

METHODS IN COGNITIVE NEUROPSYCHOLOGY

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MODULARITY HYPOTHESIS

- Our mental life is made possible by the orchestrated activity of multiple cognitive processors or *modules*.
- The concept of modularity is linked to the work of Marr (1976; 1982) and Fodor (1983).

MARR

- Based on his experience in both vision research and computer simulation of complex human abilities, he suggested that complex systems, like minds and brains, are very likely to evolve towards a modular organization.
- This is because it is easier both to detect and correct errors and to improve complex systems whose organization is modular.

FODOR'S MODULES

Properties of cognitive modules

- *Informational encapsulation*
 - A module must carry out its own form of processing in complete ignorance of, and in isolation from, the processes going on elsewhere in the total cognitive system:
 - e.g. STM's module(s) operates independently of the LTM's module(s).
- *Domain specificity*
 - Each module can accept only one particular sort of input:
 - e.g. the auditory STM cannot process visual stimuli.

- *Mandatoriness*

- The operation of modules is mandatory:
 - modules are unstoppable
 - they are beyond voluntary control
 - if the appropriate input is present, a module will carry out its particular source of processing (whether the owner of that module wishes to or not).
- Mandatoriness may be more a property of input modules than of output modules (Ellis & Young 1988).

- *Innateness*

- Modules are innate: they are part of our genetic endowment.

- Some of the early cognitive neuropsychological evidence for the existence of modular systems comes from studies of acquired reading and writing disorders.
- Yet, reading and writing are artificial, culturally transmitted skills which until recently have only been acquired by a small minority of people (Marshall 1987).

WHICH FUNCTIONS ARE MODULAR?

- Fodor argued that input processes to do with the perception of the external world (and possibly output processes to do with the control of action) are modular.
- He also suggested that higher-level thinking processes involved in reasoning, decision making, beliefs etc. are the product of operations that are not informationally encapsulated, not mandatory, not domain specific, etc.
- This claim was proven to be wrong:
 - e.g. fractionation of executive functions.

FURTHER ASSUMPTIONS

- *Neurological specificity (Shallice) or isomorphism*
 - Each module is distinctly represented within the brain itself:
 - Brain lesions will selectively impair certain modules while leaving the others intact and operating at normal, pre-injury levels of efficiency ("local" effects).
- *Transparency*
 - “The pathological performance observed will provide a basis for discerning which component or module of the system is disrupted” (Caramazza 1984).

Subtractivity

- The performance of a brain damaged patient reflects the total cognitive system *minus* those subcomponents (or connections between them) which have been impaired by the lesion (Saffran 1982).
- The lesion cannot create *new modules*.
- However, patients may develop new *strategies* for coping in a particular task, but they must do so using pre-existing *structures*.

Uniformity

- All cognitive systems are equal:
 - All individuals share the same cognitive system.
 - The effects of lesion are stronger than the individual differences.

- Association
- Simple Dissociation
- Double Dissociation

Association

- It is common in neuropsychology to observe that a patient (P) who is impaired on task 1 is also impaired on task, 3 and 5.
- **Inference**: it might be that these different tasks tap on a *common* mechanism or on a subsystem that is damaged in P.

Damaged to the Phonological Output Buffer

- Quantitative aspect: failure across tasks

writing reading repetition naming speech

X

X

X

X

X

- Qualitative aspect: errors (e.g. table)

