Behavioral science and technology to address deficits in symbolic behavior: with an emphasis on reading and writing

Deisy das Graças de Souza

Universidade Federal de São Carlos (Brazil)
National Institute of Science and Technology on Behavior, Cognition and Teaching (INCT-ECCE)


UNIVERSIDADE FEDERAL DE SÃO CARLOS
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TOPICS

. Overview (abstract)

. Symbolic Behavior:

Concept and method of investigation

. Reading and writing as symbolic behavior

Deficits in symbolic functioning represent a substantial challenge for affected individuals, their families, and their larger communities.

Illiteracy is especially challenging for individuals who live in a predominantly symbolic world (culture), where decoding written symbols is required in most activities of everyday life.

This presentation will summarize the efforts of a long-term basic, translational and applied research program on reading and writing.

A behavioral analysis of literacy behaviors - both at the conceptual and experimental level, has evolved into the development and experimental evaluation of teaching programs for beginning readers, currently available for application in large scale, in educational and clinical settings.

Proficient reading and writing were conceptualized as a complex network of stimulus-stimulus and stimulus-response relations.

Due to the generative potential of stimulus equivalence, the network evolves from simple instances of relational learning to a complex network of discriminated operants (listening, speaking, reading and writing).

The stimulus equivalence paradigm oriented the design of teaching procedures.

The procedure teachs directly only listening behaviors:

- matching pictures to dictated words (picture recognition)
- matching printed words to dictated words (word recognition).

Interestingly, learning to recognize the pictures and the printed words, results in two types of derived relations (not directly taught):

(a) The emergence of **classes of equivalent stimuli**. Dictated words, pictures and printed words become related and the relations between them have the properties of reflexivity, symmetry and transitivity.

(b) The derivation of the relevant **discriminate operants**:

- Picture naming
- Printed word reading (textual behavior), and
- Dictation-taking (writing under control of dictated words).

These operants are functionally independent, but systematic exposure to successive sets of stimuli allows them to become equivalent and functionally interdependent.

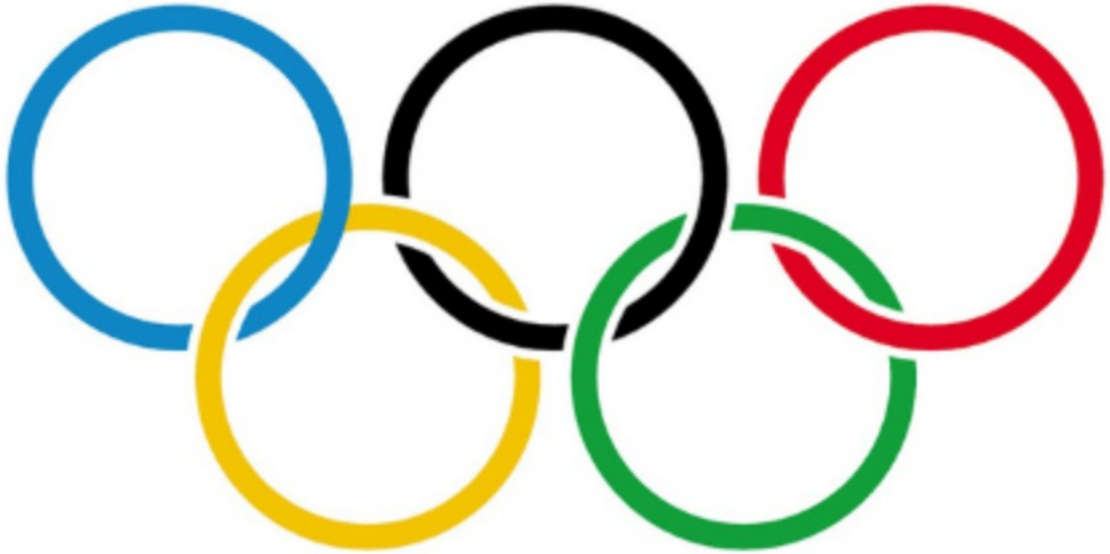
As demonstraded experimentally, our procedures promote these behaviors and have been incorporated into modules to teach repertoires under increasingly complex stimulus control.

Also, the teaching programs have been computerized, which makes their application reliable and replicable among learners, and allows detailed data recording.

Stored in a cloud environment, they can be used on a large scale to benefit elementary school students who struggle with the challenges of symbolic learning.

SYMBOLIC BEHAVIOR

Symbolic behavior is behavior under discriminative control of symbols...



Symbol of the Olympics
Pierre de Frédy (1863-1937):
Top: Europe, Africa, America
Down: Asia, Oceania

Symbolic behavior is behavior under discriminative control of symbols…

That is, a symbol is the discriminative stimulus that sets the occasion for the occurrence of a particular response – or responses, that have been reinforced in its presence;

This requires a **learning history** through reinforcement contingencies /or social agreement.

EQUIVALENCE

A reinforcement contingency produces….

equivalence relations that consist of ordered pairs of all [positive] elements that participate in the contingency

(Sidman, 2000, p.127).

Examples from laboratory studies:

SYMBOLIC RELATIONS LEARNED IN THE LABORATORY ENVIRONMENT

The Psychological Record (2019) 69:153–163
https://doi.org/10.1007/s40732-018-0327-7

ORIGINAL ARTICLE

Influence of Cartoon Characters on Children's Food Preference Via Transfer of Functions

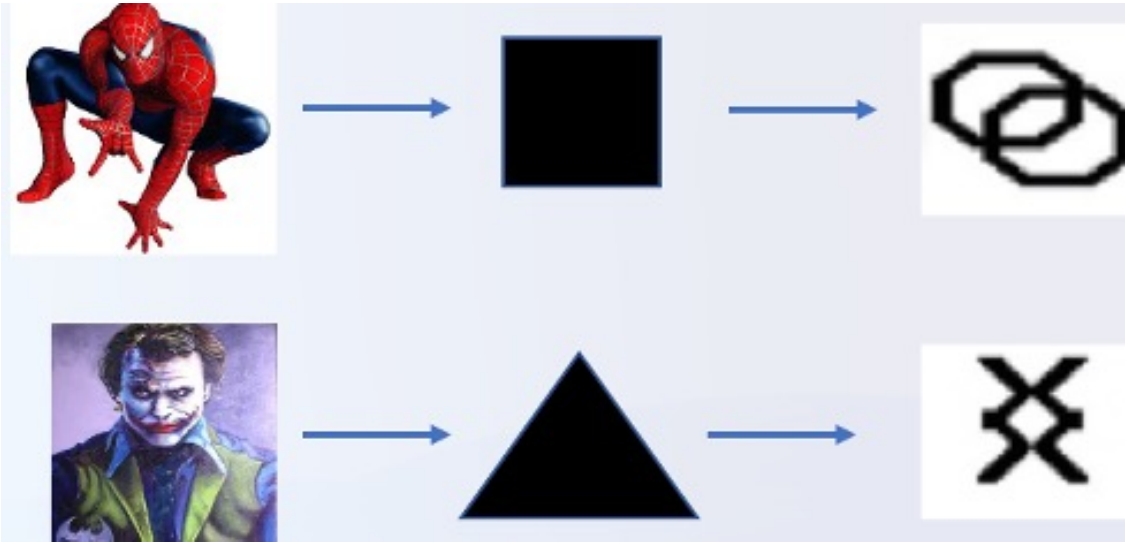
Silvana Lopes dos Santos[1] · Julio C. de Rose[1]

Published online: 28 November 2018

dos Santos, S. L., & de Rose, J. C. C. (2017). Manutenção das classes de equivalência e transferência de função: uma investigação por meio de escolhas alimentares de crianças. *Perspectivas em Análise do Comportamento*, *8*(1), 1–15. https://doi.org/10.18761/pac.2016.022

1. Teaching arbitrary relations between stimuli

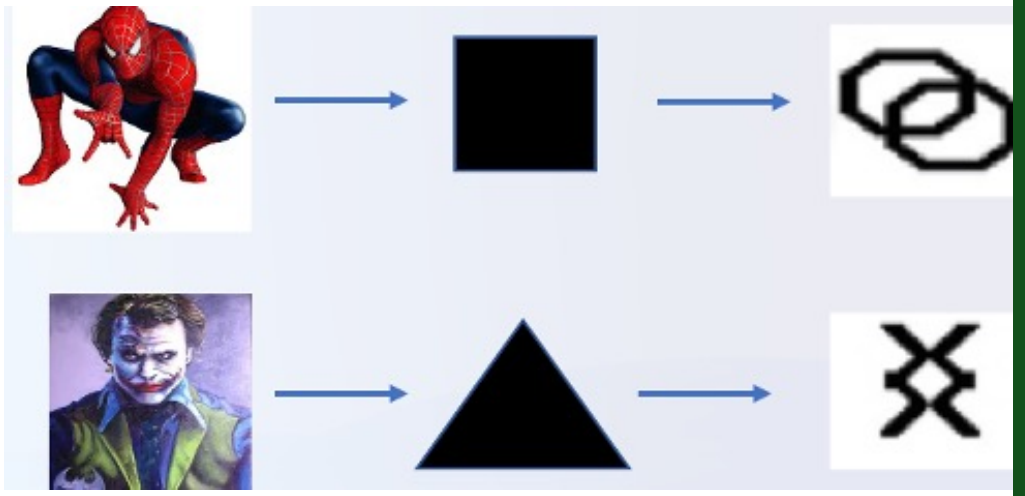
2. Testing for emergent relations (not directly taught).



Positive results:
Abstract pictures became related to the characters.

Question:
Did these pictures acquire symbolic function?

2. Testing for preference between pieces of the same food labeled with the abstract stimuli.



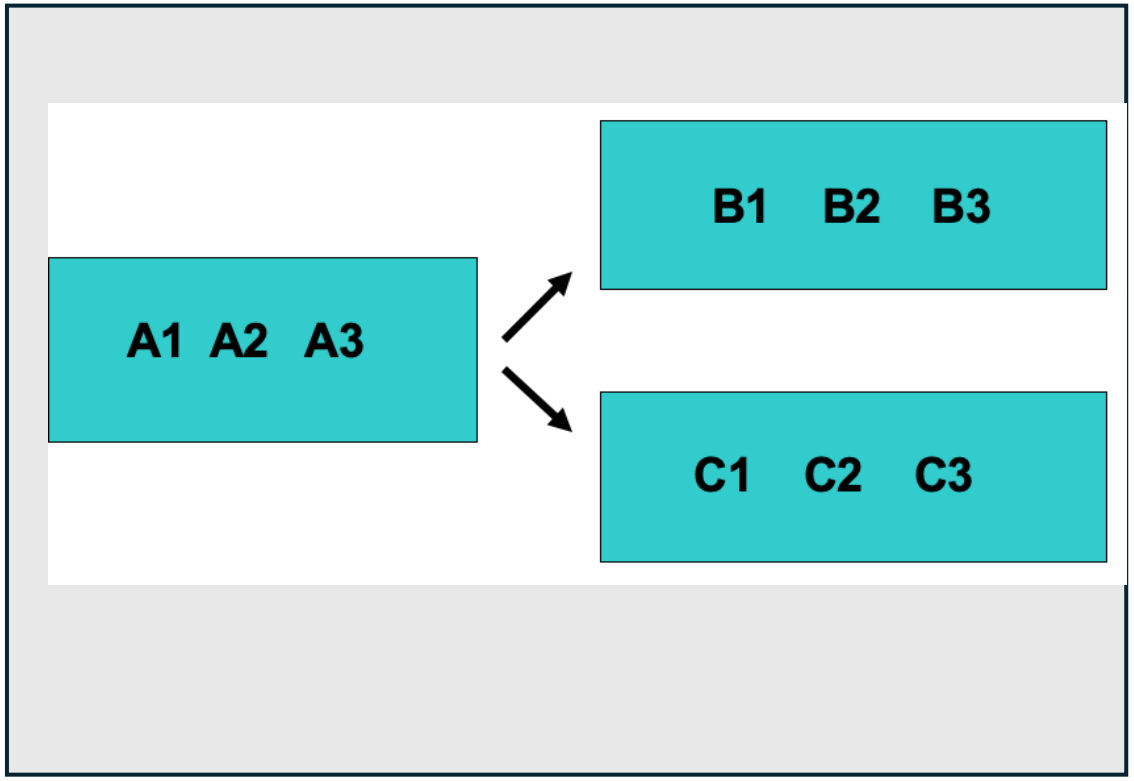
1ST choice: 32/34

Tastier: 31/34

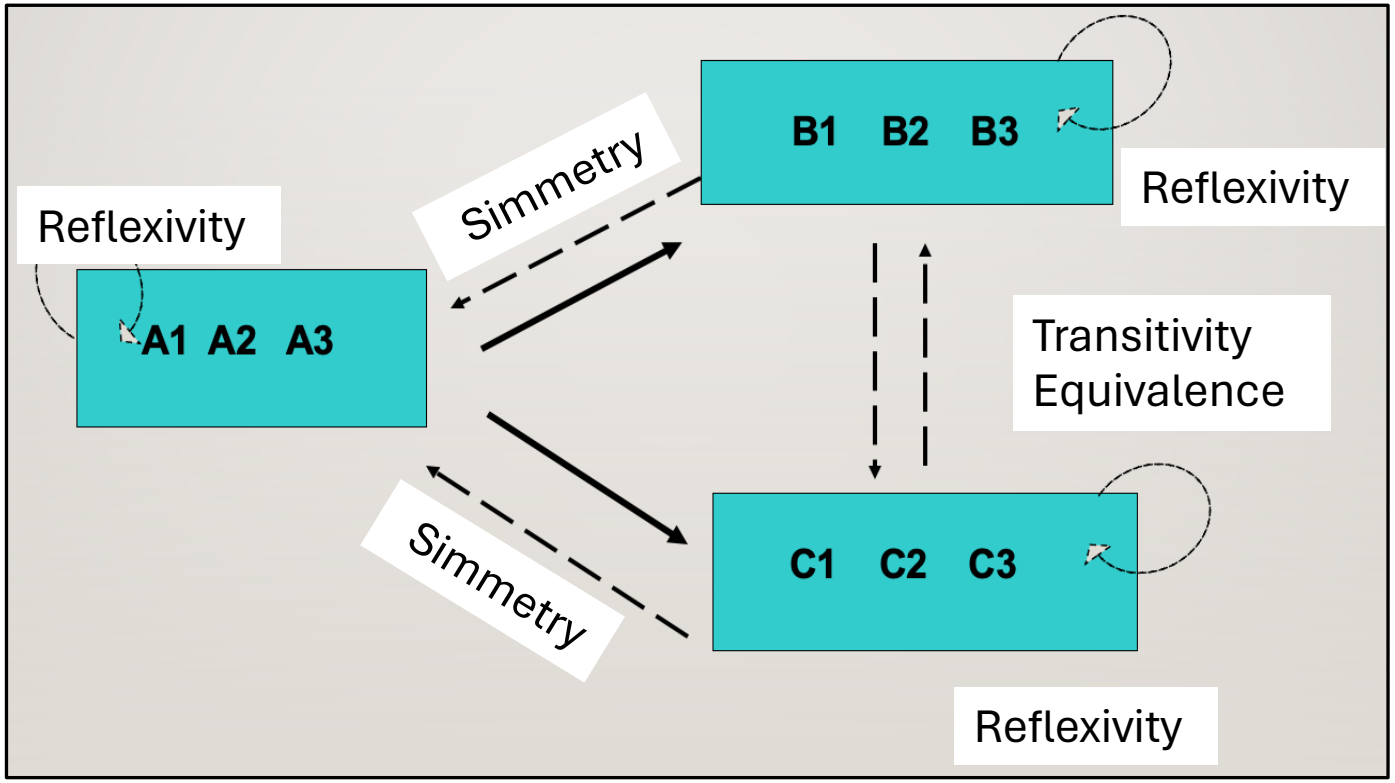
= Symbols of “good” and “evil” Influenced food choice. (acquired discriminative functions).

