

COGNITIVE PROCESSES INVOLVED IN READING & WRITING

Raffaella Ida Rumiati

Cognitive Neuroscience Sector

*Scuola Internazionale Superiore di Studi Avanzati
Trieste, Italy*

ACQUIRED DYSLEXIAS & DYSGRAPHIAS

These represent an inability to read and/or write caused by focal brain damage in patients who before disease onset had acquired a normal use of written language.

Written language is impaired in almost all aphasic language disorders but can in some rare cases be impaired in isolation with respect to the remaining language disorders:
pure alexia, pure agraphia, alexia with agraphia.

PHILOGENETICAL OBSERVATIONS

- **oral language:** developed during natural evolution and is based on a genetically determined substrate.
- **written language:** was invented about 6000 years ago, and developed on a large scale only during the last century.

WRITING SYSTEMS

- **Ideographic system:** to each graphic symbol corresponds the meaning of a word.
- **Alphabetic or syllabic systems:** to each graphic symbol (or group of symbols) corresponds a sound (or group of sounds).
- The advantage of an ideographic system: **a unique script** can be shared by different languages or dialects (e.g. Chinese).
- In reality most ideographic scripts are **mixed systems:** ideographic symbols are integrated by morphological and/or phonological information.

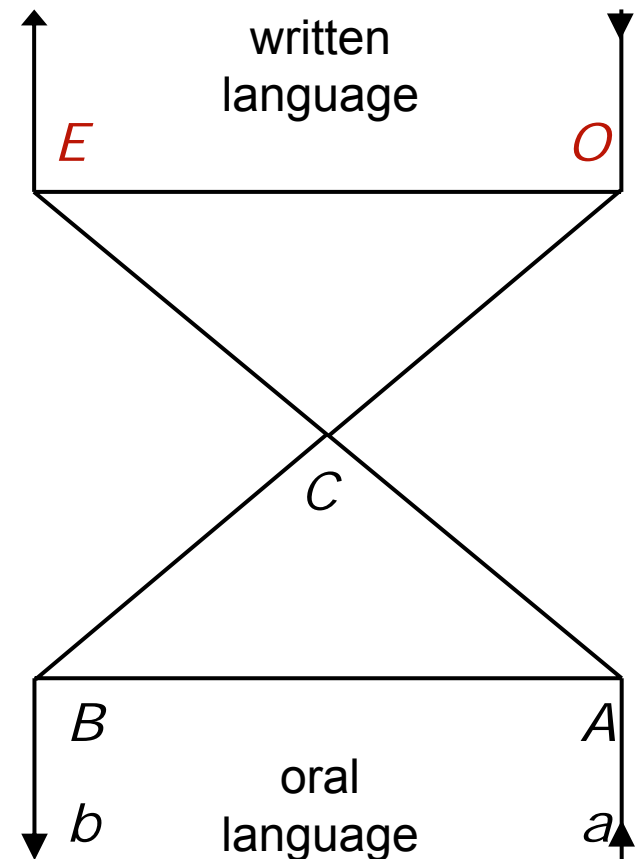
READING AND SPELLING IMPAIRMENTS IN CLASSICAL APHASIOLOGY

Lichtheim (1885) added written language to his /and Wernicke's model.

In a *first phase* the model represented written language as a **dependent** and **symmetrical** function:

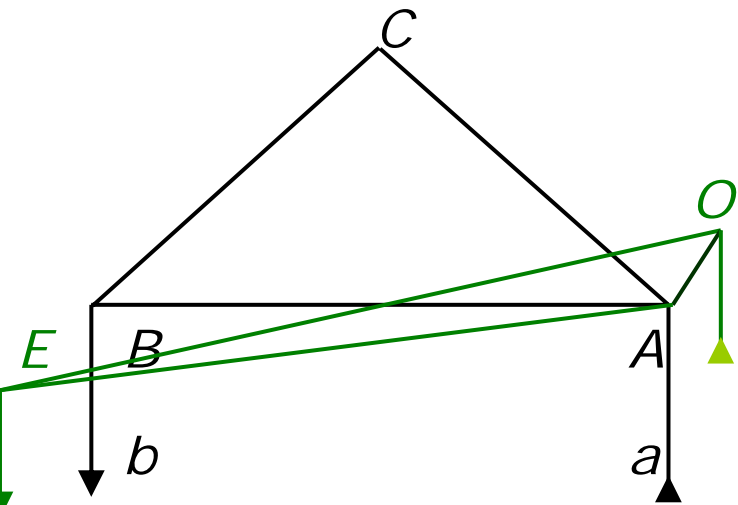
in this form, the model could not explain the presence of a spelling deficit in Wernicke's aphasia.

A = centre of the *auditory representations* of words
B = centre of the *motor representations* of words
a = *auditory analysis*
b = *articulatory programming*
C = *conceptual knowledge*
O = *centre of the visual engrams (reading)*
E = *centre of the hand motor engrams (spelling)*



In a *second phase* Lichtheim dropped the connection between the centres B and E: writing remained thus strictly dependent on the integrity of centre A (**dependent asymmetrical** model):

the model does not account for impaired reading, comprehension and spelling in Broca's aphasia



A = centre of auditory representations of words

B = centre of auditory representations of words

a = auditory analysis

b = articulatory programming

C = conceptual knowledge

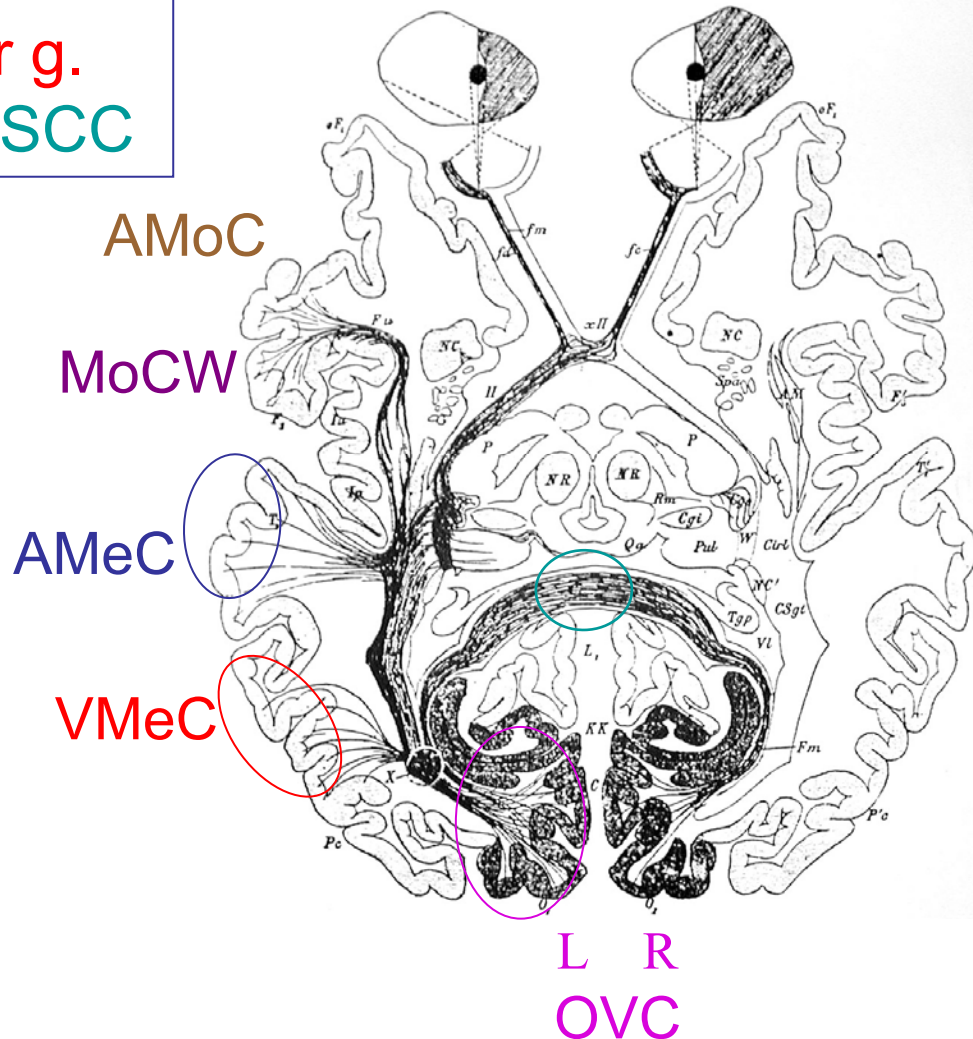
O = visual engrams (reading)