substitution

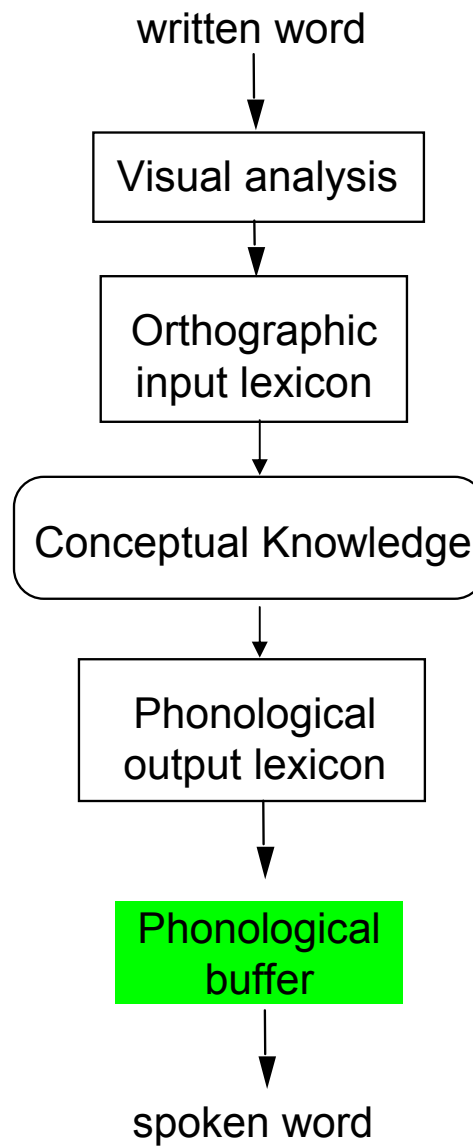
sable

transposition

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able



Problems with Association

- More often, it could be that tasks 1, 3, and 5 have no overlap in terms of the cognitive mechanisms they require for their execution, but are three tasks that are mediated by three adjacent brain areas all affected by the lesion.
- Association may not be that bad as long as the model is sufficiently detailed (Caramazza 1986).