Schematic representation of the procedure

TEACHING - Baseline*



TESTS - Emergent Relations



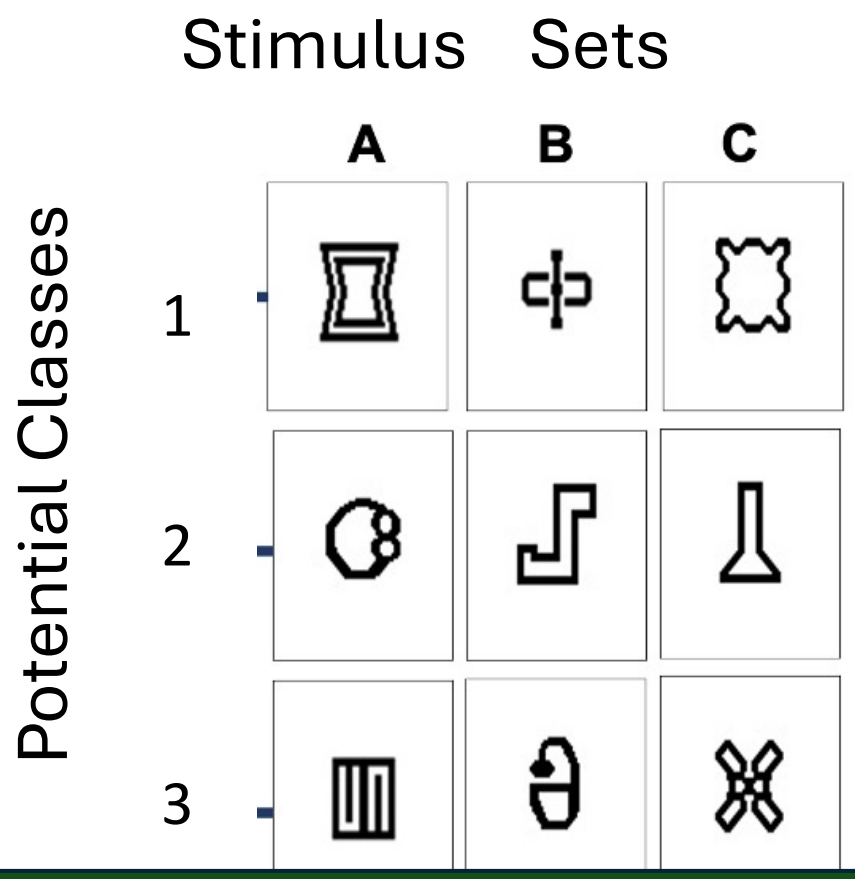
* Consider the variety of “teaching arrangements” : procedures and order

One of the most relevant properties of Equivalence relations: Transfer of functions

In the previous example the functions of the characthers transferred to the abstract pictures.

Learning arbitrary relations and formation of symbolic classes

LABORATORY SIMULATION:
Meaning depens only on teaching contingencies



Journal of the Experimental Analysis of Behavior

SEAB

Journal of the Experimental Analysis of Behavior 2021, 1–22

Merger and expansion of equivalence classes via meaningful stimuli

Ramon Marin[1,2], Vanessa Ayres-Pereira[3], and Deisy das Graças de Souza[1,2]

[1]Universidade Federal de São Carlos, Brazil

[2]National Institute of Science and Technology on Behavior, Cognition, and Teaching (INCT-ECCE), Brazil

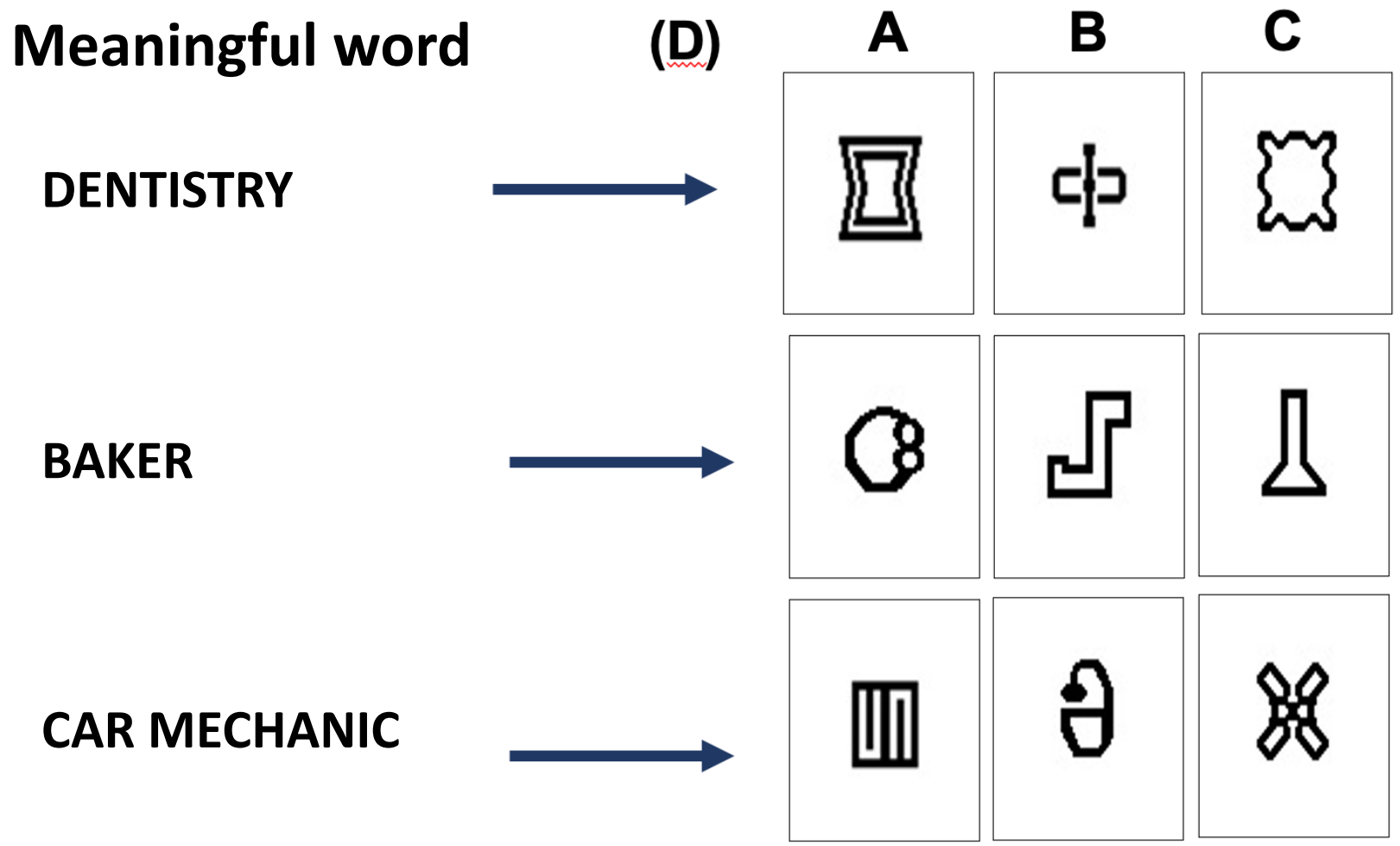
[3]University of Bergen, Norway

BASELINE: AB → AC

EQUIVALENCE PROBES: BC/CB

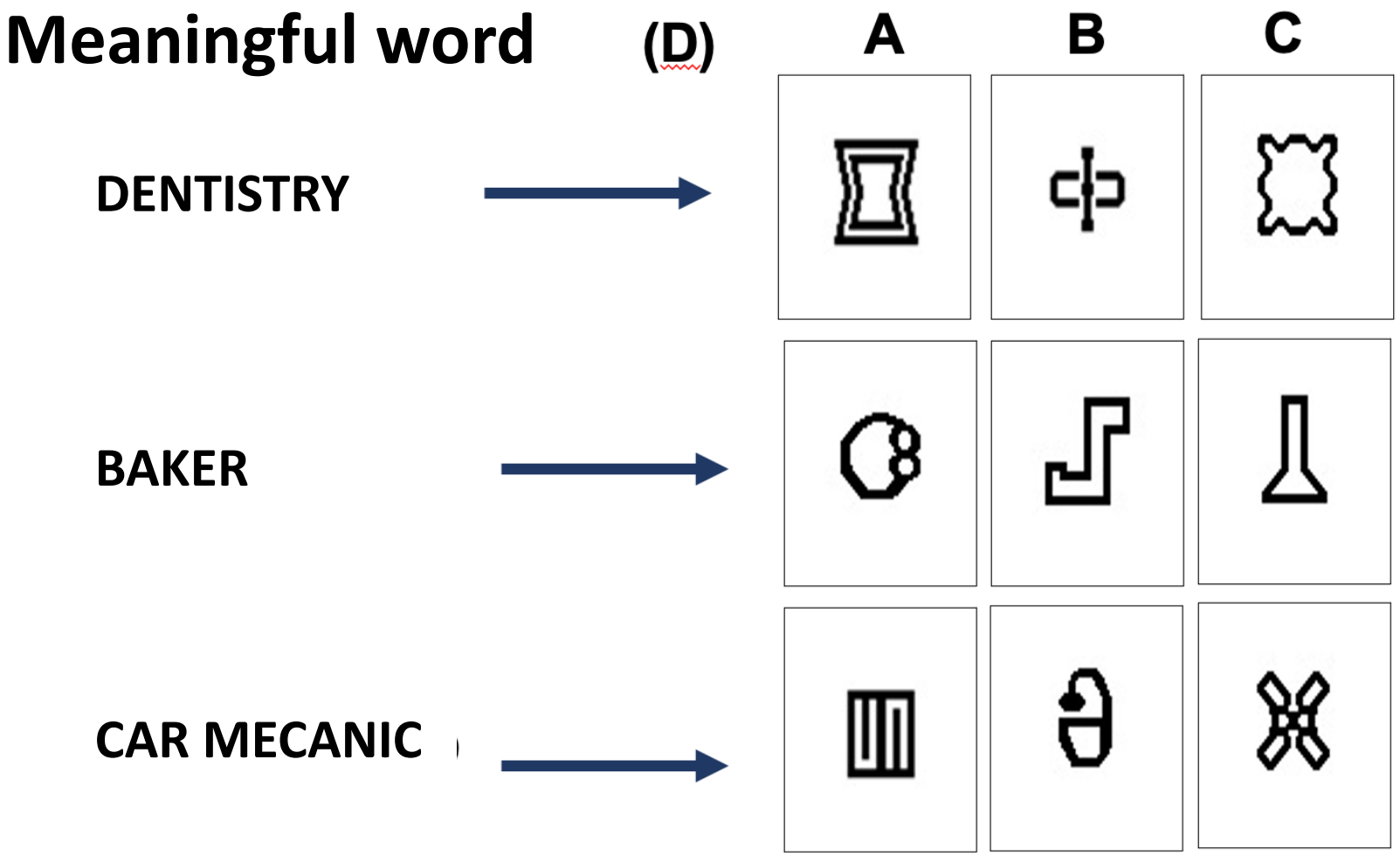
INCLUDING MEANINGFUL STIMULI IN THE CLASSES

Teaching a word-abstract stimulus relation: D → A



INCLUDING MEANINGFUL STIMULI IN THE CLASSES

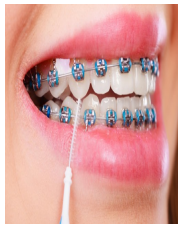
Teaching: D → A Testing: DB/BD DC/CD

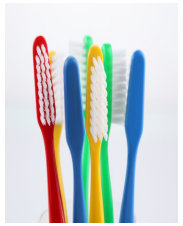


RESEARCH QUESTION:
Would stimuli with pre-experimental meaning, potentially related to the words (D), be included in the classes without any direct exposure?

Assumed pre-experimental classes

1





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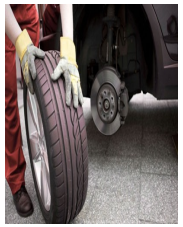
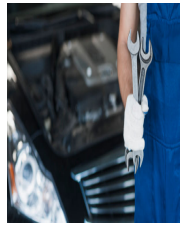
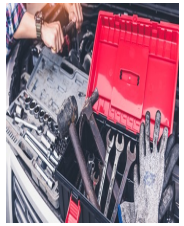
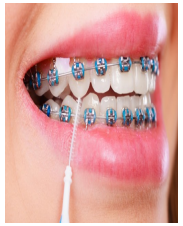




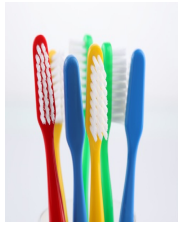
RESEARCH QUESTION:

Would stimuli with pre-experimental meaning, potentially related to the words (D), be included in the classes?

Assumed pre-experimental classes

1





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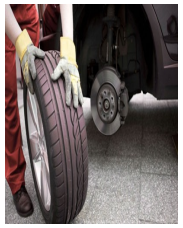
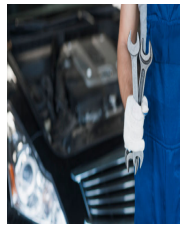
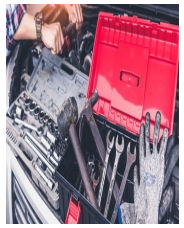
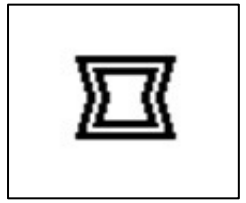
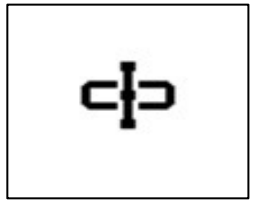
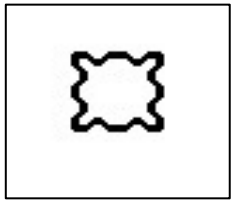
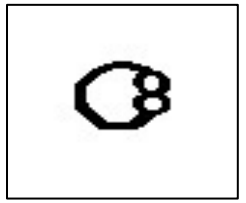
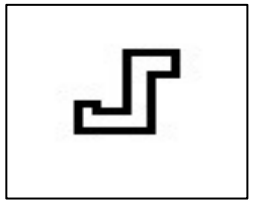
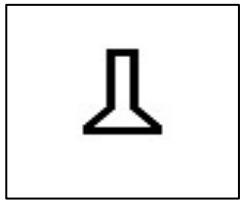
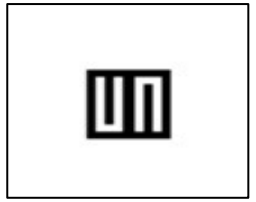
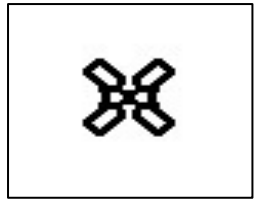
3

Classes established in the lab



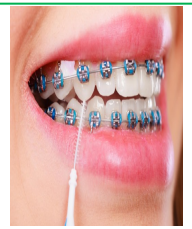
RESEARCH QUESTION:

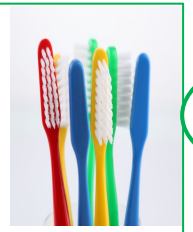
Would stimuli with pre-experimental meaning, potentially related to the words (D), be included in the classes?