E = hand motor engrams (spelling)

DEJERINE'S MODEL OF READING & WRITING (1891, 1892)

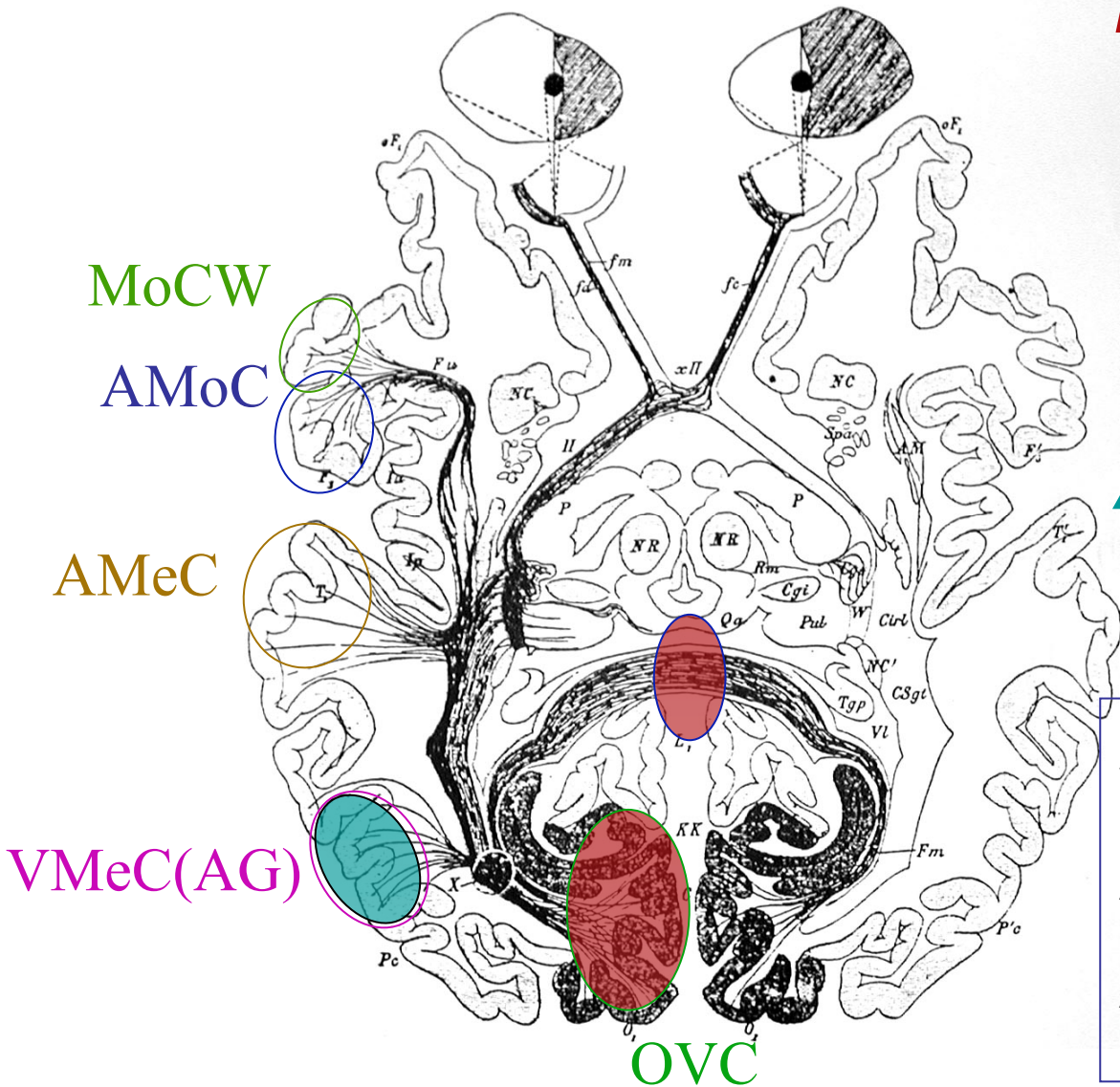
lesion

Alexia with agraphia angular g.
Pure alexia OVC left + SCC



Occipital visual centres (OVC)
 Visual memory centre (VMeC)
 [left angular gyrus]
 Auditory memory centre (AMeC)
 Splenium of corpus callosum (SCC)
 Articulatory-motor centre (AMoC)
 Motor centre of writing (MoCW)

PURE ALEXIA & ALEXIA with AGRAPHIA (Déjerine, 1892, 1892)



Pure alexia:

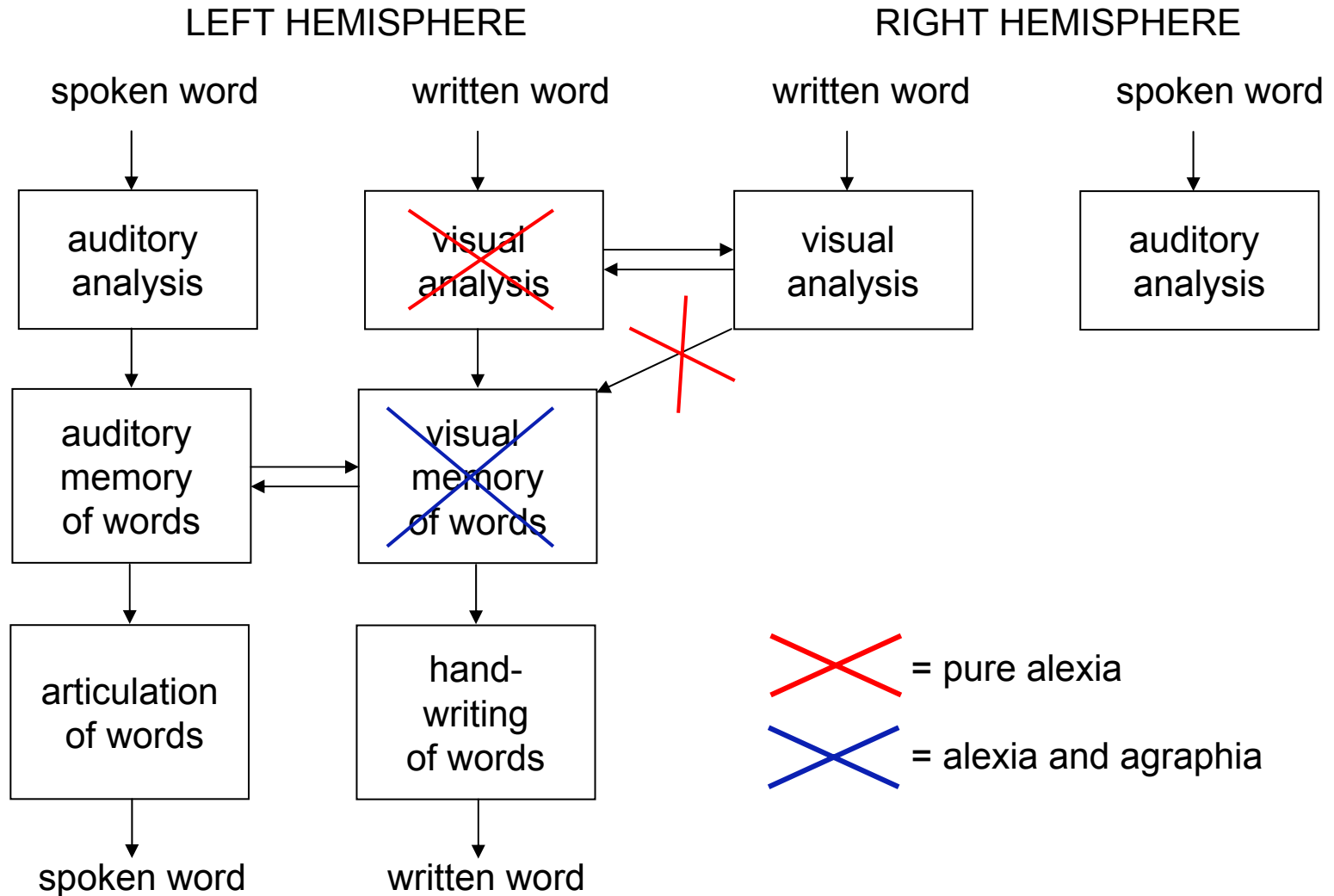
Disconnection between the **visual areas** in RH and the **visual-verbal centre** (angular gyrus) in LH.