Simple Dissociation

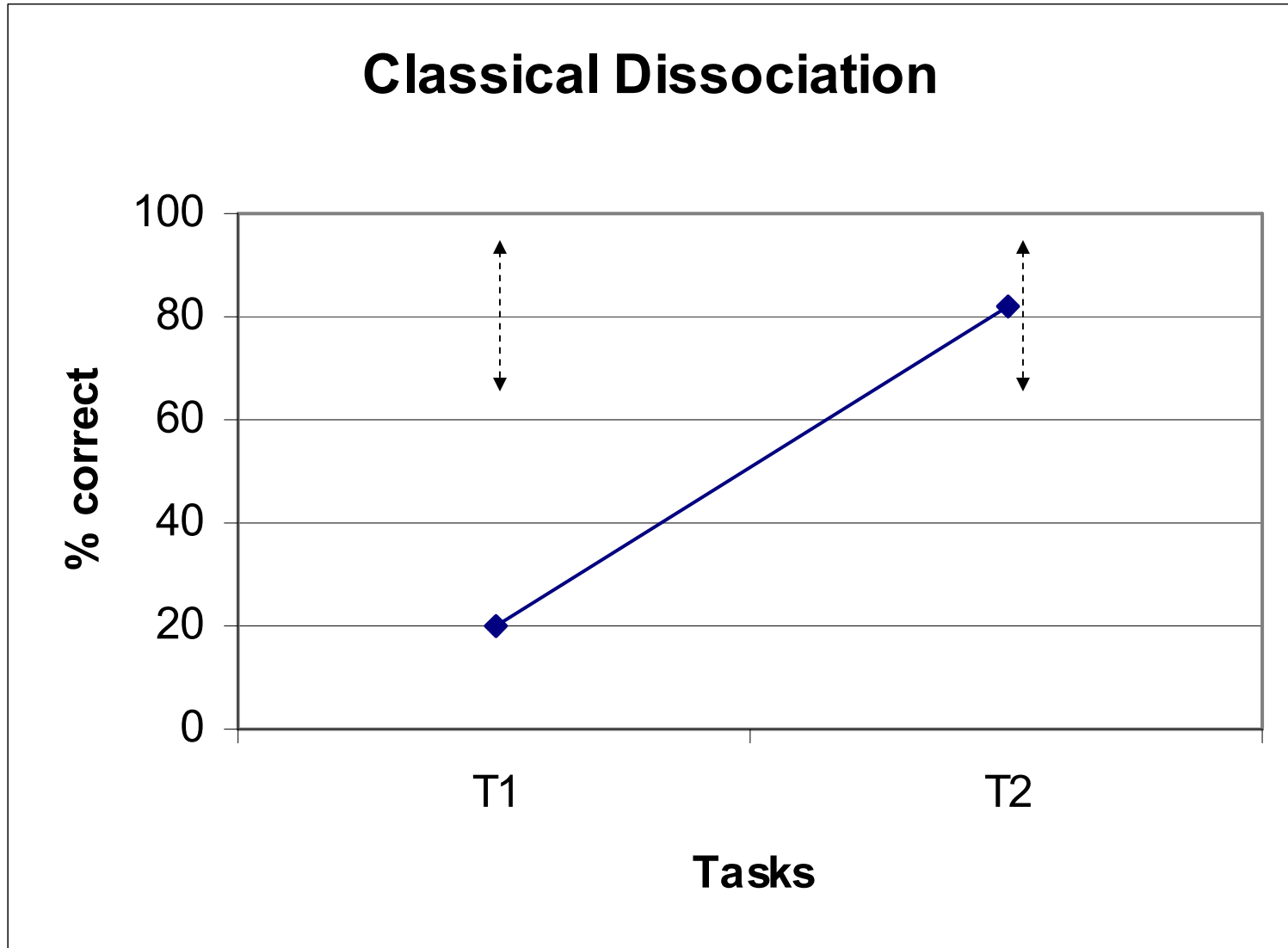
- P1 is impaired on T1 but not on T2

Example

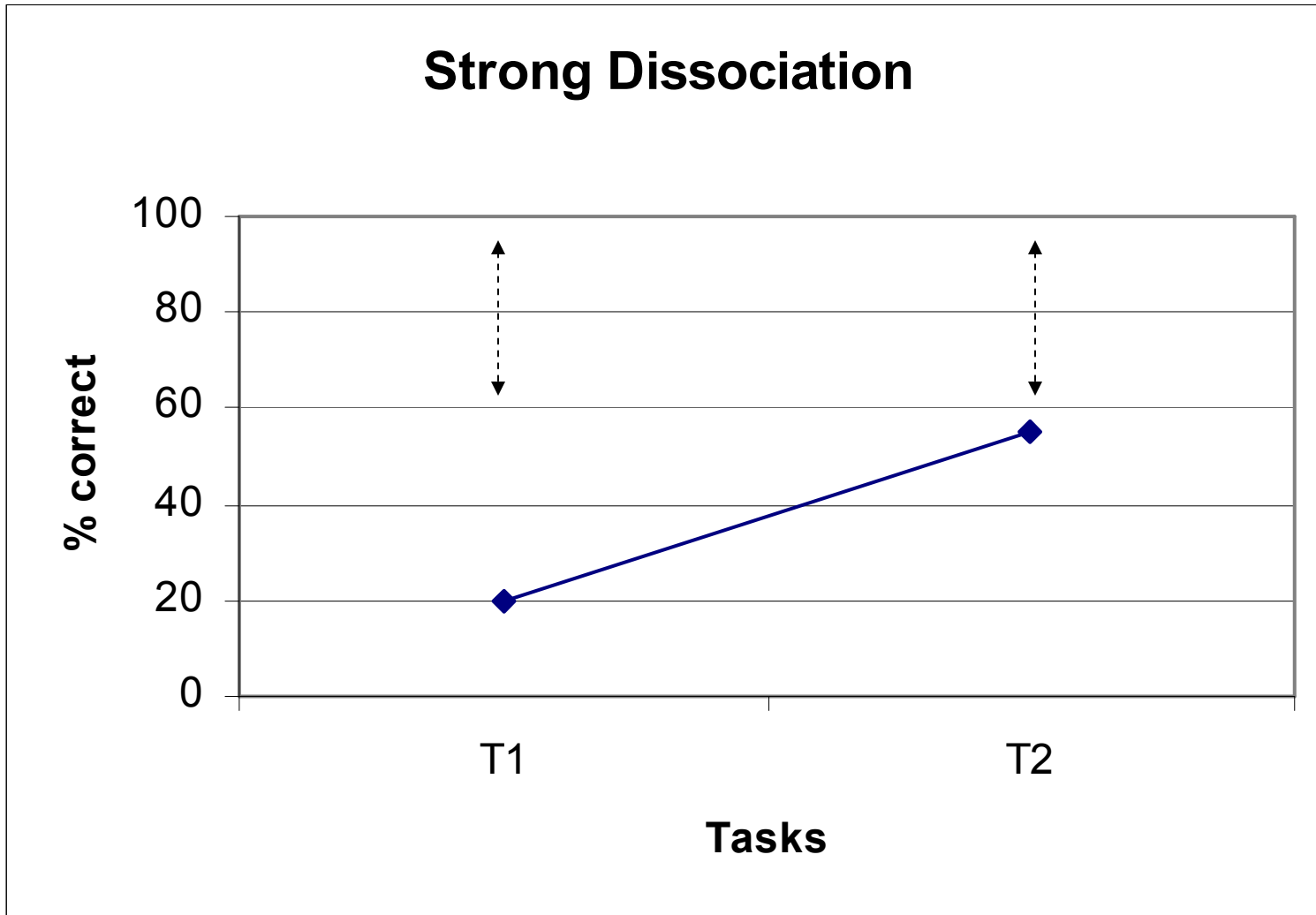
	T1	T2
	Digit span	List learning