Assumed pre-experimental classes

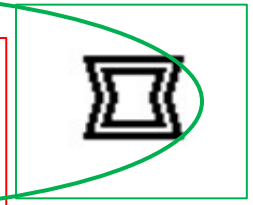
Classes established in the lab

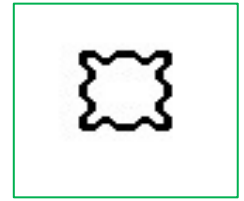
1





[Dentistry] →





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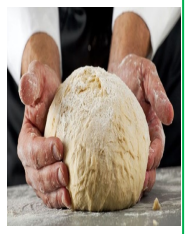
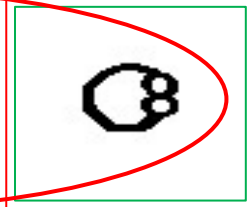
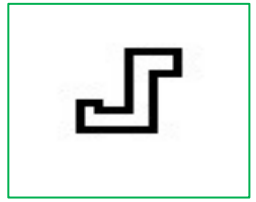


[Baker] →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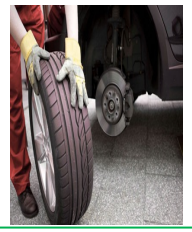
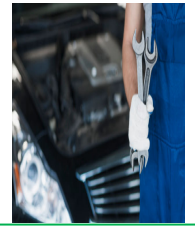
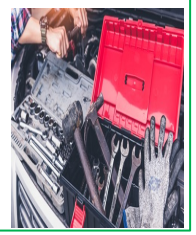
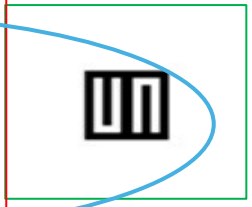




[Car mechanic] →



Merging classes: stimuli with pre-experimental meaning and abstract stimuli

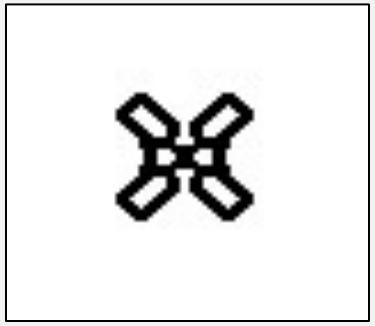
SAMPLE PROBE TRIAL (B1 X1)

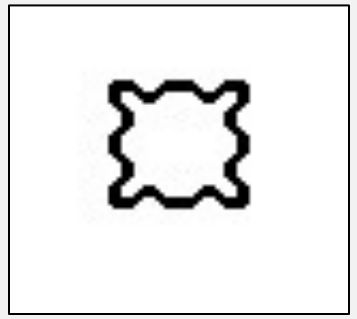
Merging classes: stimuli with pre-experimental meaning and abstract stimuli

SAMPLE PROBE TRIAL (B1 X1)

Merging classes: stimuli with pre-experimental meaning and abstract stimuli

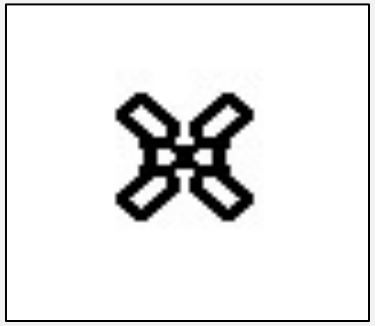
SAMPLE PROBE TRIAL (X2 C2)

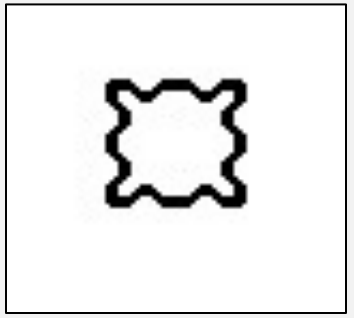




Merging classes: stimuli with pre-experimental meaning and abstract stimuli

SAMPLE PROBE TRIAL (X2 C2)





RESEARCH QUESTION:

Would stimuli with pre-experimental meaning, potentially related to the words (D), be included in the classes?

RESULTS:

Yes: 20 out of 20 participants related the abstract stimuli (B and C) to the pictures in the first probe trial of each type.

CONCLUSION:

Abstract stimuli became symbols of “professions”.

What is a **Symbol**? Where does its meaning come from?

According to Sidman (1994, 2000) a relation is symbolic when stimuli are equivalent.

We will not go into details, but we emphasize that the stimulus equivalence paradigm, pioneered by Sidman, provided both the concept of stimulus equivalence and a method for experimentally verifying the underlying learning processes.

Therefore,

 = a Symbol of "good"

Is the S^D for the response of choosing a food just this abstract shape?

The S^D is the whole class, including the favorite Character and related events (more on this later)

Suficient for our purpose to note that:

Equivalent stimuli are semantically related: have similar meaning;

Equivalent stimuli substitute for each other (in certain contexts);

Equivalence relations generate emergent (derived) relations;

Functions acquired by a stimulus transfer to equivalent stimuli;

Transfer/transformation of functions (ToF): a central concept.

Symbolic relations are conventional/invented
- Individually
- in small groups
- in a culture…

All kinds of language are symbolic in nature (the relations between its elements and Other events of the world are arbitrary)

READING AND WRITING
as symbolic behavior

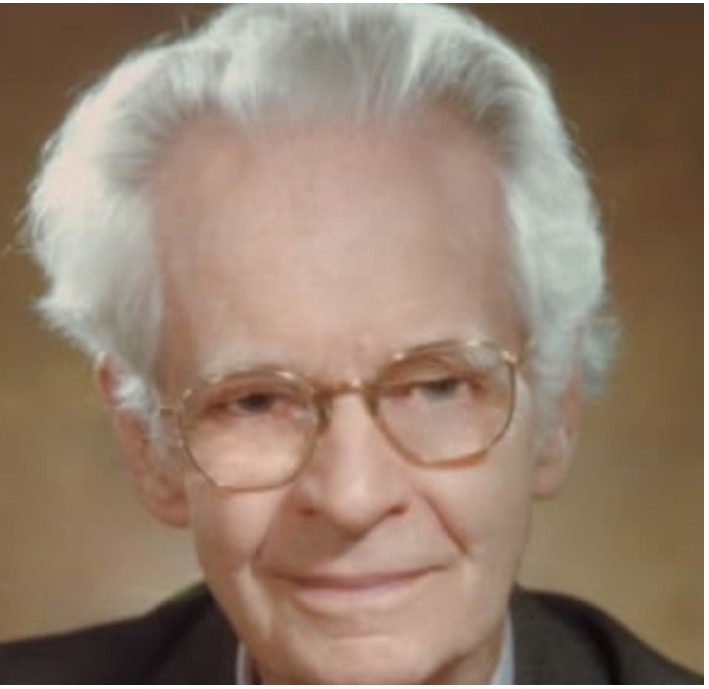
Implications for understanding, teaching, remediation

FOUNDATIONS:

Science & Human Behavior
Verbal behavior
Technology of teaching

Personalized. System of Instruction (PSI)

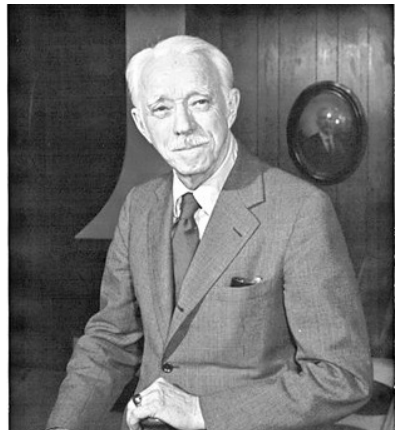
Stimulus Equivalence



B. F. Skinner

Fred Keller

Carolina Bori



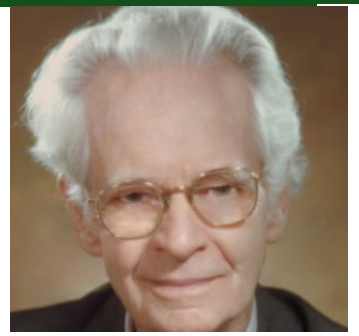
Murray Sidman
(Credit: Iver Iversen)

Reading and Writing

Simple behaviors…

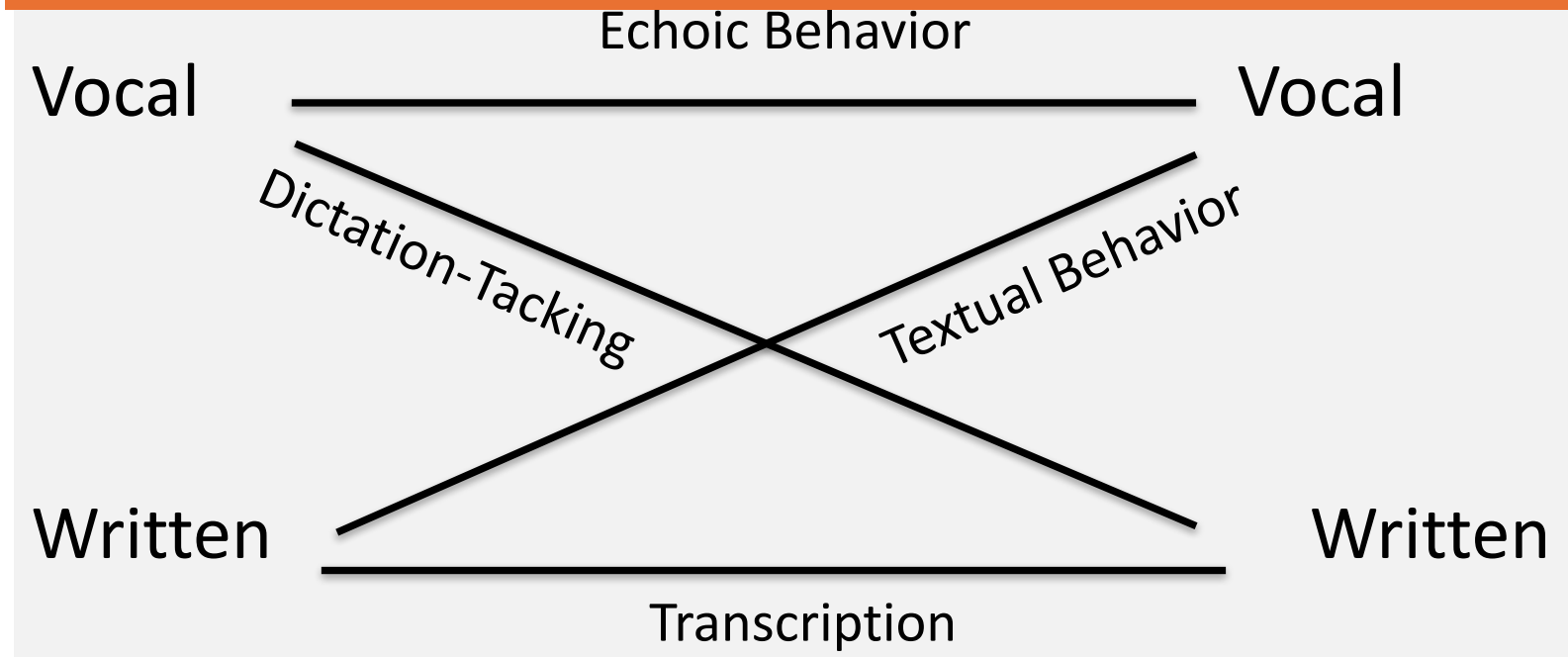
Simplicity is deceptive if we consider only the topography of the stimuli and responses

Text	**Vocal response**	**Written response**
ARGENTINA	*/Argentina/*	*Argentina*
BEGOZA	*/Begoza/*	Begoza



VERBAL BEHAVIOR: FORMAL CONTROL

(Classes of) Stimuli	Responses



(From Catania, 2007, p. 246)

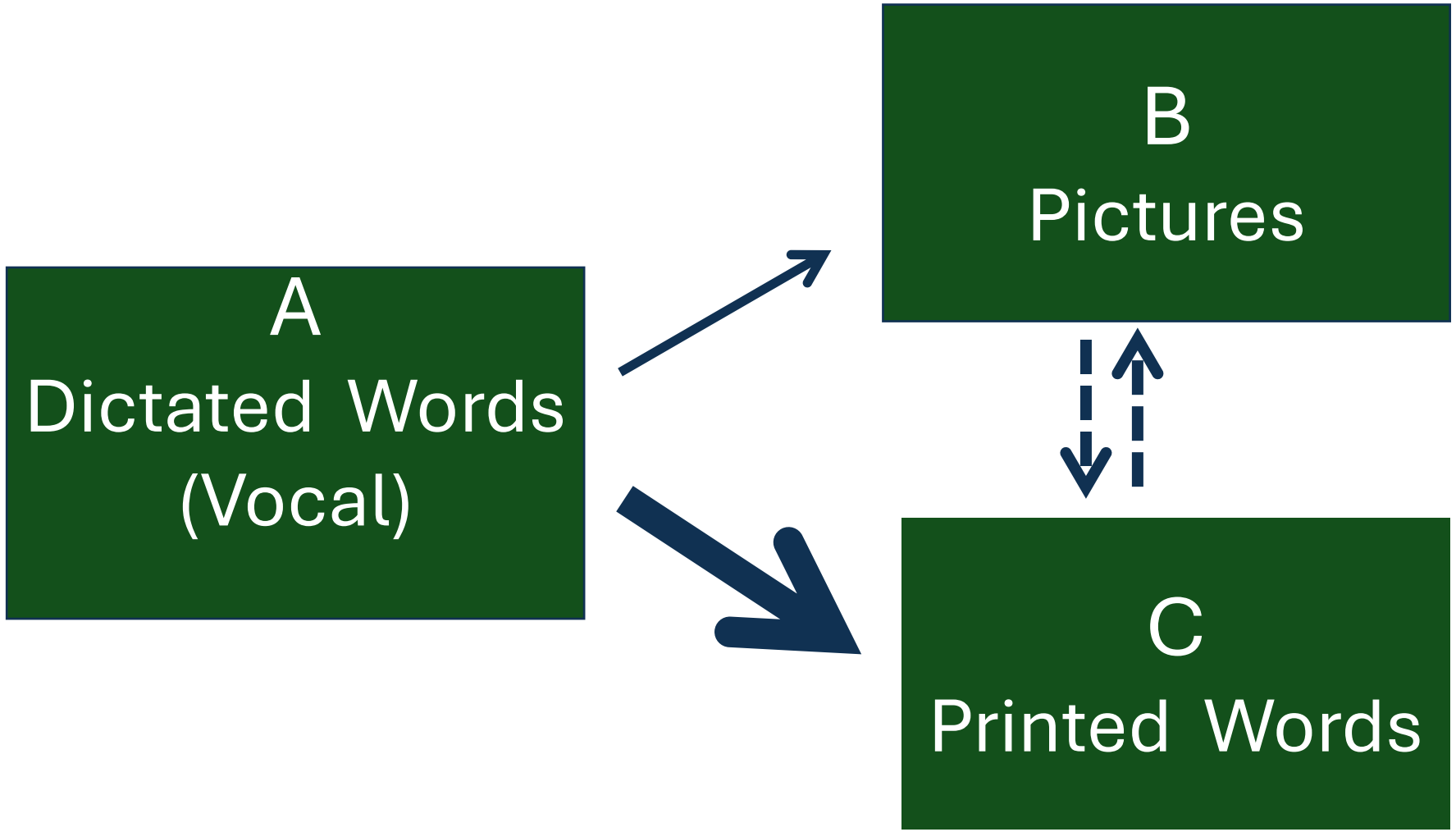
Murray Sidman

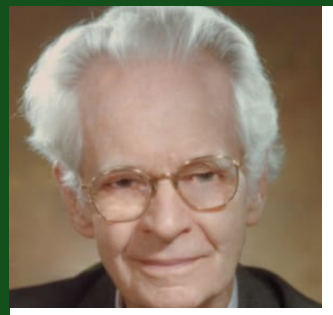
In the seminal paper on the study of stimulus equivalence (Sidman,1971), novel stimulus-stimulus relations emerged as a by-product of the participant directly learning some stimulus-stimulus relations.