Alexia with agraphia:

Damage to the **visual-verbal centre**.

- Occipital visual centres (OVC)
- Visual memory centre (VMeC)
- [left angular gyrus]
- Auditory memory centre (AMeC)
- Splenium of corpus callosum (SCC)
- Articulatory-motor centre (AMoC)
- Motor centre of writing (MoCW)

DIAGRAM TO READING & SPELLING FOLLOWING DEJERINE (modified)



LIMITS OF DEJERINE'S MODEL

The model cannot account for some phenomena that can be associated with dyslexic and dysgraphic deficits such as:

- *grammatical class effects* (e.g. nouns vs. grammatical words)
- *imageability effect*
- *semantic paralexias* (e.g. hound \Rightarrow dog)
- *lexical effects* (Word Frequency, Age of Acquisition etc.)

The model does not account for differences among scripts:

- *regular / irregular orthographies*

The model does not consider different types of stimuli:

- *words / non-words*

Marshall & Newcombe (1966, 1973)

REGULAR & IRREGULAR ALPHABETIC SYSTEMS

- **Regular alphabetic systems:** there is a correspondence between characters and sounds:
 - by applying G-to-P rules one can read and write without lexical access.
- **Irregular alphabetic systems:** pronunciation or orthography cannot be obtained by applying conversion rules:
 - reading and writing is based on **lexical knowledge (English, Farsi)**.

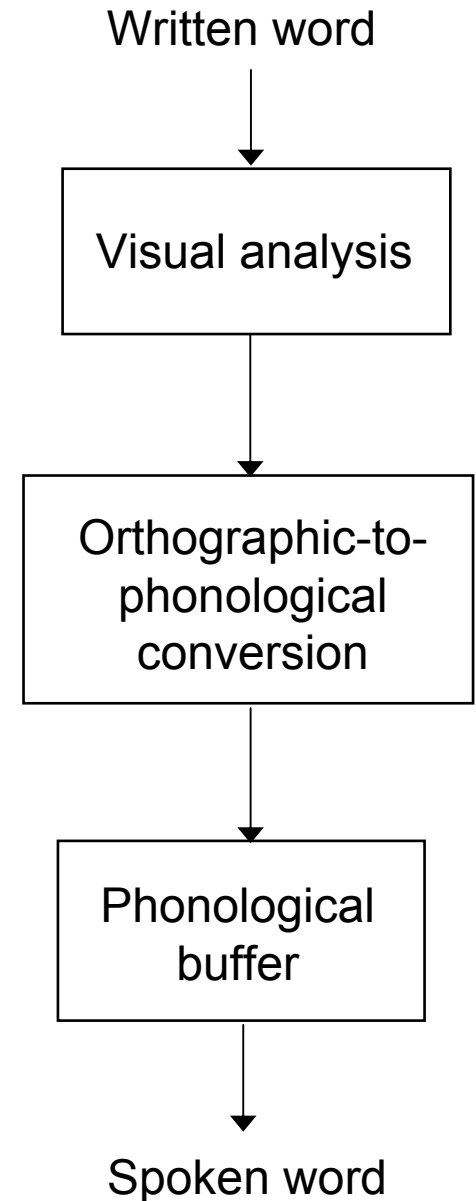
reading: EA \Rightarrow /i:/ in VEAL /vi:l/
/ɛ/ in HEAD /hɛd/
/ʌ/ in HEART /hʌrt/
/ei/ in STEAK /steik/

spelling: /ei/ \Rightarrow BRAIN in /brein/
FRAME in /freim/
/iə/ \Rightarrow DEER in /diər/
DEAR in /diər/

READING MODELS:
DUAL-ROUTE MODELS OF READING

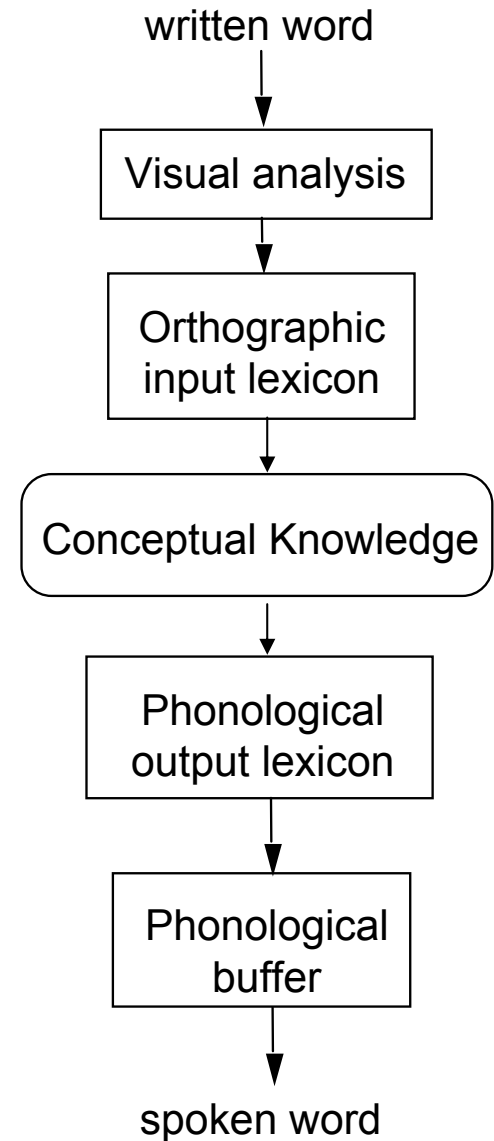
Sub-lexical Procedure

- This is based on Grapheme-to-Phoneme conversion rules.
- *It comprises of 3 components:*
 - ◇ *isolation* of graphemes
 - ◇ *conversion* into the corresponding phonemes
 - ◇ *assembling* a phonemic string corresponding to the letter string.
- *It allows reading:*
 - regular words
 - non-lexical orthographic strings (non-words)
- *It does not allow reading:*
 - irregular words



Lexical Procedure

- ◇ *orthographic* input *lexicon* (OIL)
 - ◇ *semantic system*
 - ◇ *phonological* output *lexicon* (POL)
- The *OIL* and *POL* store words known by an individual.
 - *It allows:*
 - ◇ *faster reading performance* but only for words that are already known to the reader;
 - ◇ *only* procedure to read words with irregular orthography
 - *It does not allow reading:*
(regular) non-words.

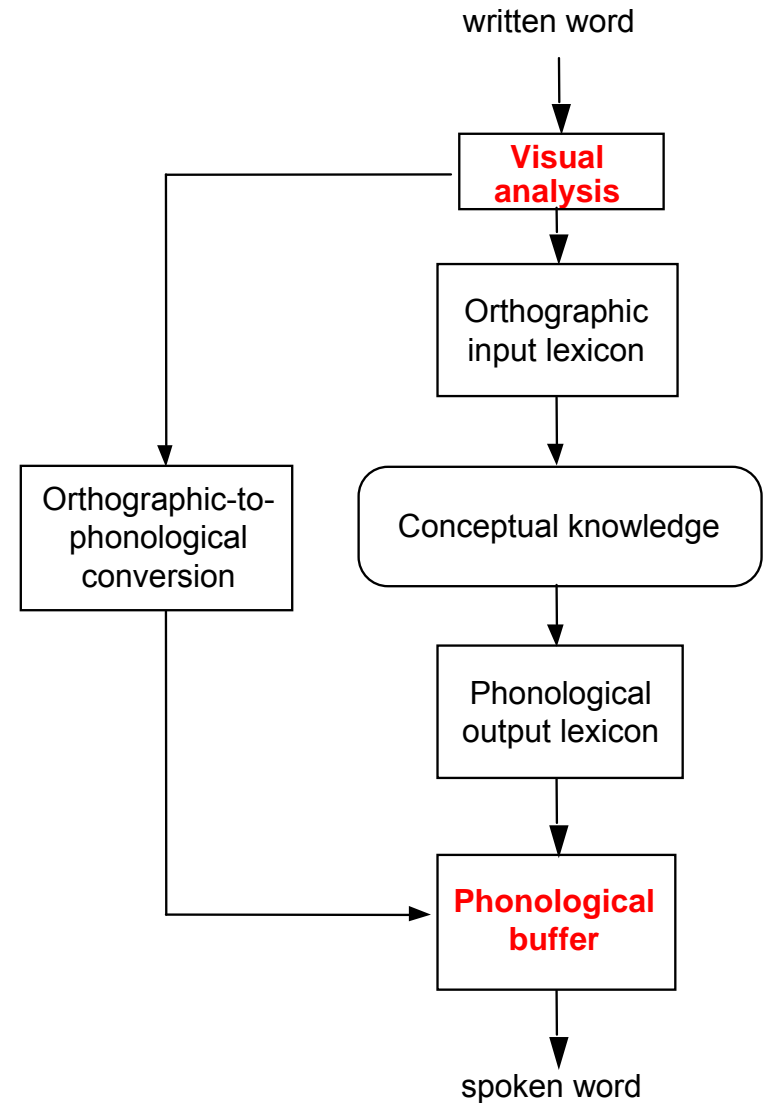


Visual Analysis & Buffer

- Above and below the two routes, the model contains two further units:

◇ *visual (orthographic) analysis*

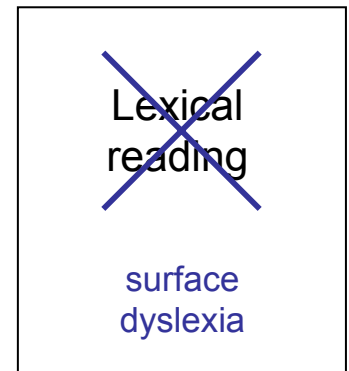
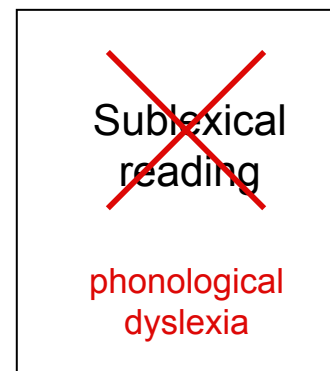
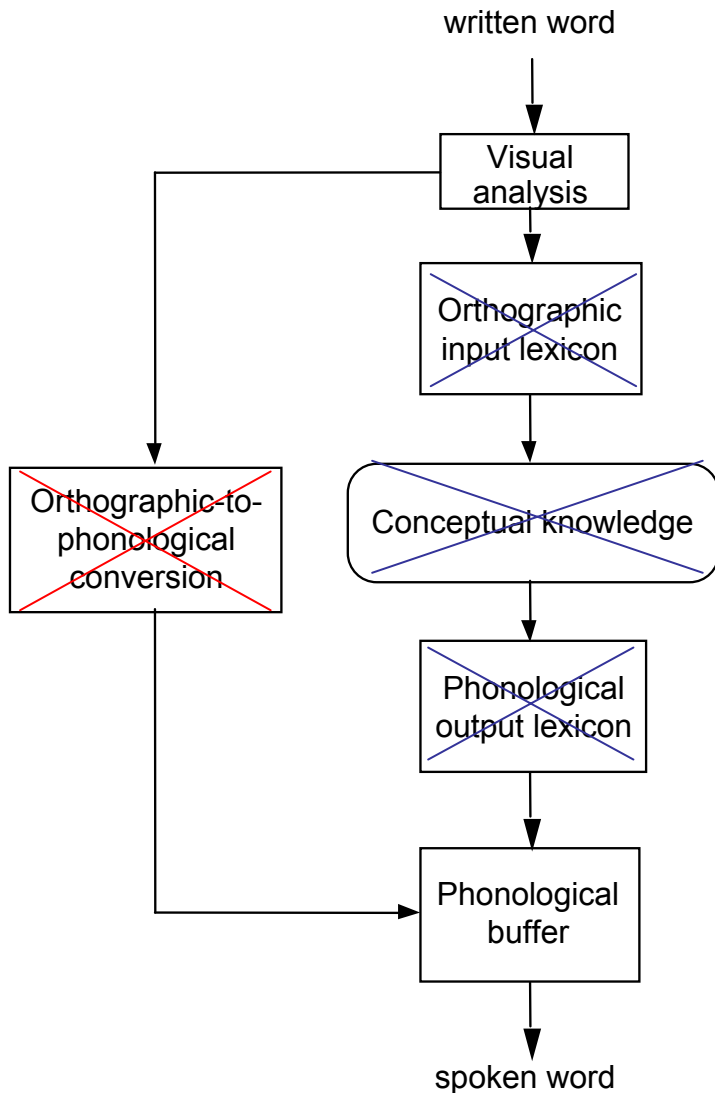
◇ *phonological output buffer*



ACQUIRED DYSLEXIAS

- Evidence in support of a dual-route model comes from

- ◇ *acquired dyslexia*
- ◇ *normal subjects can read irregular words as well as non-words*



PHONOLOGICAL & SURFACE DYSLEXIA

	<i>phonological dyslexia</i>	<i>surface dyslexia</i>
<i>damage to the ...</i>	<i>sub-lexical route</i>	<i>lexical route</i>
<i>regular words</i>	yes	yes
<i>irregular words</i>	yes	no (→ reg.)
<i>non-words (regular)</i>	no	yes

lexical effects

(WF, gramm cl., concr.) *normally present* absent

DIRECT & DEEP DYSLEXIA

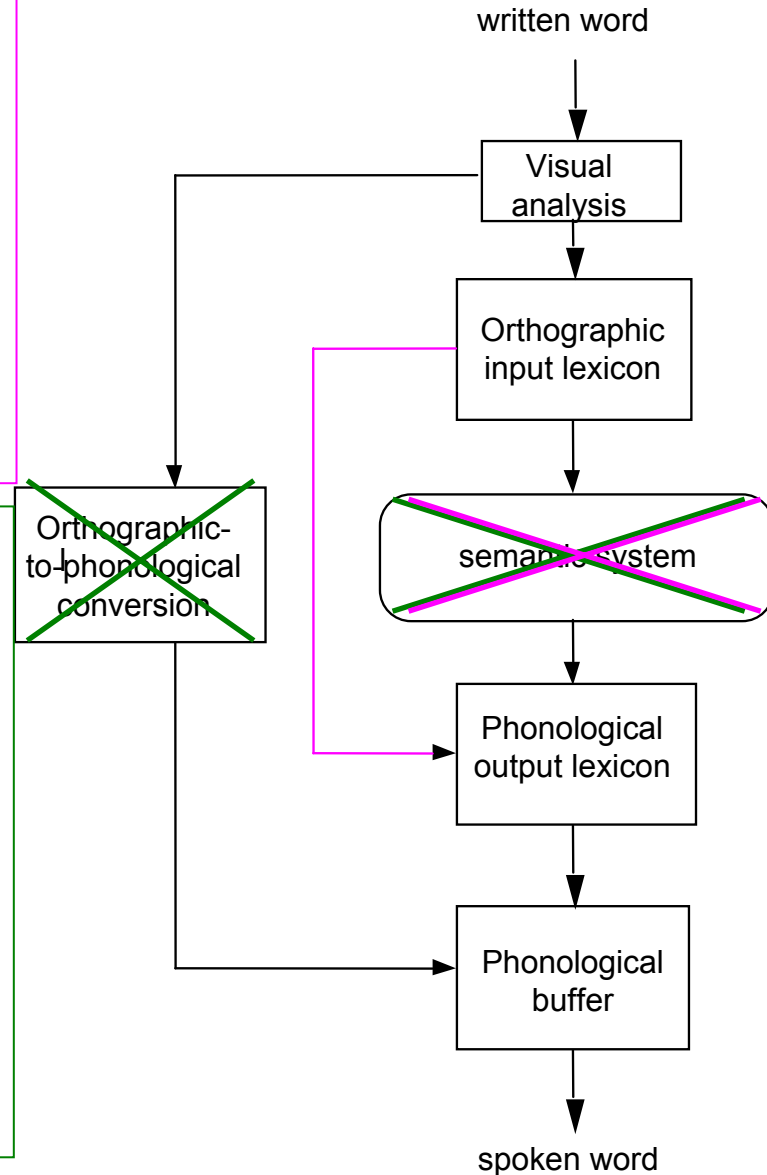
Direct dyslexia (WLP: S, M & S, 1979)

WLP read irregular words, whose meaning she did not understand: this pattern of impairment suggests the existence of a *direct route* connecting the 2 lexicons & bypassing the SS.

Deep dyslexia

It is associated with impaired sub-lexical reading (as phonological dyslexia). Patients make also **semantic errors**.