P1	X	V

- There are different types of dissociations

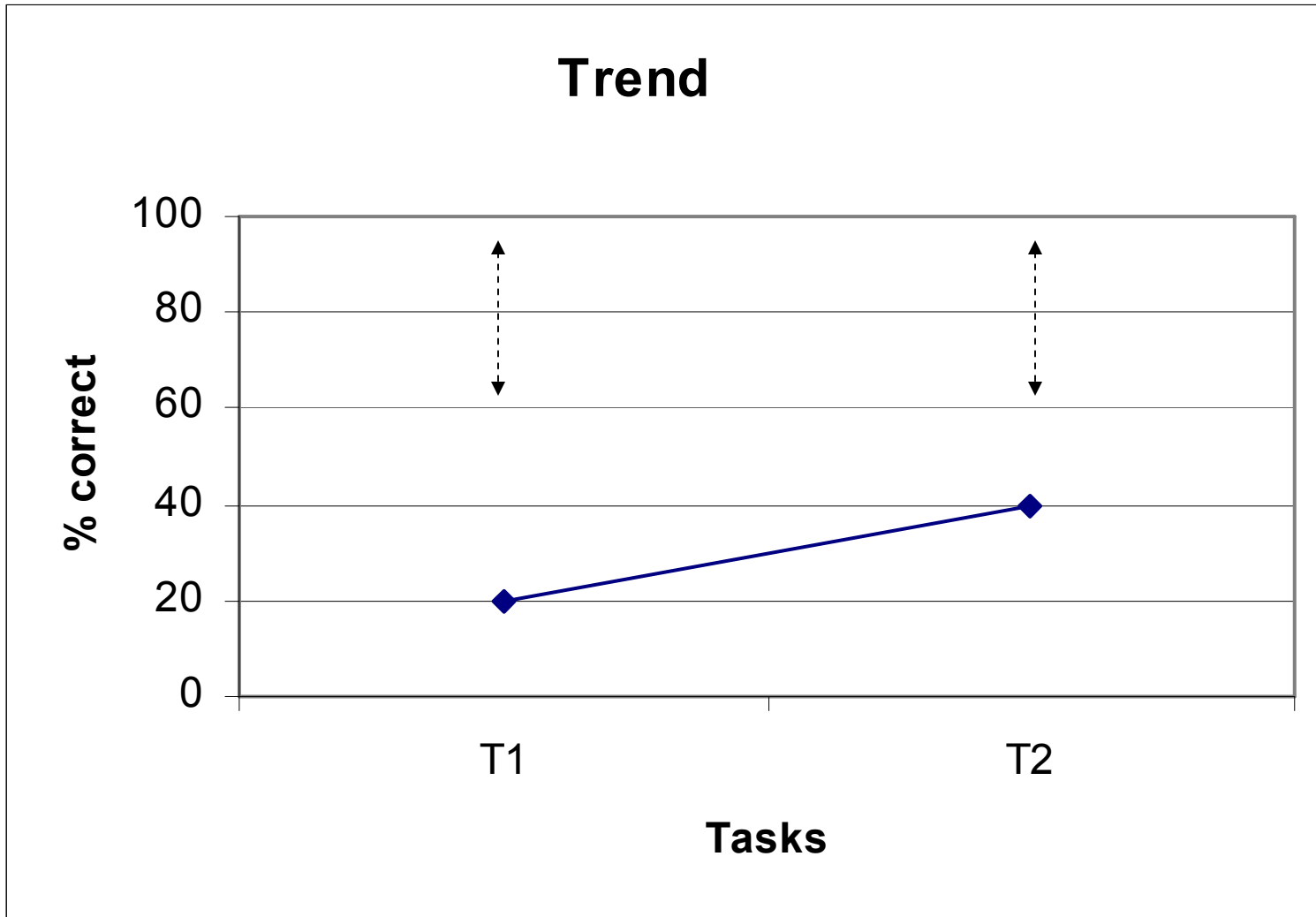
Classical Dissociation



T1 < T2 with normal performance on T2