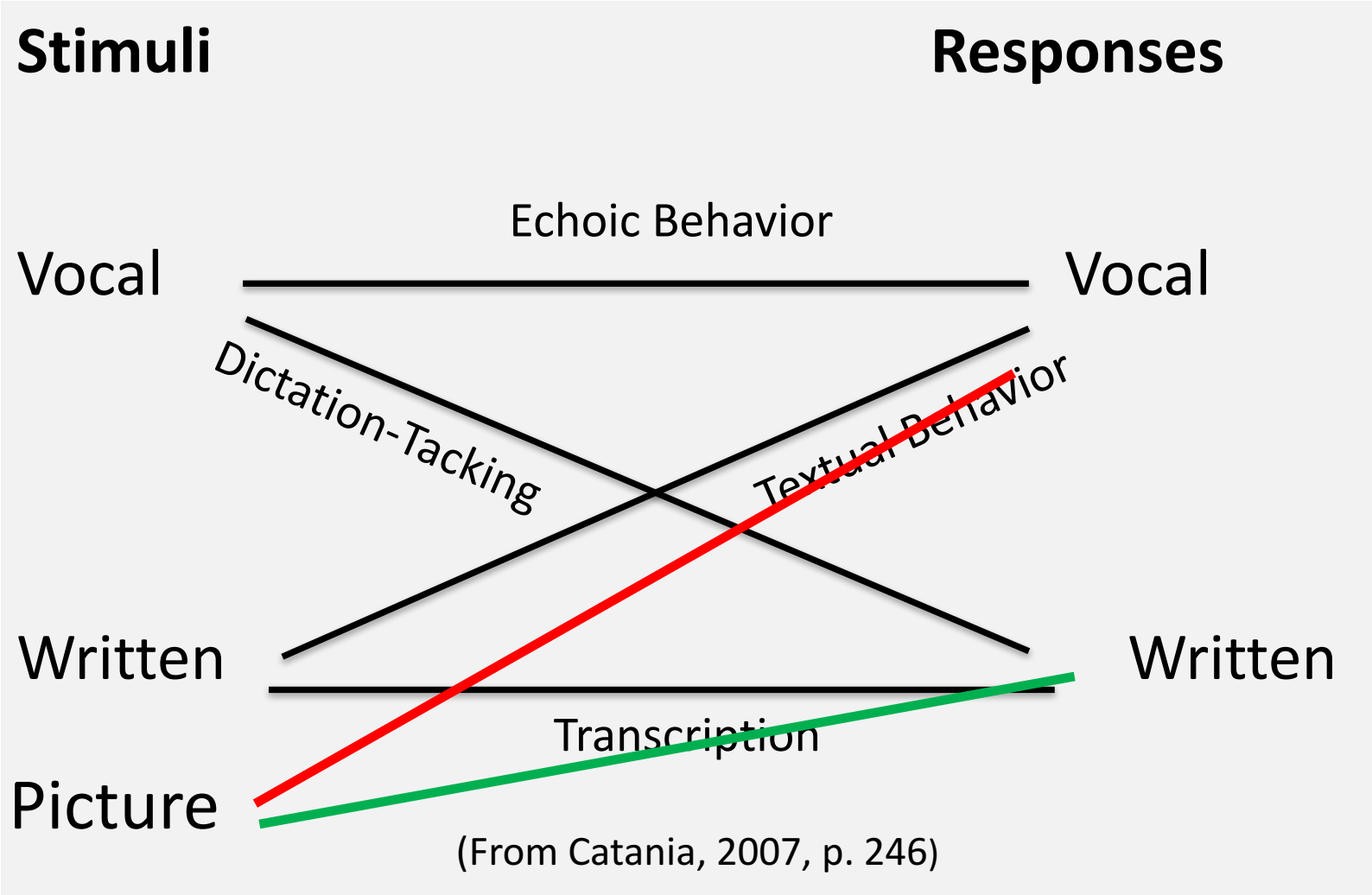
Teaching the basic relations -> Testing derived relations

Stimulus-stimulus relations (Listener skills)

Murray Sidman







(From Catania, 2007, p. 246)

Tact (vocal)

Tact (written)

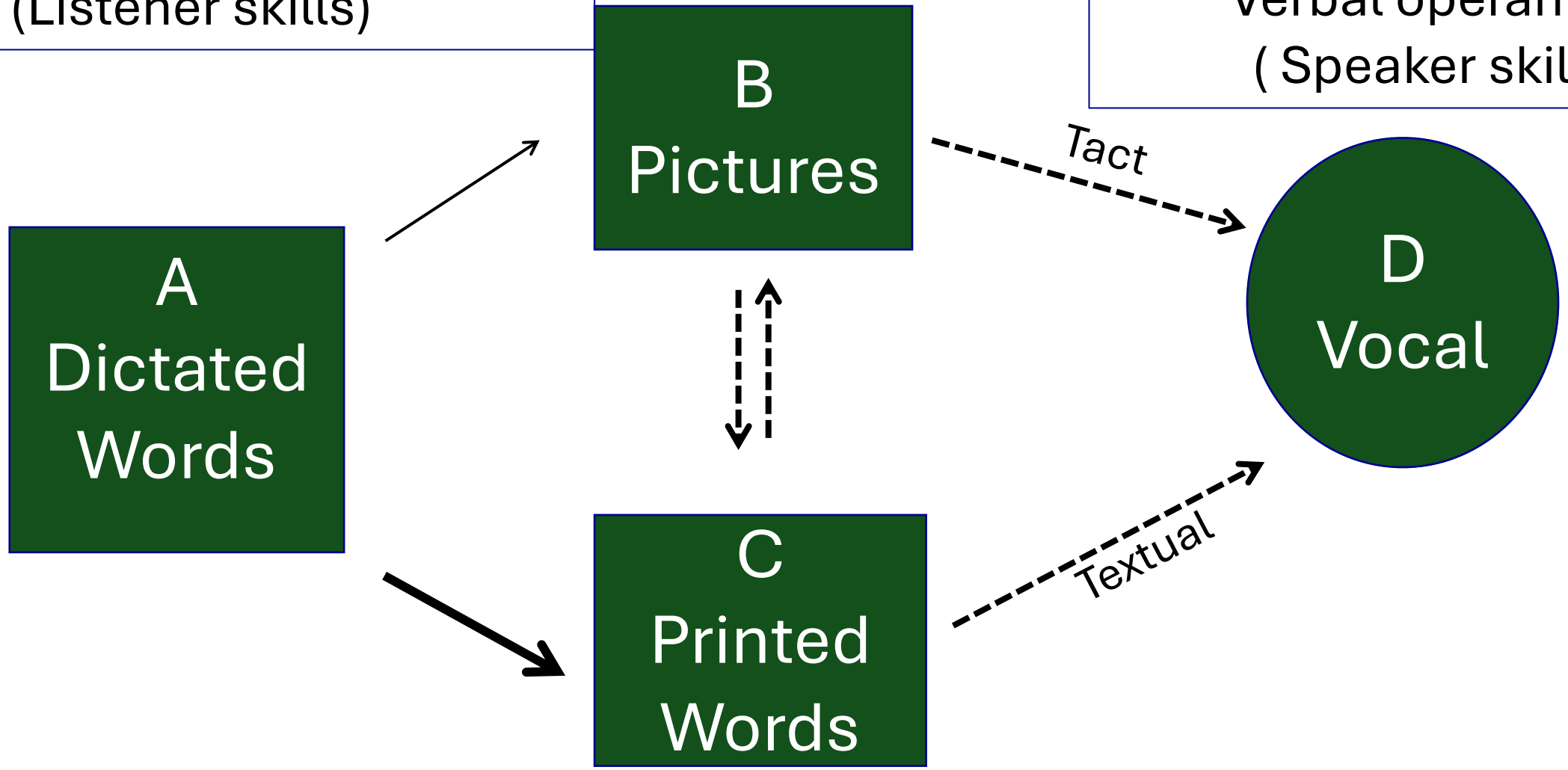
In terms of Verbal Behavior (Skinner, 1957)
Picture naming and
Printed word naming

were, respectively:
Tact
Textual
(**discriminated** [verbal] **operants**)

Teaching the basic relations/ Testing derived relations

Stimulus-stimulus relations
(Listener skills)

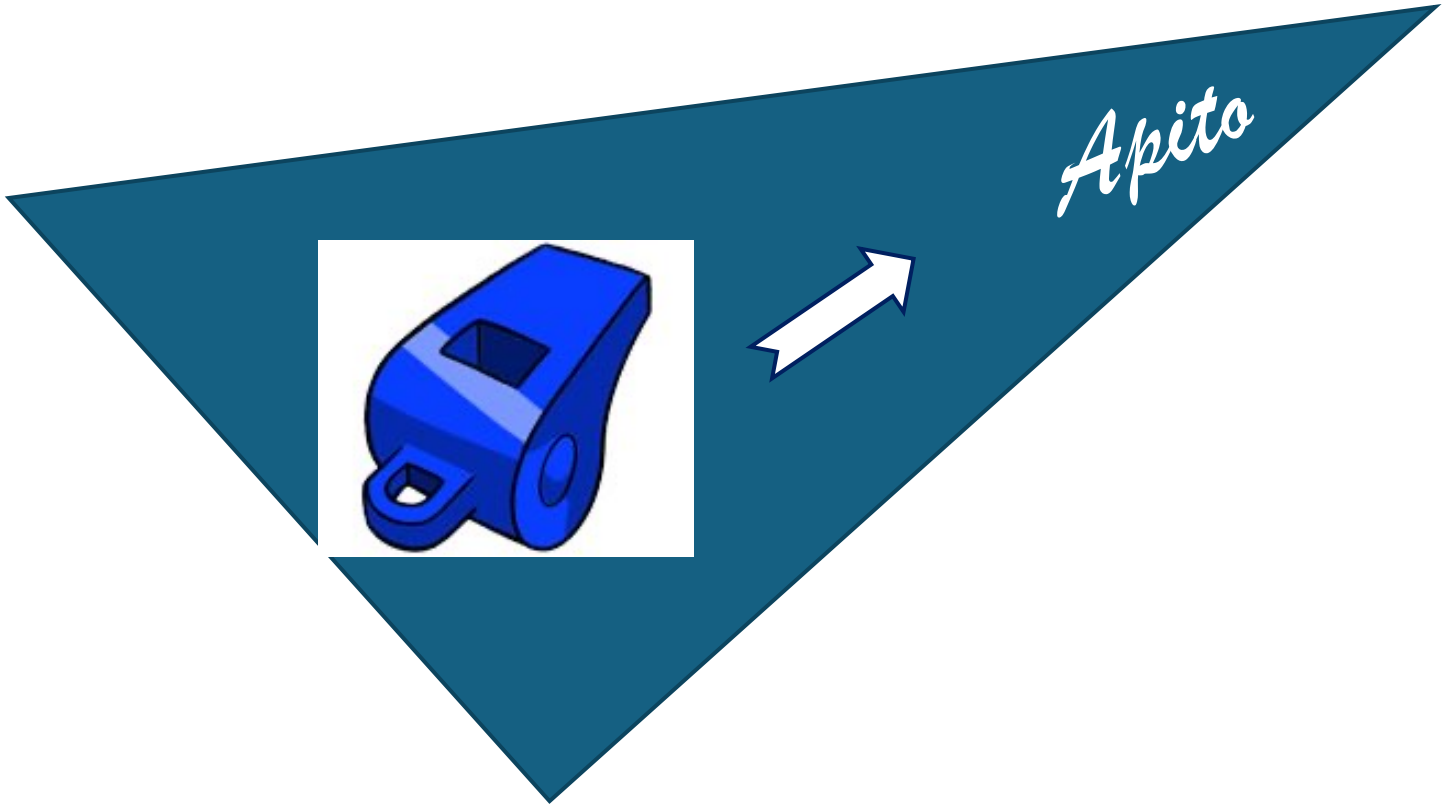
Stimulus-response relations
Verbal operants:
(Speaker skills)