- residual reading ability of the RH.
- instability of the semantic system in absence of phonological control.



LETTER-BY-LETTER DYSLEXIA

This is a severe reading impairment that is not associated with any other language deficit (see *pure alexia*, Déjerine 1892).

It consists in the inability to read a word using either the lexical or the sublexical route.

In some cases, a patient can name single letters (often using a *kinaesthetic strategy*) without being able to produce the corresponding sounds, which cannot be bound in a string.

In others, a letter string may be read aloud, but with slow and laborious procedure (*backward spelling*) (but requires good STM).

Presence of length effect, but not of Word Frequency or grammatical class effect.

Several hypotheses have been put forward to account for *L-by-L dyslexia*:

- Perceptual deficit
- RVF deficit (but L-by-L dyslexia also without RVF deficit)
- simultagnosia (but L-by-L dyslexia also without SA)
- orthographic processing deficits

Kinsbourne & Warrington, 1962; Patterson & Kay, 1982;
Coslett & Saffran, 1989

NEGLECT DYSLEXIA

This is a reading impairment that is associated with *left unilateral neglect*.

Dyslexia is caused by a representational damage of visual, spatial or body-schema information.

When reading, patients neglect the left side of words and sentences.

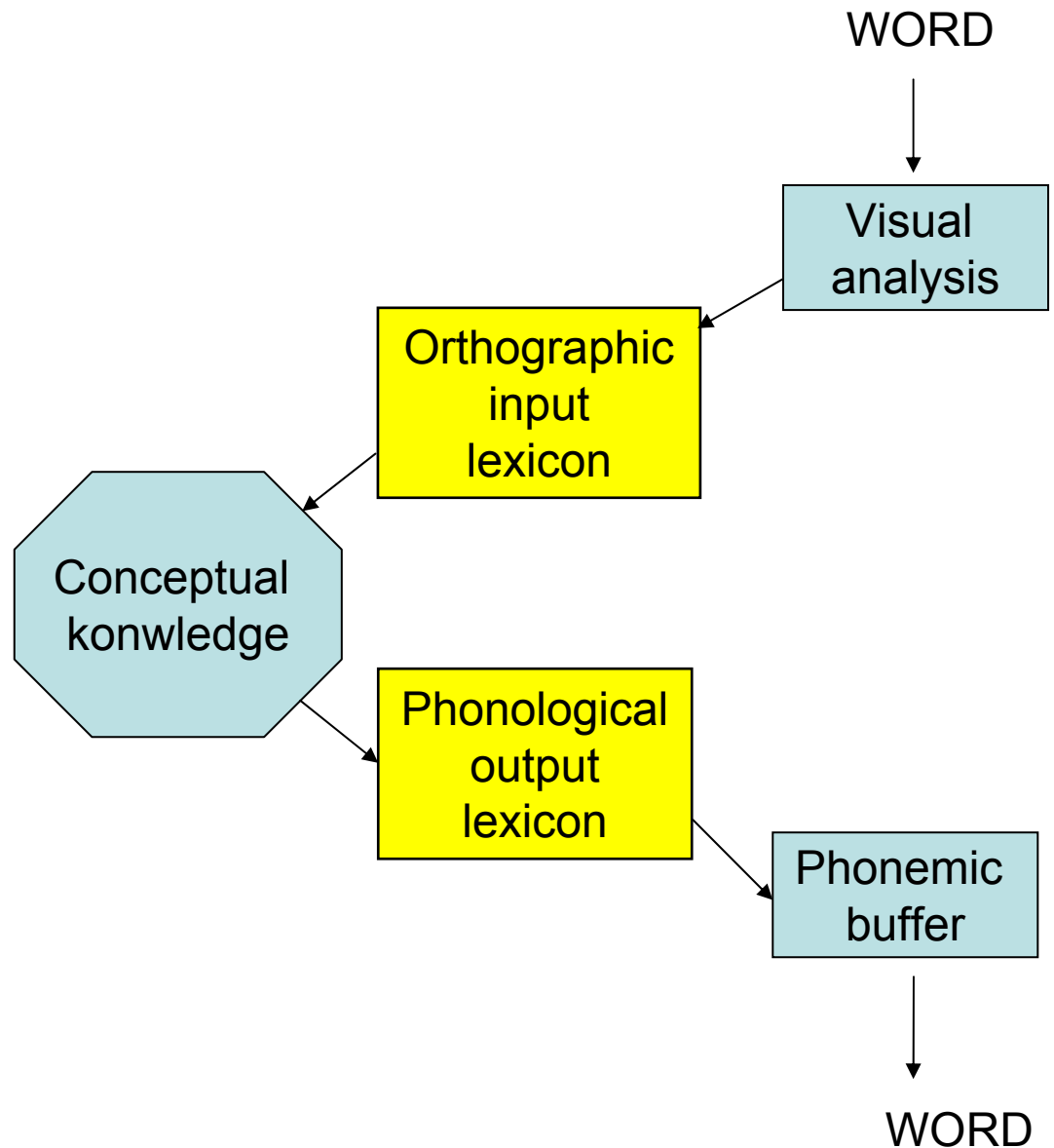
- *omissions* (studying \Rightarrow dying)
- *substitutions* (meadow \Rightarrow window)

Neglect dyslexia is often associated with neglect dysgraphia thus suggesting a representational cause of the disorders:

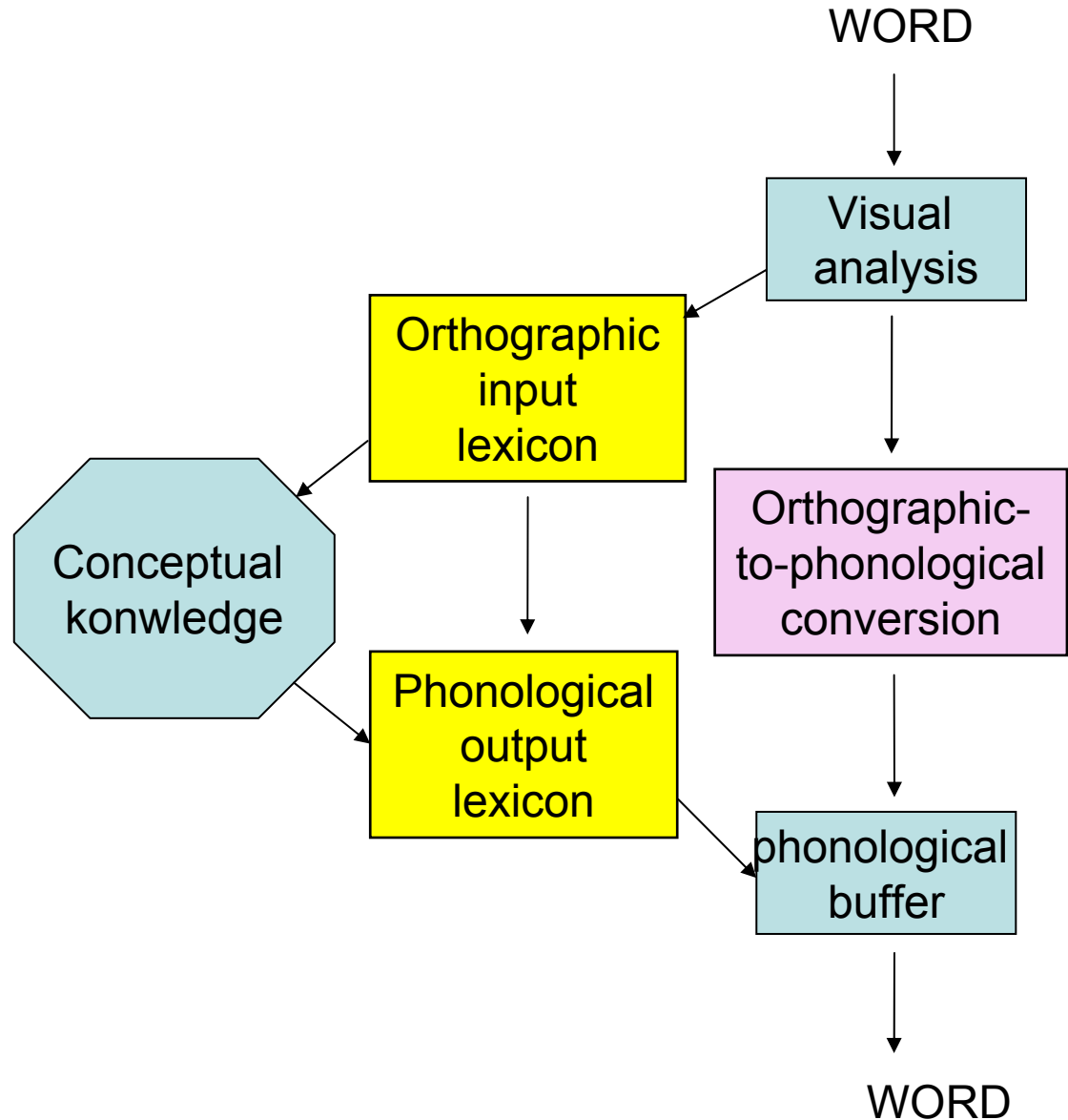
- the left side of the orthographic mental representation is neglected.