T1 < T 2 but performance on both tasks is below normal range



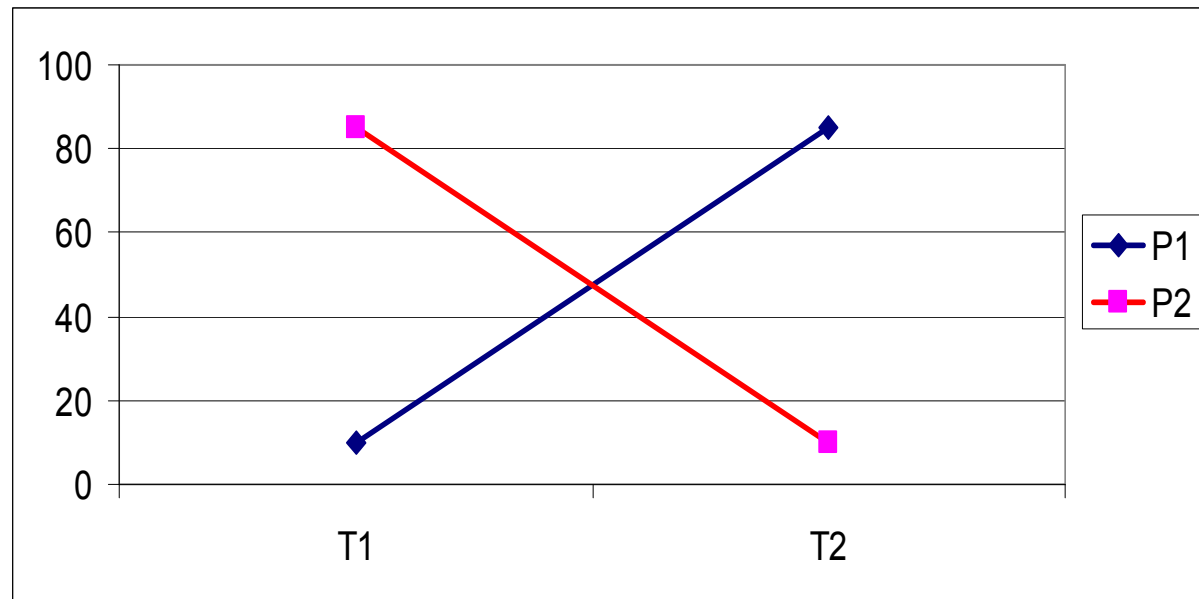
Significant but small difference between T1 and T2, but below normal range