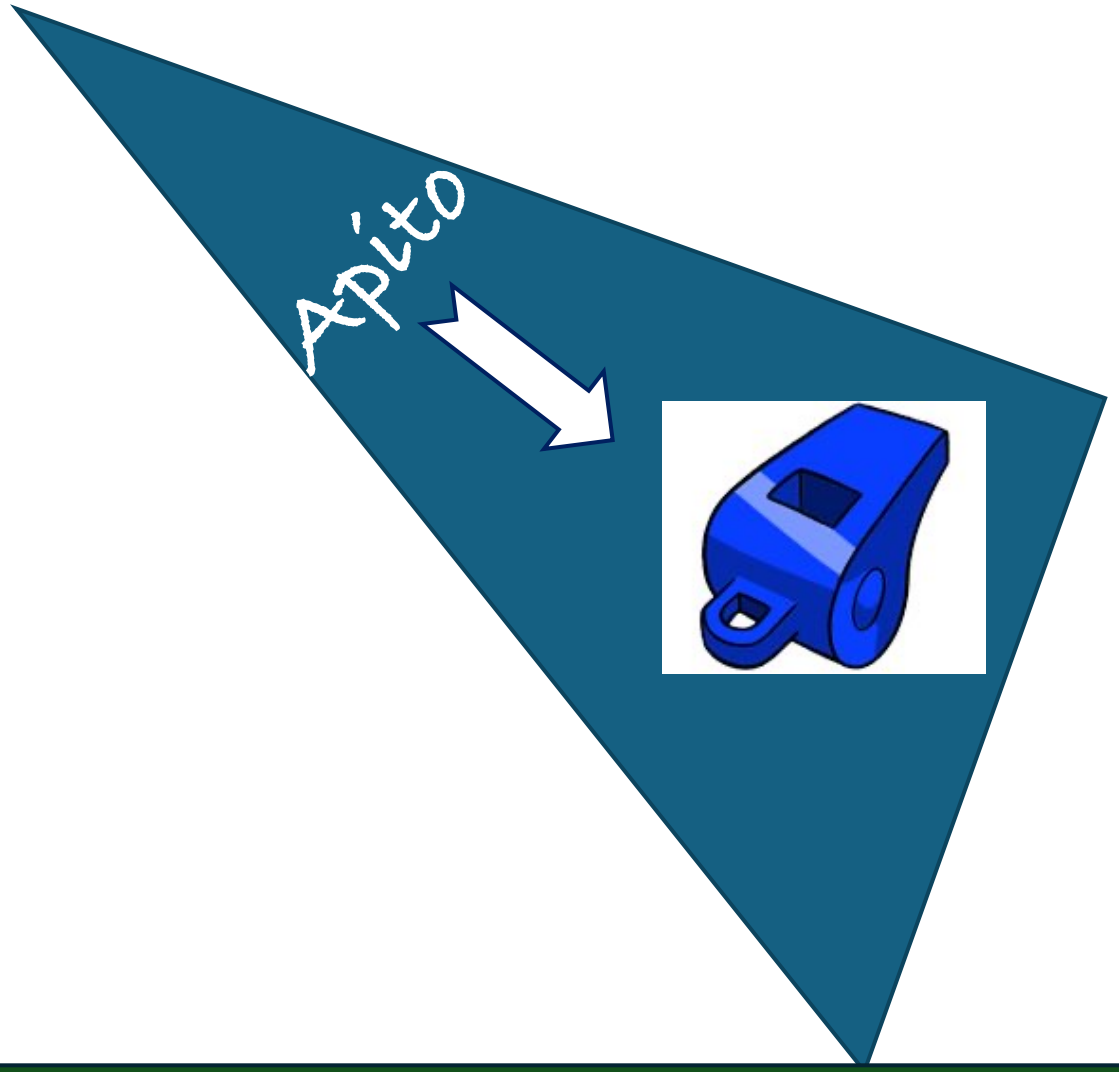
”A tact is a term to describe a type of functional relation between an antecedent stimulus, a behavior, and a consequence. It is a verbal operant in which the topography (i.e., what is said, written, or signed) is under functional control of a nonverbal discriminative stimulus (e.g., an object, a property, an action), which has been differentially correlated with nonspecific or generalized reinforcement for the emission of a specific topography”. (Skinner, 1957)

TACT

SPEAKER

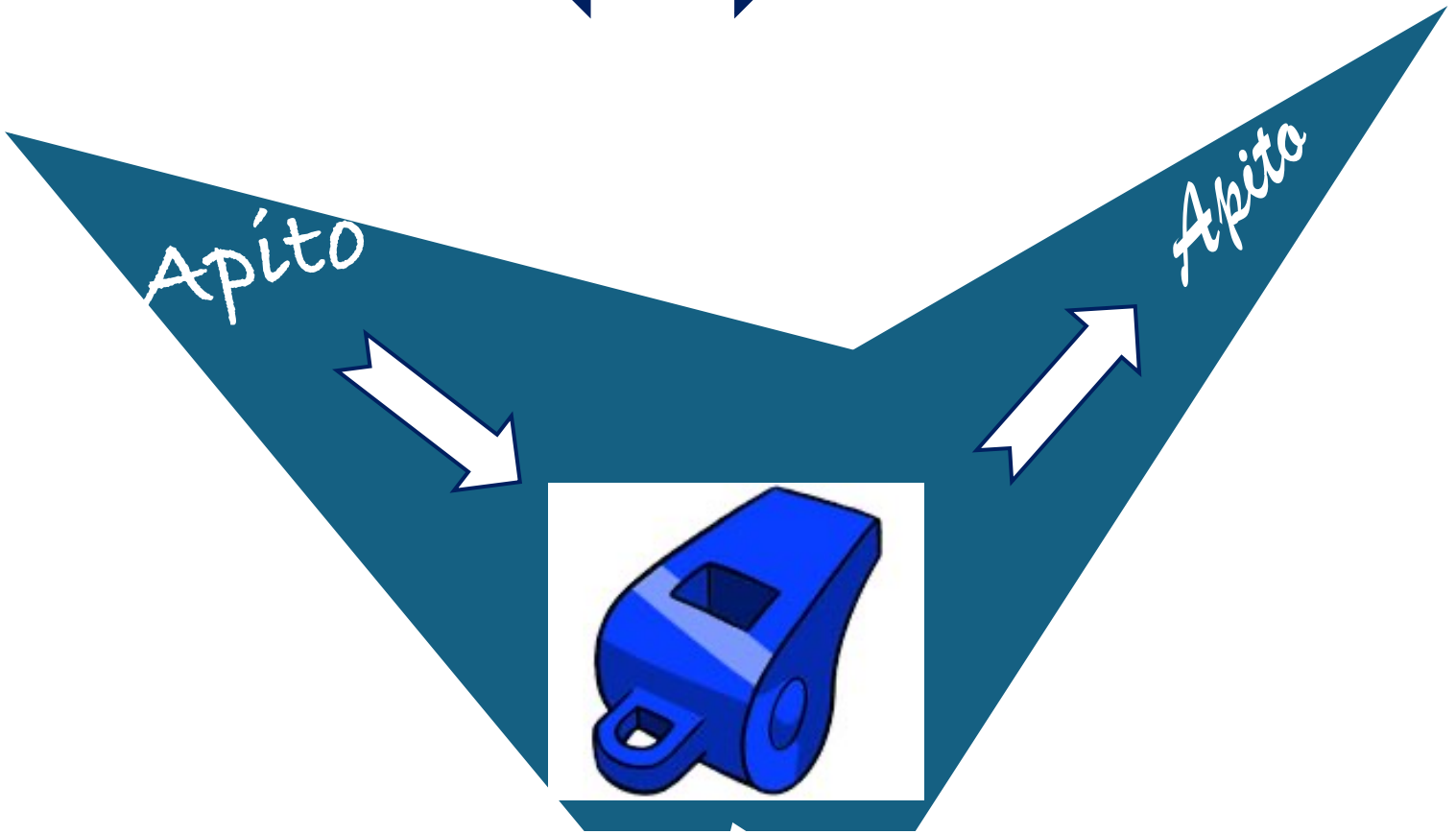


AUDITORY RECOGNITION
LISTENER



BI-DIRECIONAL NAMING

LISTENER ⟷ SPEAKER



AUDITORY RECOGNITION

TACT

Greer (several)
Miguel, 2016

"The term tact emphasizes the functional relation among a **stimulus**, **response**, and **reinforcer**".

"The term tact should be used solely to refer to verbal topographies under control of nonverbal discriminative stimuli". (Miguel, 2016).

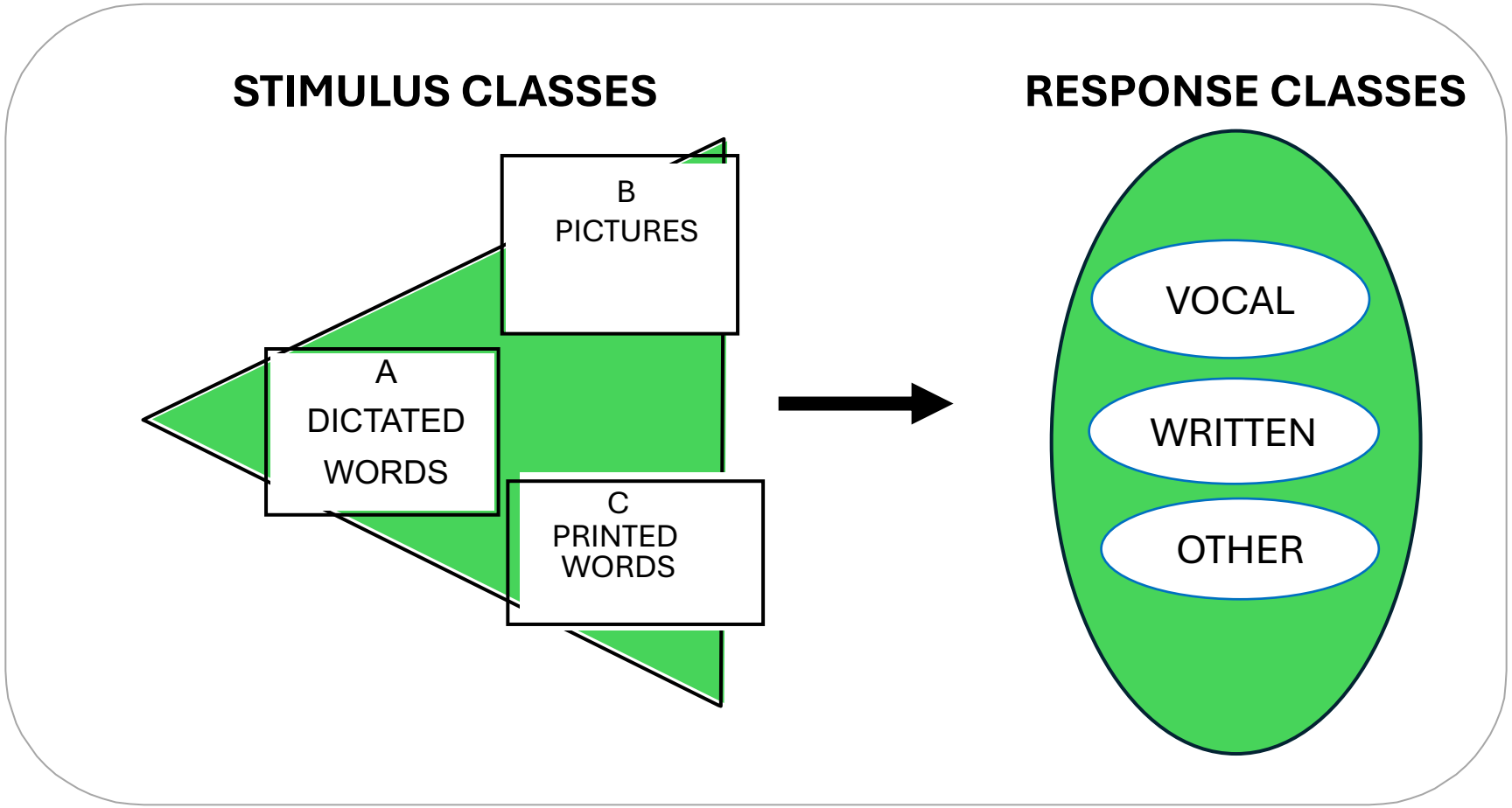
The discriminative stimulus itself is a RELATION between the spoken word and the nonverbal element.

Stimulus Type	Antecedent Stimulud	Response	Consequence	Verbal Operant
Vocal	Spoken Word*	Spoken Word		ECÓICO
Vocal	Spoken Word*	Written Word		DICTATION TAKING
Written	Written Word*	Written Word		Transcription (Copying)
Written	Written Word*	Spoken Word		Textual Behavior
Object, Event, Action, etc	Picture*	Spoken Word		TACT (vocal)
Object, Event, Action, etc	Picture*	Written Word		TACT (Print)

Each relation can be acquired independently, but in the repertoire of a proficient reader, the stimuli and responses are related by equivalence.

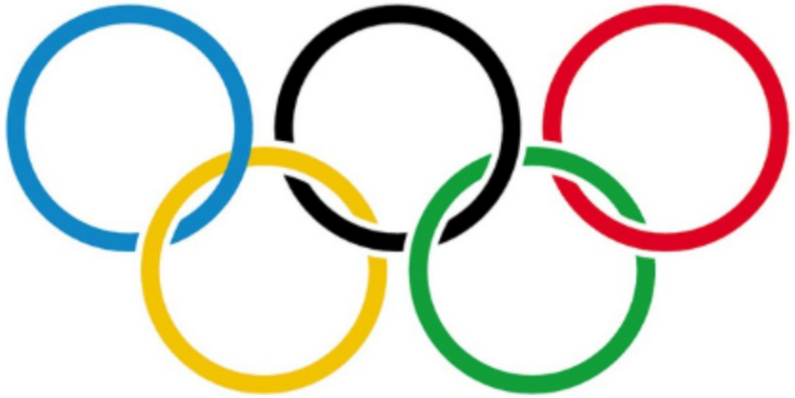
READING AND WRITING AS A NETWORK OF EQUIVALENCE RELATIONS

VERBAL OPERANTS: CLASSES OF RESPONSES UNDER THE CONTROL OF STIMULUS EQUIVALENCE CLASSES



FUNCTIONAL INDEPENCE → INTERDEPENDENCE or INTEGRATED REPERTOIRES

These PICTURES are not just pictures for this audience….



These WORDS are not just words for this audience….

- BEHAVIOR
- REINFORCEMENT CONTINGENCIES
- EXTINCTION
- AVOIDANCE
- DISCRIMINATION
- EXCLUSION

- Each word belongs at least to one equivalence class that includes the spoken word, a possible translation (vocal and written)
- Some words belong to different classes (Context is necessary)

Any symbol acquires its meaning by participanting in an equivalence relation (that can be extended in networks of increasing complexity – see Deacon (1997).