Patients are often unaware of their impairment (*anosognosia*).

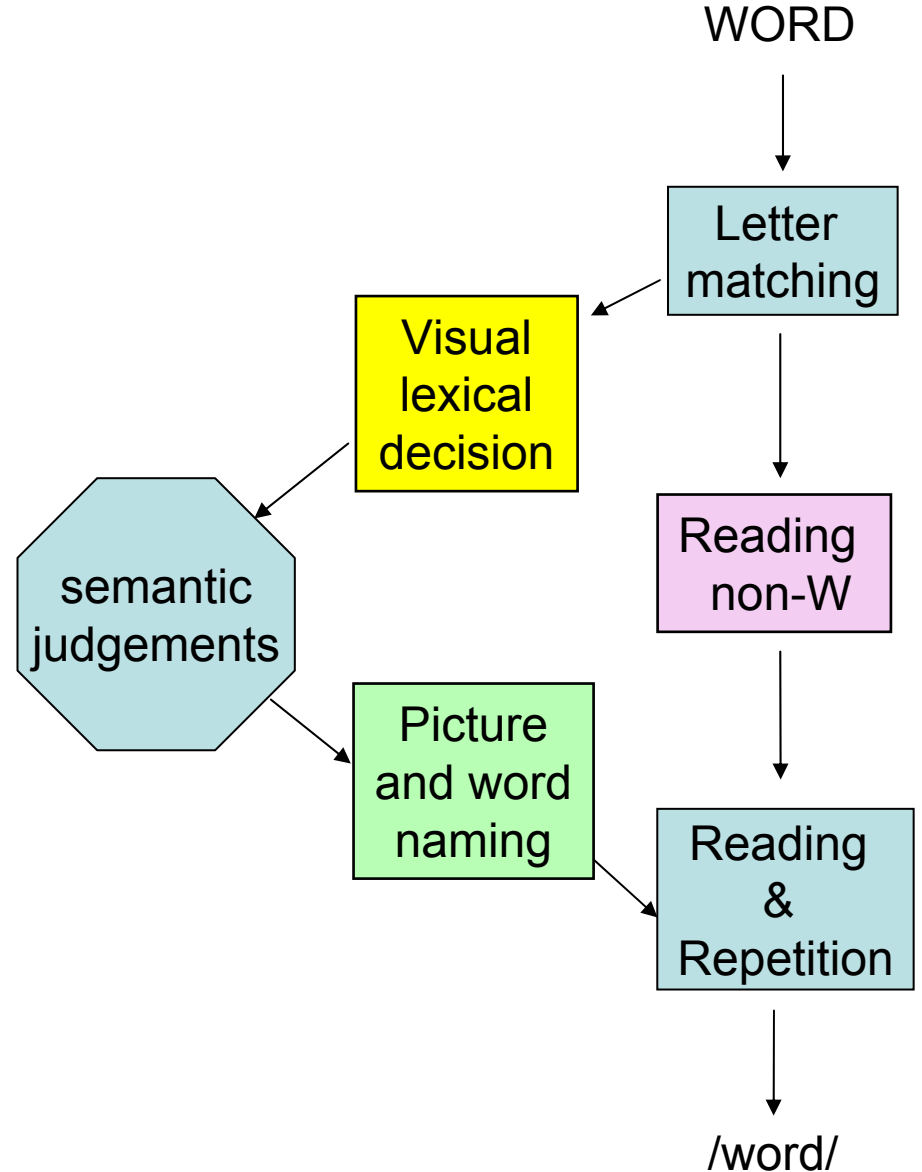
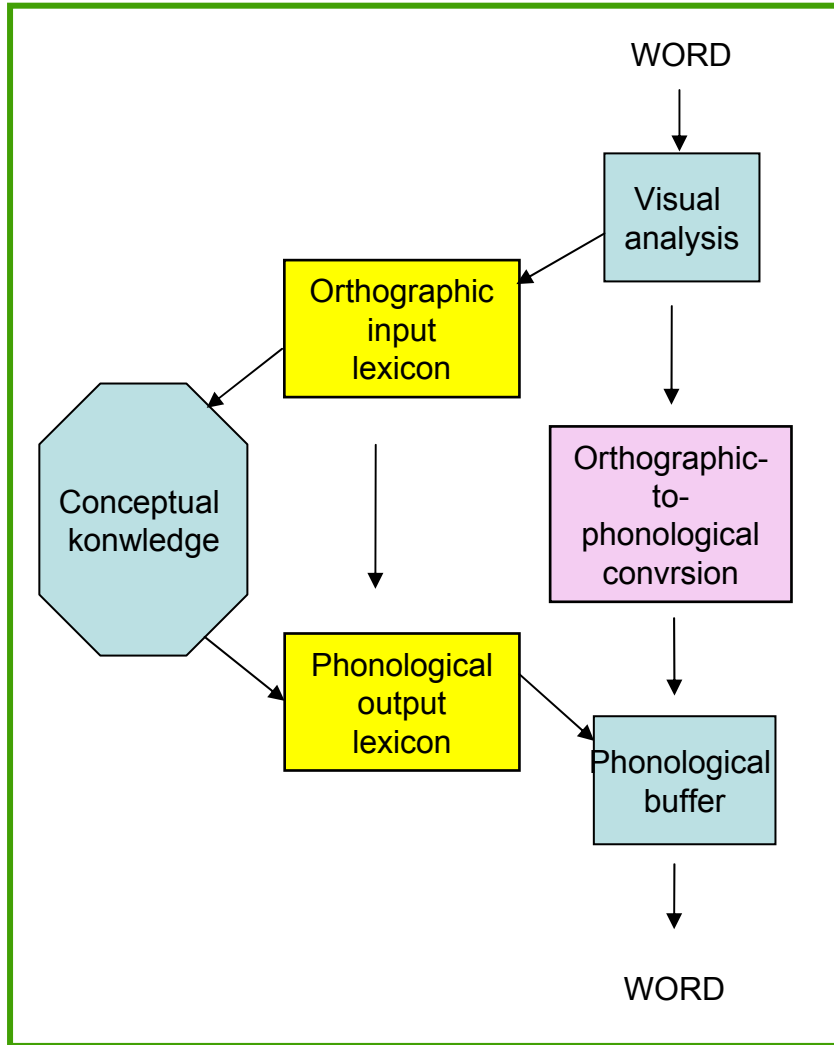
COGNITIVE MODELS OF READING



COGNITIVE MODELS OF READING



EVALUATION OF THE READING ABILITIES



CLINICAL CASE (P.S.)

45 year-old male; *primary progressive aphasia*.
Severe nonfluent aphasia with *agrammatic speech output*.

Reading words and non-words

<i>Performance</i>	N=	% correct
- concrete nouns	29	97
- “irregular” nouns (irreg. stress)	18	89
- abstract nouns	24	71
- function words	20	65
- legal non-words	28	11

Effects (normal)

<i>Word / non-word difference</i>	++
<i>imageability</i>	+
<i>Grammatical class</i>	+

Diagnosis: phonological dyslexia

CLINICAL CASE (G.G.)

50 years-old White-collar employee; head trauma 15 months before;

Cerebral CT: left TO intraparenchymal hematoma.

Reading aloud

	<i>N=</i>	<i>% correct</i>
(1) concrete nouns	29	93
(2) irregular nouns (stress)	18	88
(3) Abstract nouns	24	100
(4) function words	20	100
(5) legal non-words	28	96

Examples of errors

PINT ⇒ /pint/ /paint/

COLONEL ⇒ /colonel/ /cornel/

YACHT ⇒ /yacht/ /jot/

Diagnosis: surface dyslexia

CLINICAL CASE (A.D.)