Limits of Simple Dissociations

- **Inference:** differences in performance on T1 and T2 suggest that the two tasks could involve two partially independent subsystems.
- However, a simple dissociation could simply be **due to T1 being more difficult than T2.**
- **How can we overcome this problem?** It is necessary to observe a patient showing the opposite pattern.

Double Dissociation

- P1 is impaired on T1 but still able to perform T2.
- P2 is still able to perform T1 but he is impaired on T2.



	T1	T2
	Digit span	List learning
Patients type X	- -	+ +
Amnesic Patients	+ +	- -

+ + = completely normal

- - = grossly impaired

Inferences

- The two tasks could reflect the operation of two memory subsystems:

System A Episodic
 Memory

System B Short-term
 Memory

- According to Caramazza (1986), however, a *double dissociation* is not more important for inferences to be made than any other theoretically relevant observation.

SINGLE CASE & GROUP STUDIES

- Traditional neuropsychologists performed both single-case and group studies.
- As to single-case studies, however, individual patients were often poorly described, and showed multiple deficits.
- In group studies, on the other hand, patients were often clustered based on classical syndromes (e.g. Broca's aphasia).
- Syndromes are too coarse-grained and form groups on the basis of symptoms that co-occur for anatomical rather than functional reasons.
- Thus, if the aim of a study is to address issues concerning the structure of cognitive processes, it is better not to select patients based on classical syndromes (Caramazza 1984).

SINGLE CASES/SMALL SERIES

- Cognitive neuropsychologists preferred single case studies are small series of single cases.
- At the beginning, they had less interest in mere localization and in clinical aspects.
- Single cases allow drawing inferences using a double dissociation methodology.
- The selective deficit suggests, but does not prove, that there is a damage to a putative specific system.
- The potential function attributed to the system needs to be checked by further investigation.

Single-case: Methodology

Procedures: controlled quantitative analysis of patient's performance.

Time: constant clinical patient's conditions (qualitatively and quantitatively).

