disorders : Mostly management (1-14)*. Toronto: Allyn and Bacon.

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