19 year-old female student; stroke.

Reading aloud

	<i>N=</i>	<i>% correct</i>
(1) Concrete nouns	29	55
(2) irreg. words (stress)	18	44
(3) Abstract nouns	24	17
(4) Function words	20	0
(5) Legal non-words	28	0

Some errors

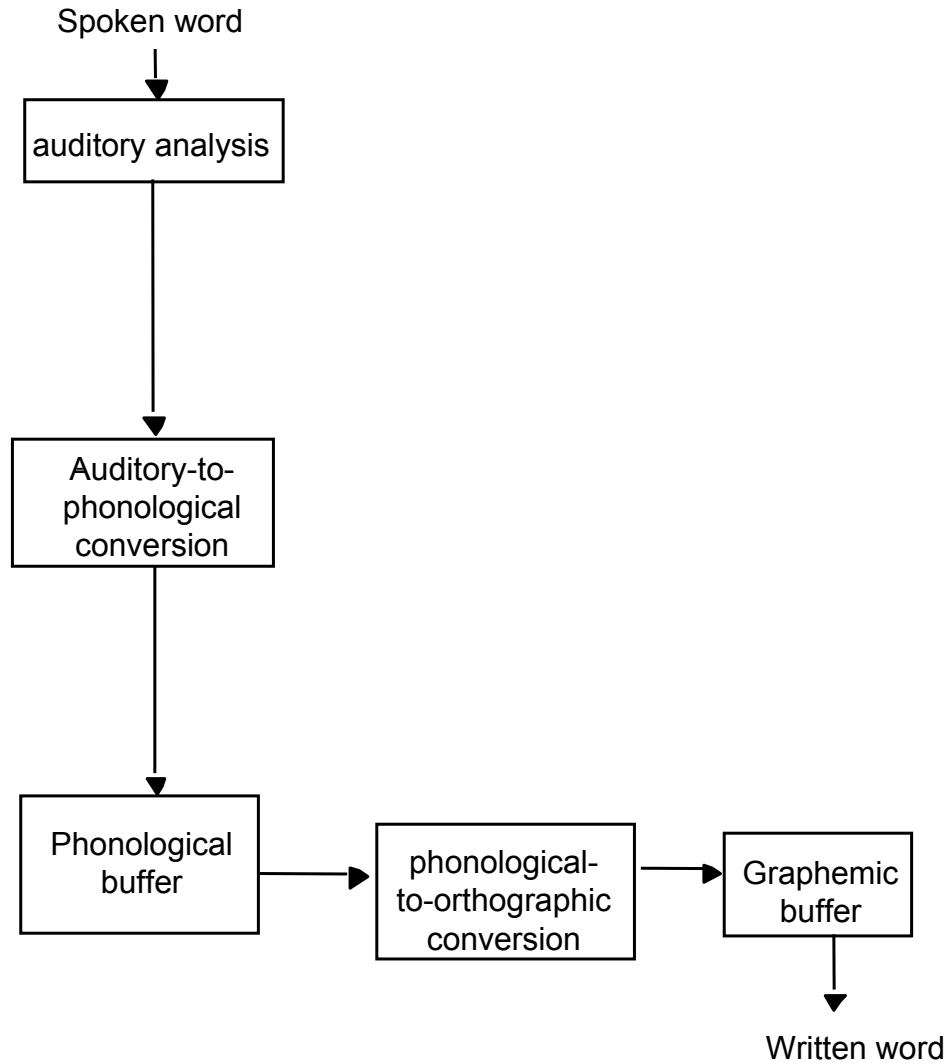
helmet ⇒ hat; tiger ⇒ lion, no!; group ⇒ blood;
sting ⇒ shoe; petal ⇒ the flowers, no!;
pole ⇒ igloo; stationmaster ⇒ the train.

Diagnosis: deep dyslexia

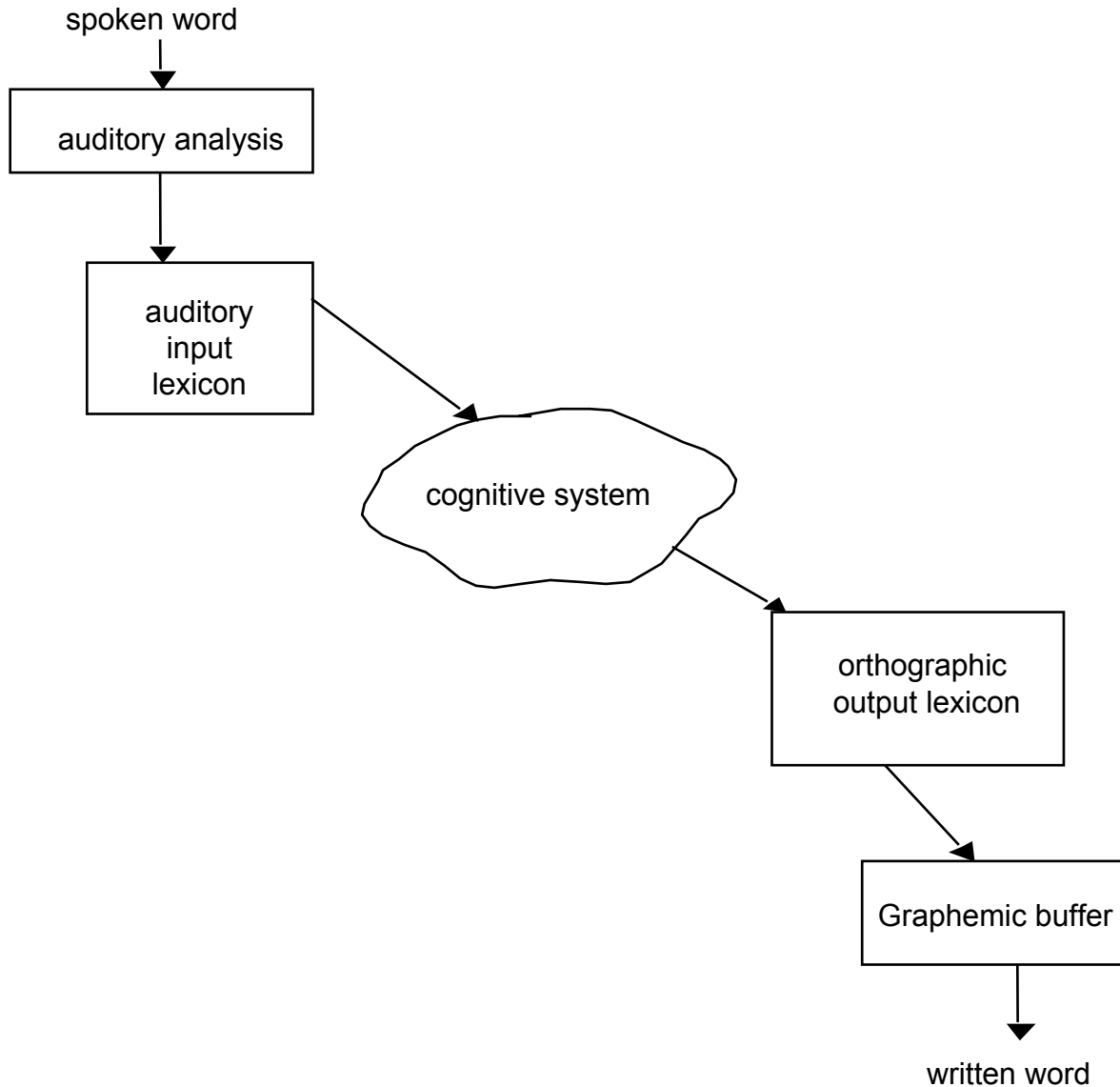
SPELLING MODELS

(writing to dictation)