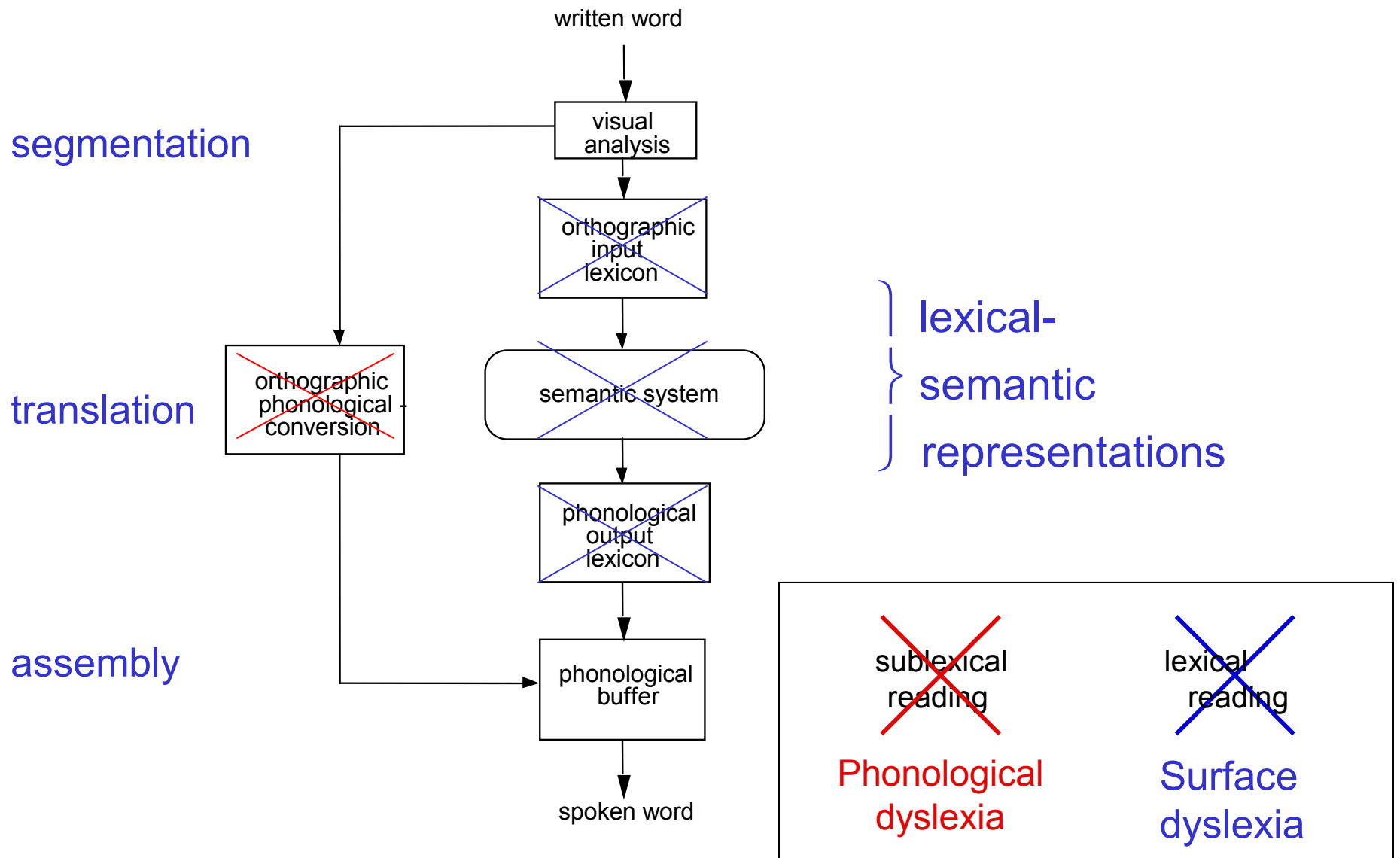
Norms: standardized tests.

SINGLE CASE STUDIES

Dissociations

- Partial separation between different transmission routes
 - e.g. reading using the phonological route or the lexical route
- Tasks requiring two different subsystems
 - e.g. category specificity: separation between sensory (living) and functional (nonliving) semantic subsystems,

TWO-ROUTES MODELS OF READING



Associations

They allow to identify the impairment of one subsystem common to different tasks:

- Different tasks require the same impaired subsystem
- Error pattern
- e.g. phonological output buffer
- e.g. access vs. storage deficits

Problems with the single-case method

- Replication

It can take years before other single patients with the same behavioral pattern are reported.

- Practical problem

Small database.

- Localization

Lesions tend to be large and so an overlap method needs to be used.

Best to combine lesion study with functional imaging.

GROUP STUDIES

- Classical syndrome-based
 - e.g. Broca's vs Wernicke aphasics
- Lesion location-based
 - e.g. LH vs RH
- Disease-based: useful for a small # of brain regions
 - e.g. Parkinson patients vs. controls
- Functionally putatively pure syndrome-based
 - e.g. amnesic vs controls (amnesia = autobiographical memory deficit)

Criticisms to the group-study approach

Problems of practical difficulty (Shallice, 1988):

- **NOISE**: Averaging artifact
- **SLOWER** than the single-case approach:
 - Larger criteria of inclusion
 - Less flexibility (parameters fixed before starting the data collection)
- **INCLUSION CRITERIA**: selection artifact.