Once meaning is acquired it seems to be very difficult “breaking” the class (implications)

Journal of
Applied Behavior Analysis

TEACHING READING AND SPELLING: EXCLUSION AND STIMULUS EQUIVALENCE

Julio C. de Rose, Deisy G. de Souza, Elenice S. Hanna

First published: Winter 1996 | https://doi.org/10.1901/jaba.1996.29-451 | Citations: 137

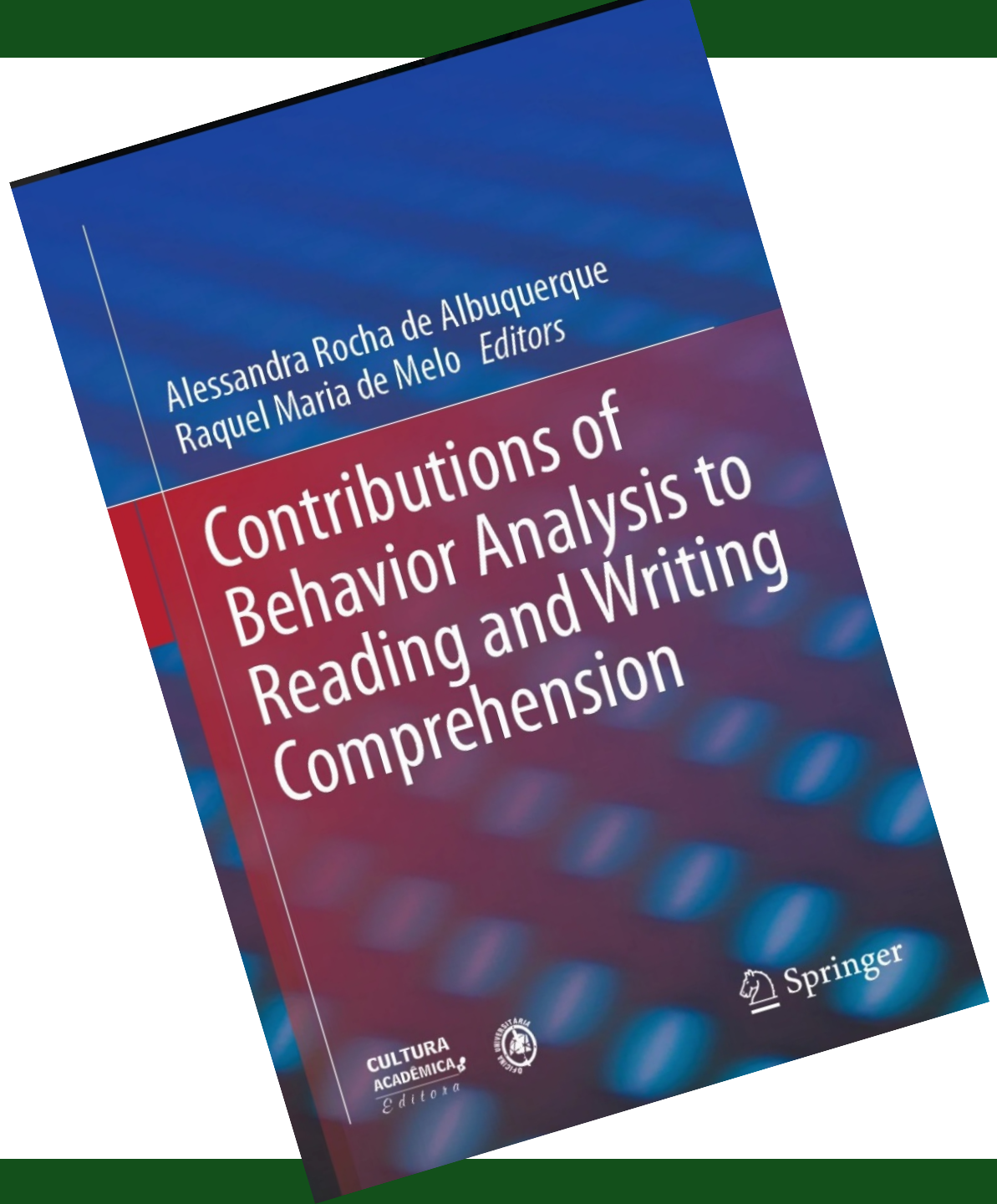
International Journal of Psychology and Psychological Therapy 2009, 9, 1,19-44

Teaching Generative Reading Via Recombination of Minimal Textual Units: A Legacy of Verbal Behavior to Children in Brazil

Deisy G. de Souza*[1], Julio C. de Rose[1], Thais C. Faleiros[1], Renato Bortoloti[1], Elenice Seixas Hanna[2], William J. McIlvane[3]

[1]Universidade Federal de São Carlos, Brazil [2]Universidade de Brasília, Brazil

[3]University of Massachusetts Medical School, Shriver Center, USA


Alessandra Rocha de Albuquerque
Raquel Maria de Melo Editors
Contributions of Behavior Analysis to Reading and Writing Comprehension
CULTURA ACADÊMICA Editora
Springer

INCT | ECCE
Instituto Nacional de Ciência e Tecnologia sobre **Comportamento, Cognição e Ensino**

A CURRICULUM TO TEACH READING AND WRITING

inct institutos nacionais de ciência e tecnologia

FAPESP

CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico

COMPUTERIZED MODULES FOR INDIVIDUAL LEARNIING

inct
institutos nacionais de ciência e tecnologia

Gerenciador de Ensino Individualizado por Computador (GEIC)

MÓDULOS DO GEIC

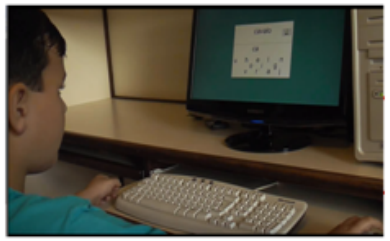
MÓDULO EQUIPE
Cadastro de tutores, professores, e pesquisadores e que fazem uso do GEIC. Permite criar grupos de trabalho com a indicação de alunos para cada membro de equipe.

MÓDULO ALUNOS
Cadastro de alunos e demais usuários dos programas de ensino criados no GEIC.

MÓDULO CONSULTA
Consulta do desempenho dos alunos e exportação, no formato de planilha, das sessões feitas no GEIC

MÓDULO PLAYER
Execução dos programas de ensino do GEIC.

MÓDULO AUTORIA
Criação e teste dos programas de ensino do GEIC.



O GEIC é uma plataforma de software que permite criar, editar e aplicar tarefas de aprendizagem e programas de ensino por meio de qualquer computador com acesso à internet. Esse tipo de acesso possibilita o uso desta ferramenta de modo remoto e independe de uma monitoria presencial. O software permite o cadastro e gerenciamento de instituições, professores e alunos ou participantes de pesquisa que farão uso dos programas de ensino ou de pesquisa criados na plataforma. Por essa razão, o GEIC está organizado em diferentes módulos (equipe, alunos, consulta, player).

www.ufscar.br/ecce/geic/

Na presente fase, o GEIC disponibiliza programas de ensino de leitura e escrita para leitores principiantes (por exemplo, crianças com dificuldades de aprendizagem) e para a estimulação auditiva de usuários de implante coclear.

Os desempenhos dos usuários nos diferentes programas são registrados em um servidor, que mantém estes dados para finalidades de pesquisa. Para visualizar o desempenho de um usuário, um professor ou pesquisador com senha de acesso autorizada pela equipe pode acessar o Módulo Consulta que disponibilizará um protocolo com a sequência das tarefas realizadas e o registro de acertos e erros. Além disso, é possível exportar o registro dos desempenhos dos usuários para um formato de arquivo compatível com editores de planilha e programas de tratamento estatístico.

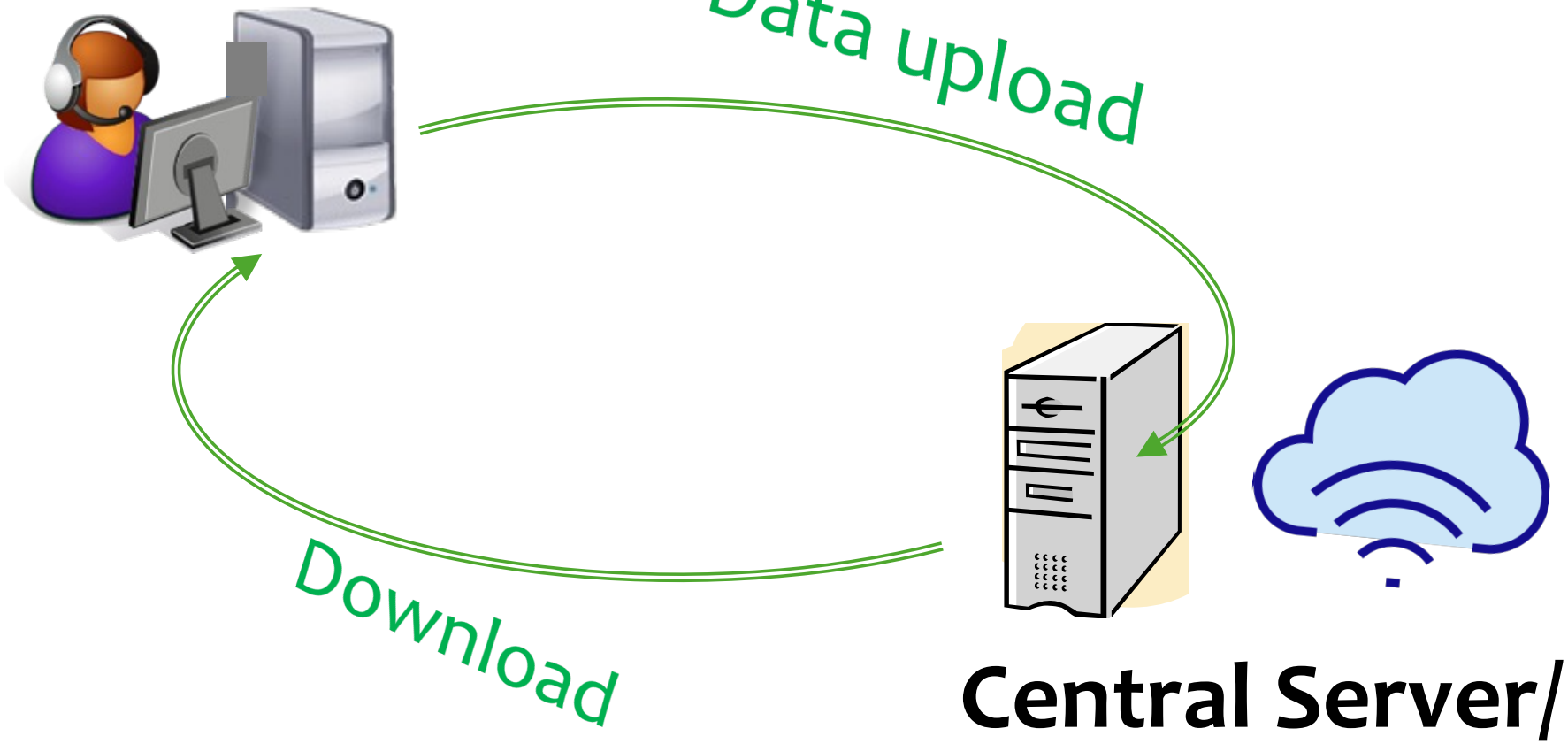
Tela do Módulo Player (exemplifica uma sequência de blocos de tarefas

O GEIC permite o desenvolvimento e a aplicação de programas de ensino ou de pesquisa em tarefas de aprendizagem, em qualquer computador com acesso à internet. A plataforma possibilita o cadastro e a monitoria de alunos e outros usuários dos programas de ensino criados. Os resultados obtidos também podem ser facilmente acessados online.

GEIC
UFSCar
2010

GEIC
Software System

Teaching session



Main goals

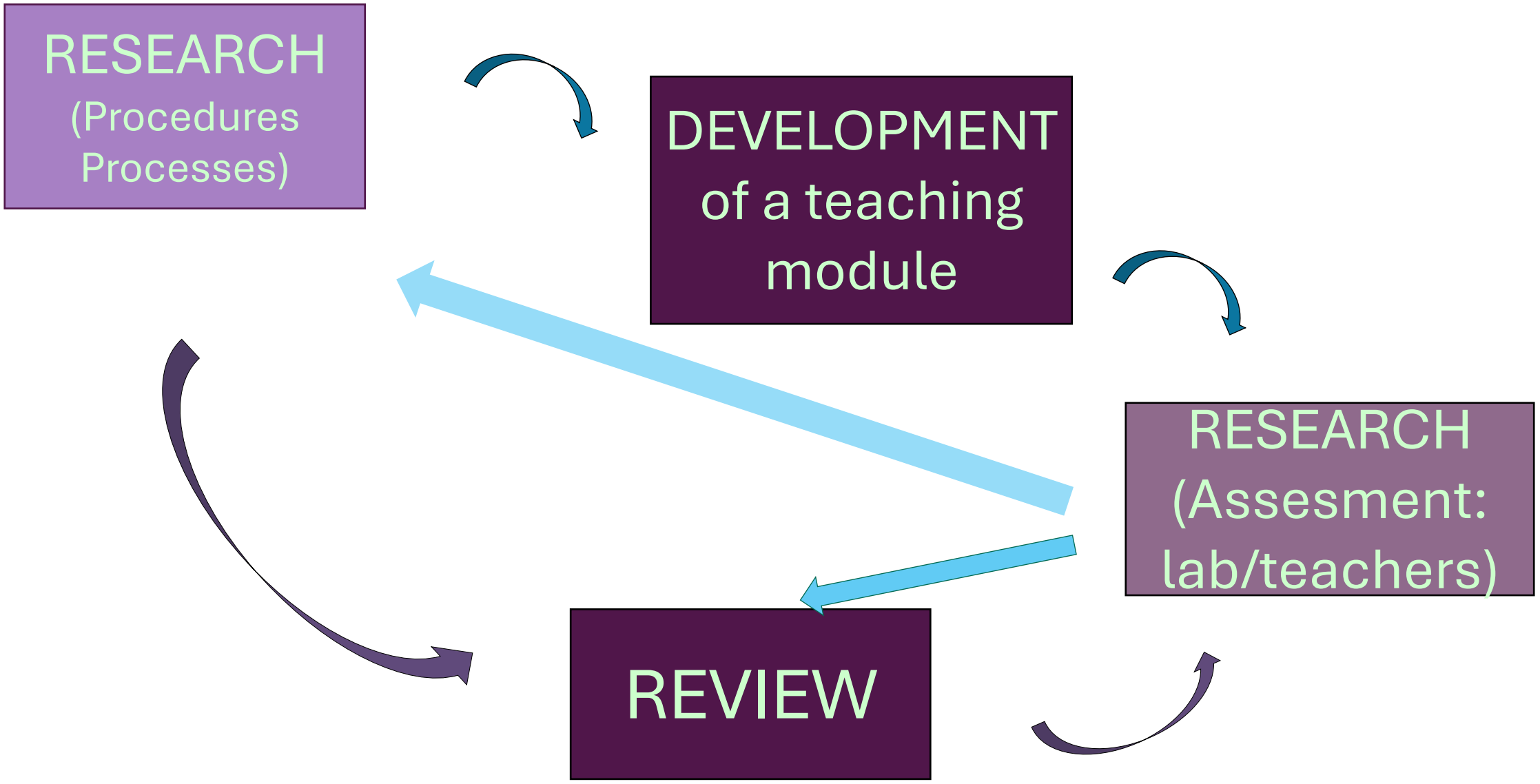
- Develop a curriculum to be used as a supplementary service for children who have difficulty learning under conventional procedures.