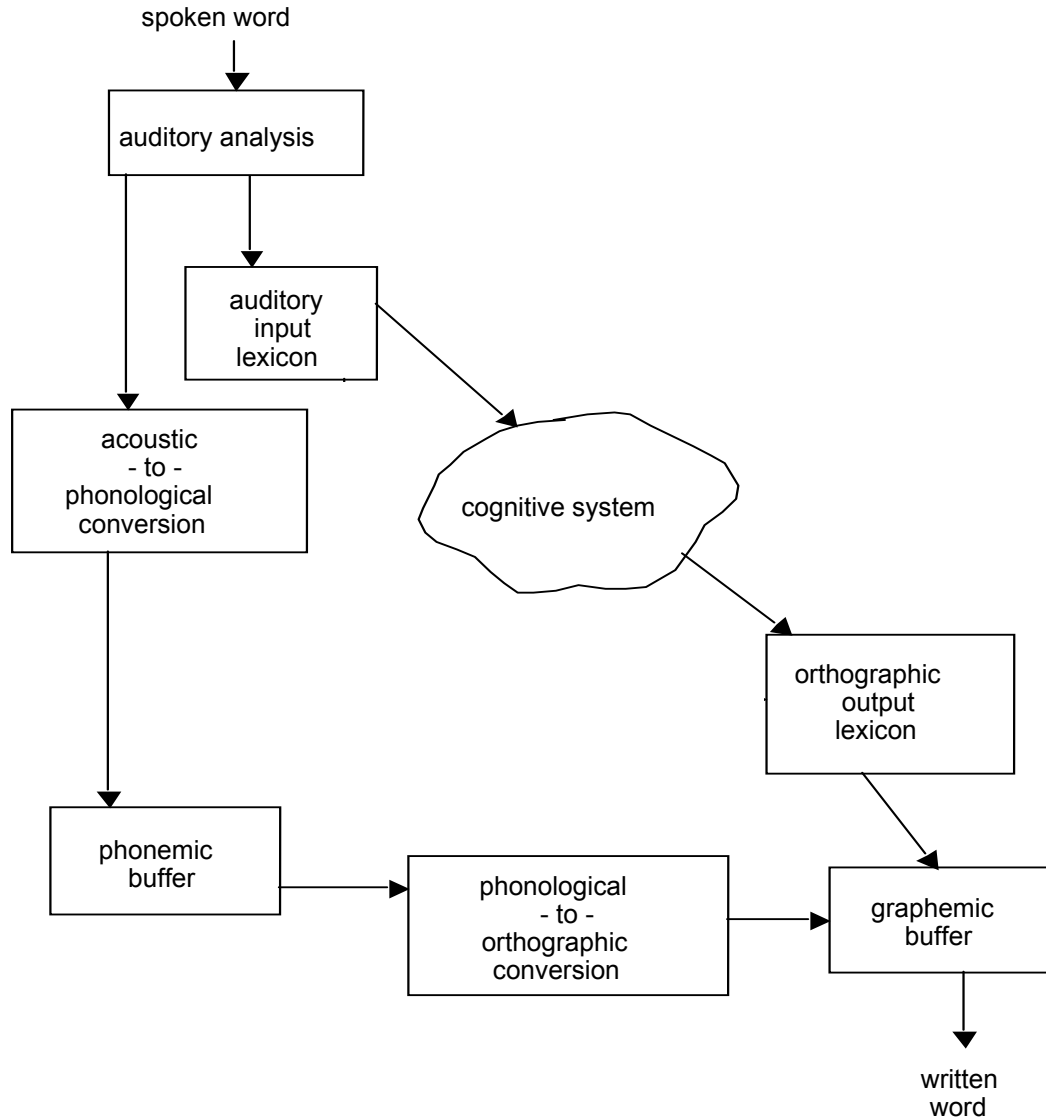
SUBLEXICAL SPELLING



LEXICAL SPELLING



LEXICAL & SUB-LEXICAL SPELLING ROUTES



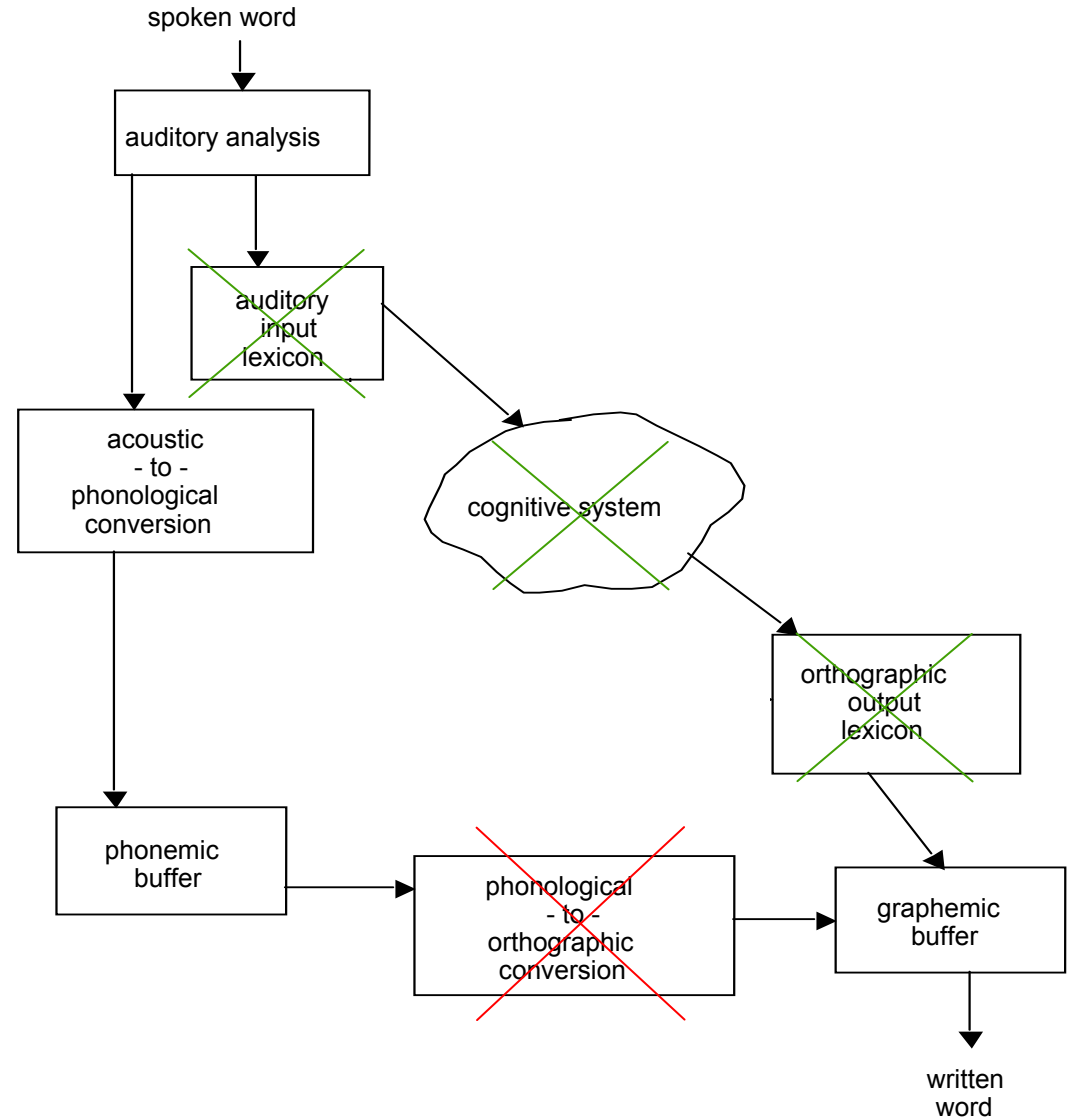
SPELLING ALONG THE LEXICAL & SUB-LEXICAL ROUTES

~~X~~ *phonological dysgraphia*

Impaired spelling
of non-words

~~X~~ *surface dysgraphia*

Impaired spelling
of irregular words



PHONOLOGICAL AND SURFACE DYSGRAPHIA

	<i>phonological dysgraphia</i>	<i>surface dysgraphia</i>
damage to the ...	sub-lex route	lexical route
<i>regular words</i>	+	+
<i>irregular words</i>	+	– (→ reg.)
<i>regular non-words</i>	–	+
<i>lexical effects</i>		
(WF, gramm. classs, imageabil.)	yes	no

CLINICAL CASE : G.G.

55 years-old male; left TP hematoma

Spelling

	<i>N=</i>	<i>R+</i>	<i>%</i>
Regular words	95	91	96
Irregular words	55	33	60
Loan words	8	1	13
Non-words	25	21	84

27 out of 63 possible surface errors (43%):

Examples: CUBO ⇒ QUBO; OLIO ⇒ OGLIO;
GENIO ⇒ GEGNIO; CUOCO ⇒ QUOCO;
CUORE ⇒ QUORE

Surface dysgraphia

ORAL AND WRITTEN LEXICAL PROCESSING