- Evaluate (basic and translational research):

  (a) The effects of the teaching procedures

  (b) The adequacy of content

GENERAL STRATEGY



THE CURRICULUM:
Learning to read and write in Small Steps

Developed, evaluated and in use:

Three modules

In preparation:

Two module

Module 1: Reading comprehension (Equivalence)

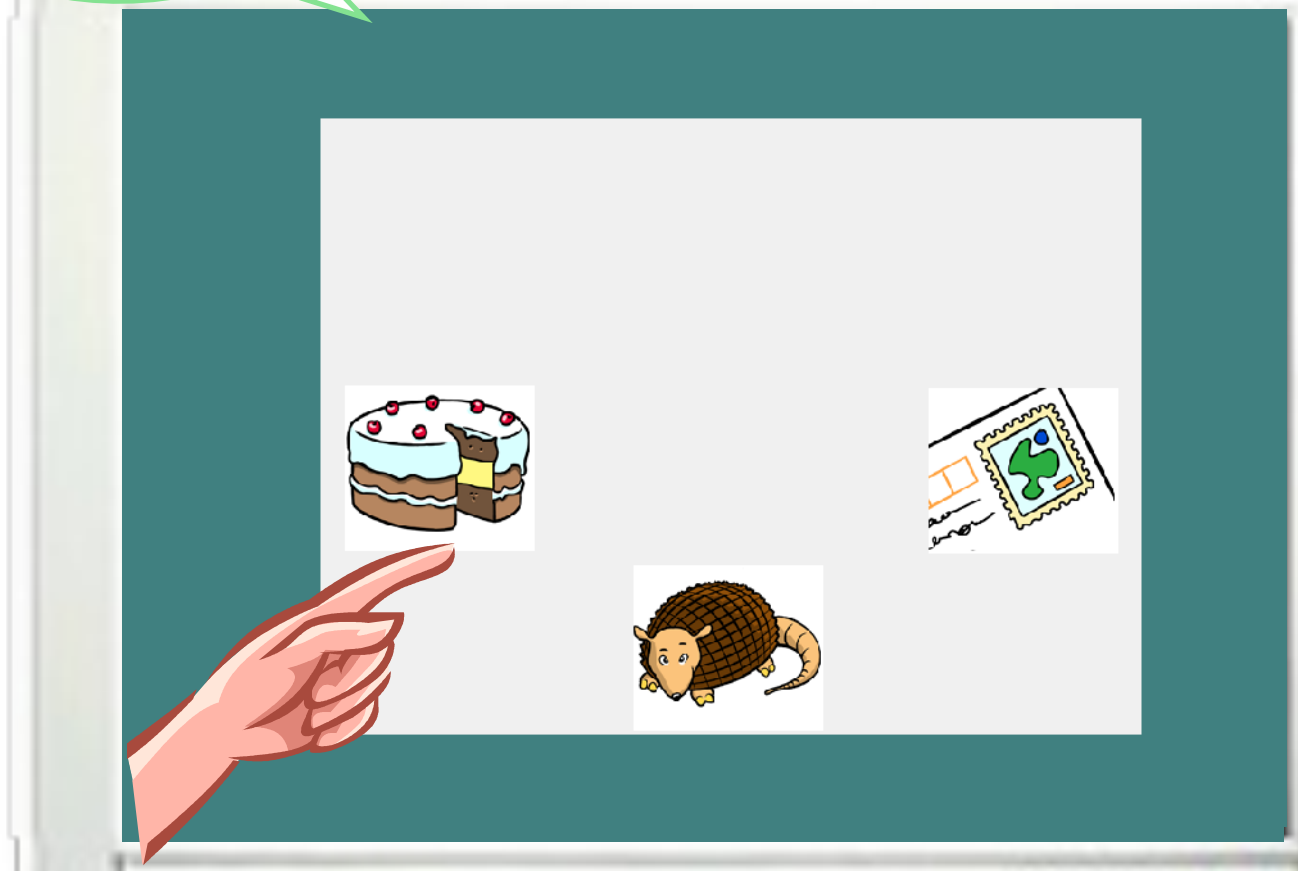
Main procedure:

Matching-to-sample by exclusion (teaching listening – obtaining the relevant verbal operants)

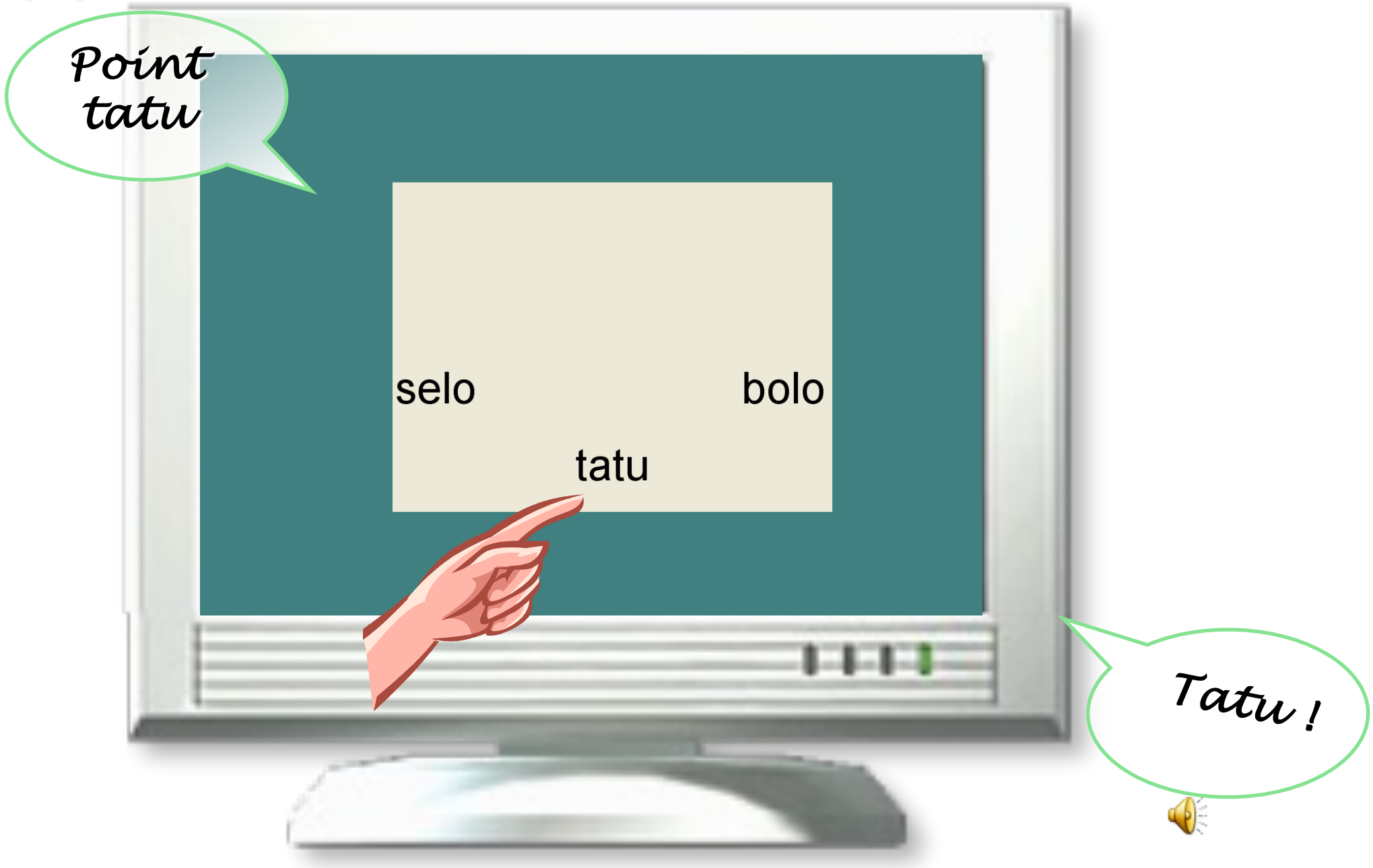
Words with regular orthography

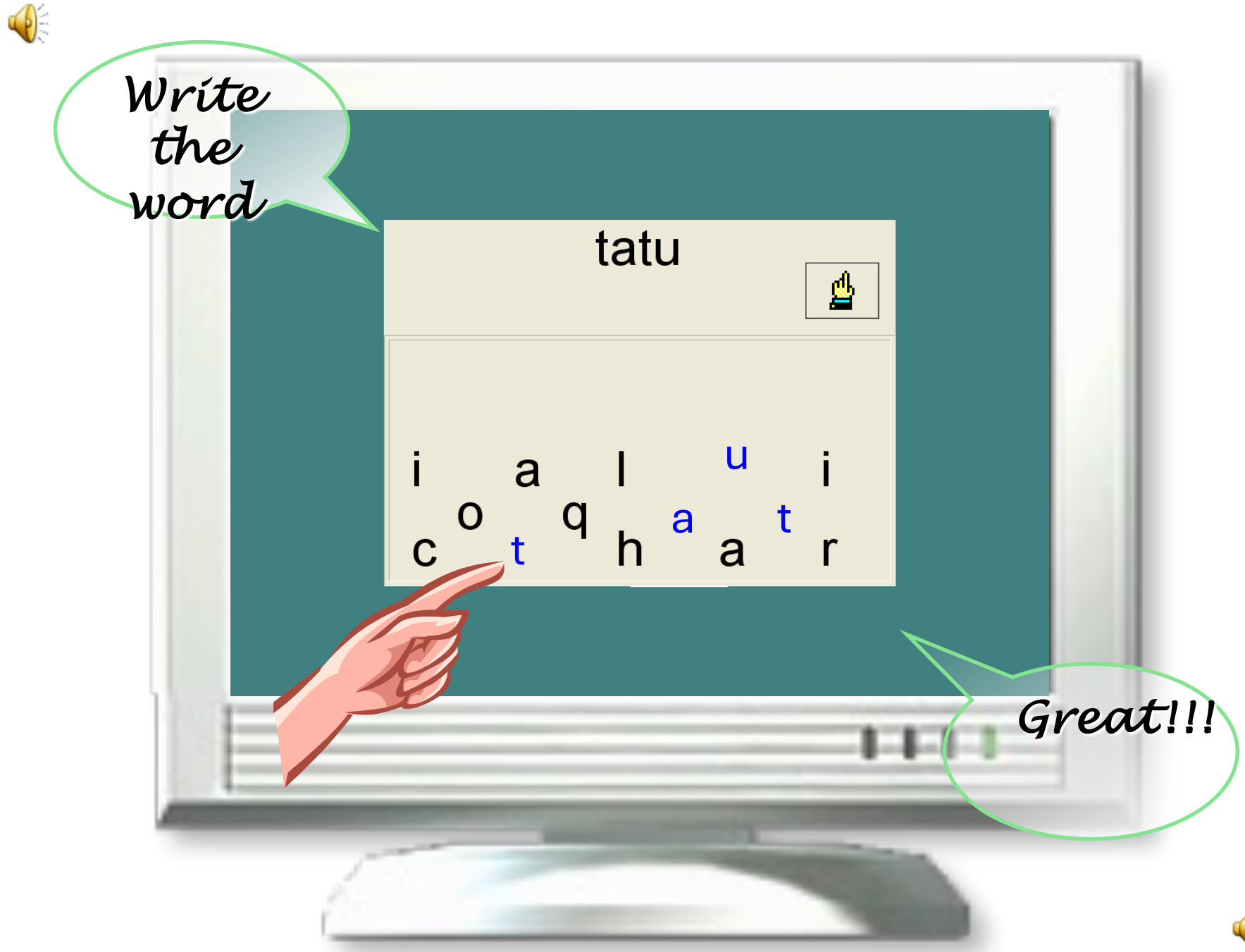
Examples of discrete trials

Point
CAKE

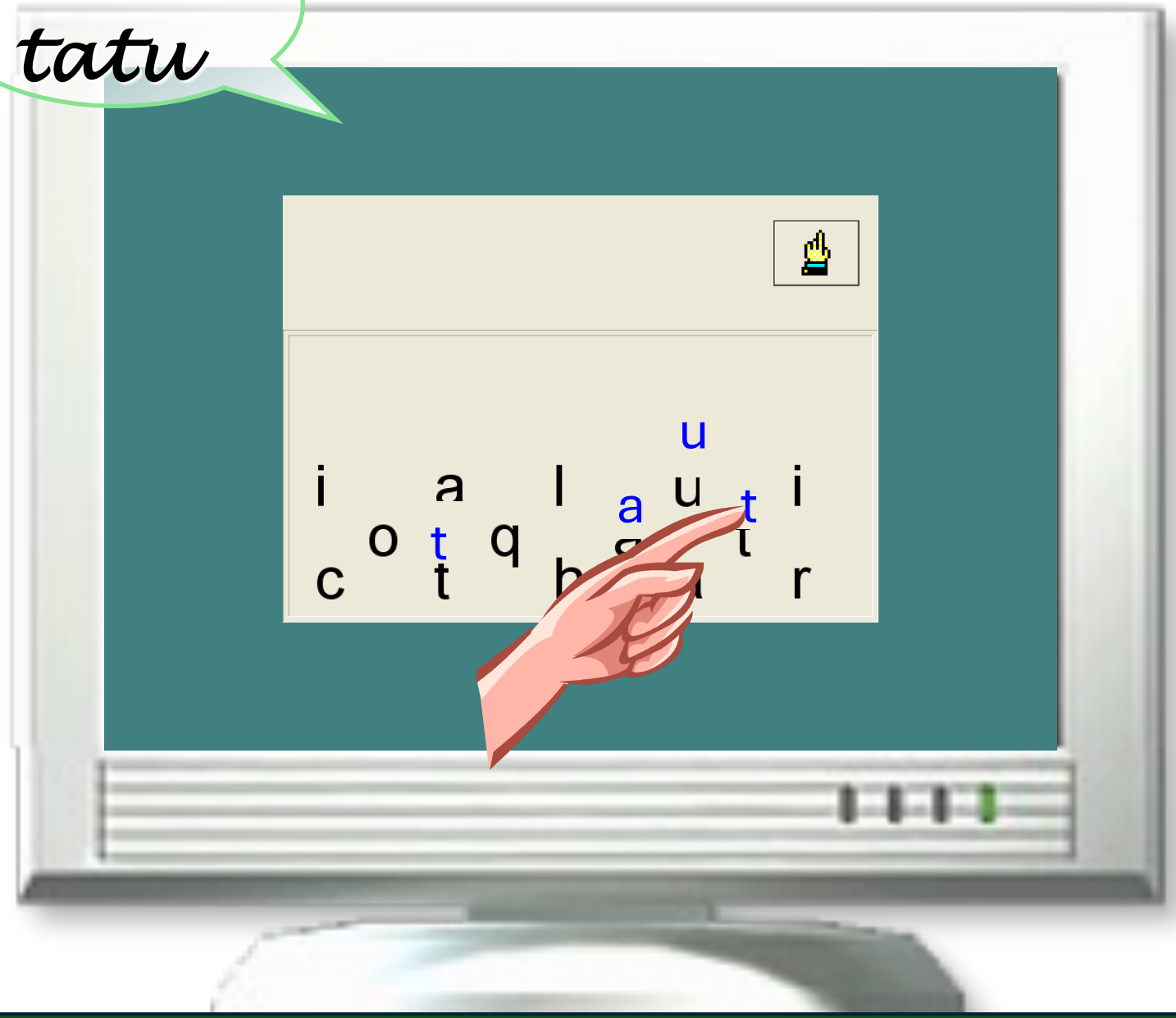


Corret!


Point tatu
selo
bolo
tatu
Tatu !


Write the word
tatu
i a l u i
o q a t
c t h a r
Great!!!

Write tatu



Point the same

tatu

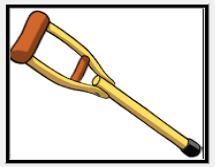
selo

tatu

toco

Yes!!!

Point the word



boca

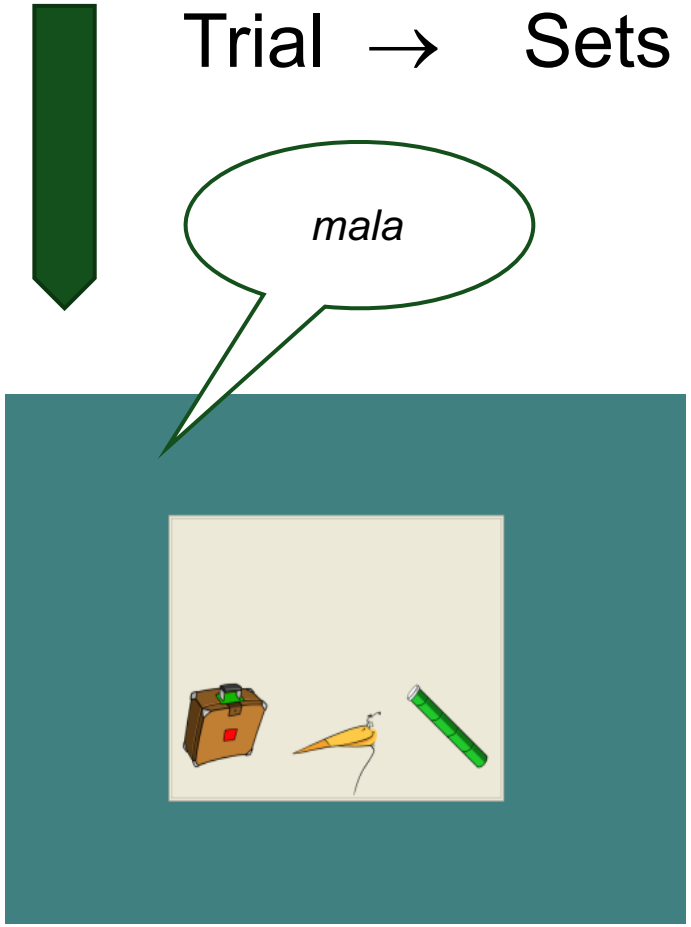
toco

muleta

Point the picture

boca

The organization of tasks as a sequence of “lessons” or steps (PSI)



Trial → Sets of trials

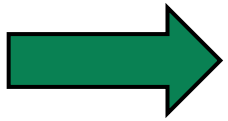
Block → Sets of Blocks

Lesson → Set of lessons

Teaching Module

RECOMBINATIVE READING - SYLABIC UNITS

TEACHING	NOVEL
bolo	boca
vaca	lata
tatu	luta
mala	mato
luva	
tomate	



If we use only whole words in teaching, how can the student read novel words ?

- Discrimination of smaller units
- Abstraction of syllables)

MODULE 2

Words with orthographic complexities

PROCEDURES:

TEACHING

Matching printed words to dictated words

PROBES

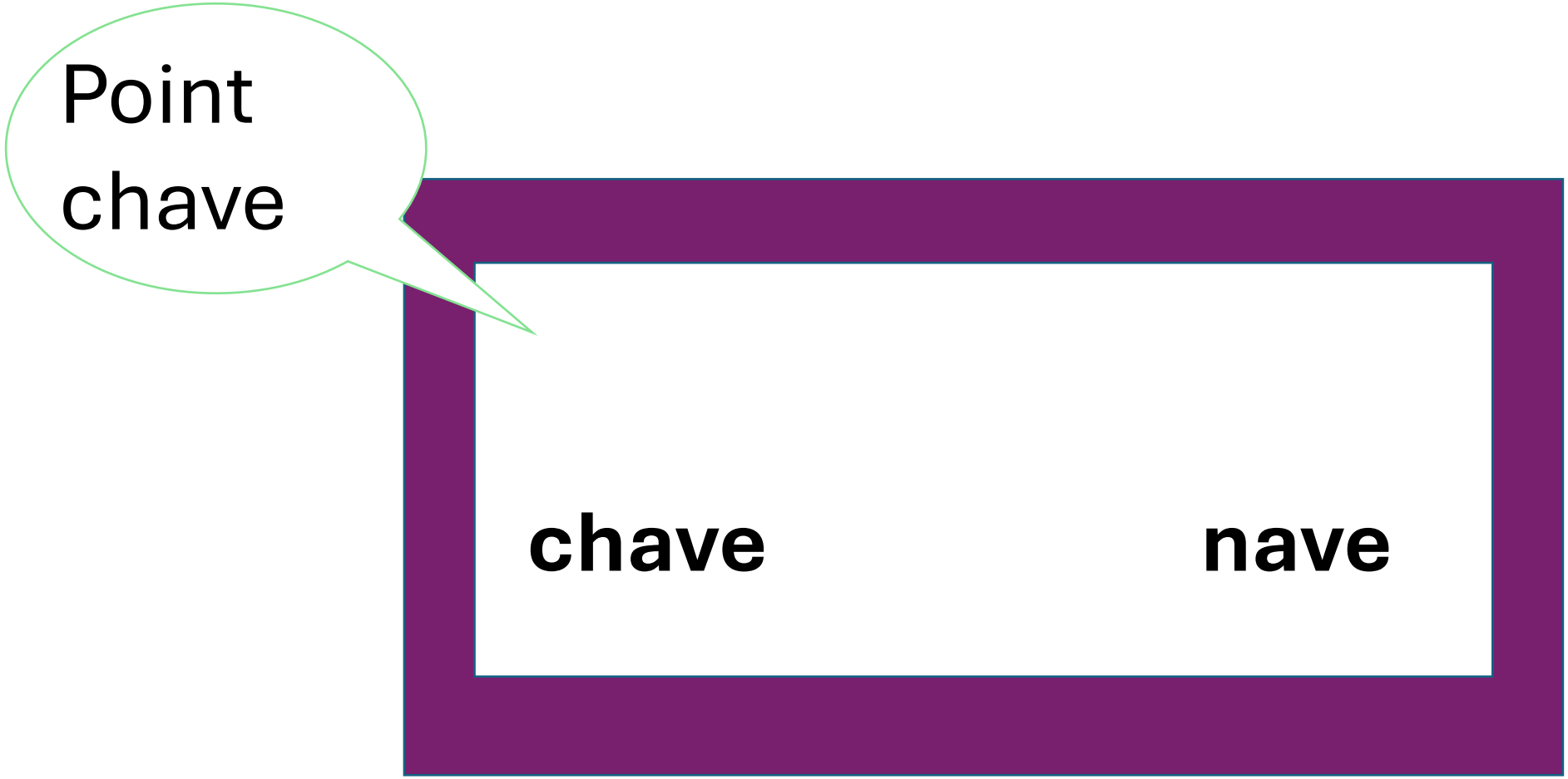
Textual behavior

Dictation taking

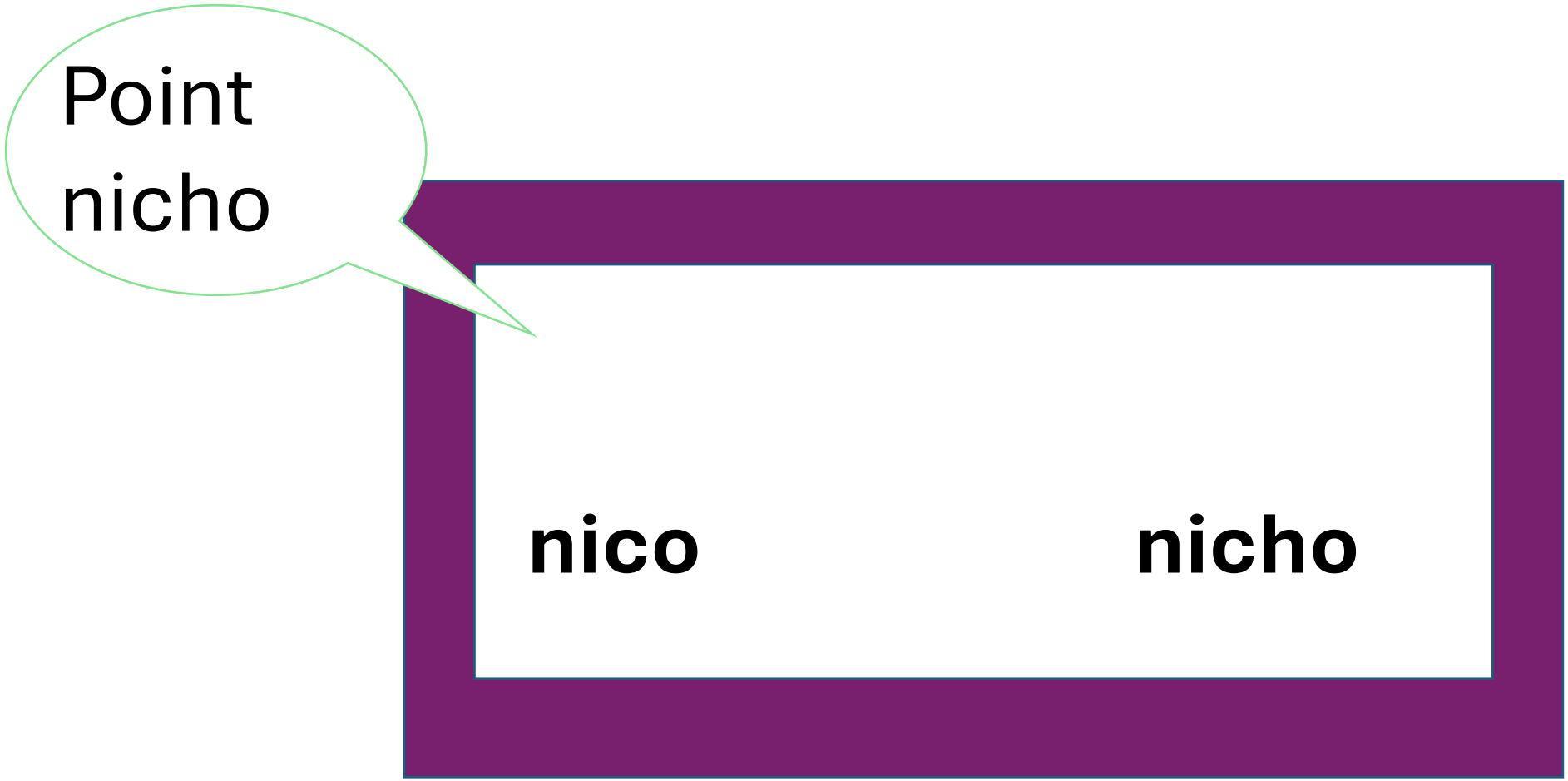
PRINCIPLES:

Abstraction and recombination of minimal units

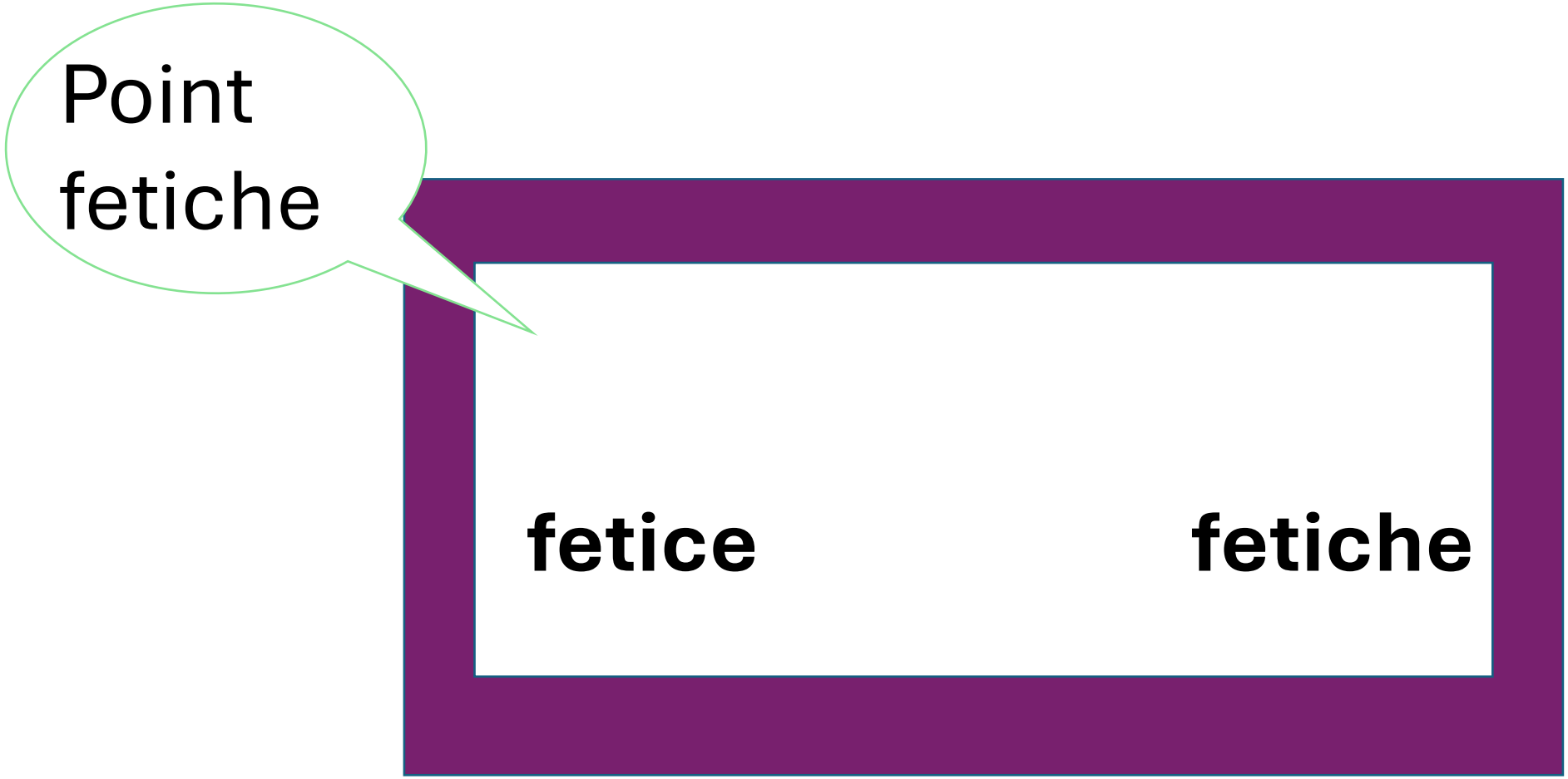
Example: **CH**



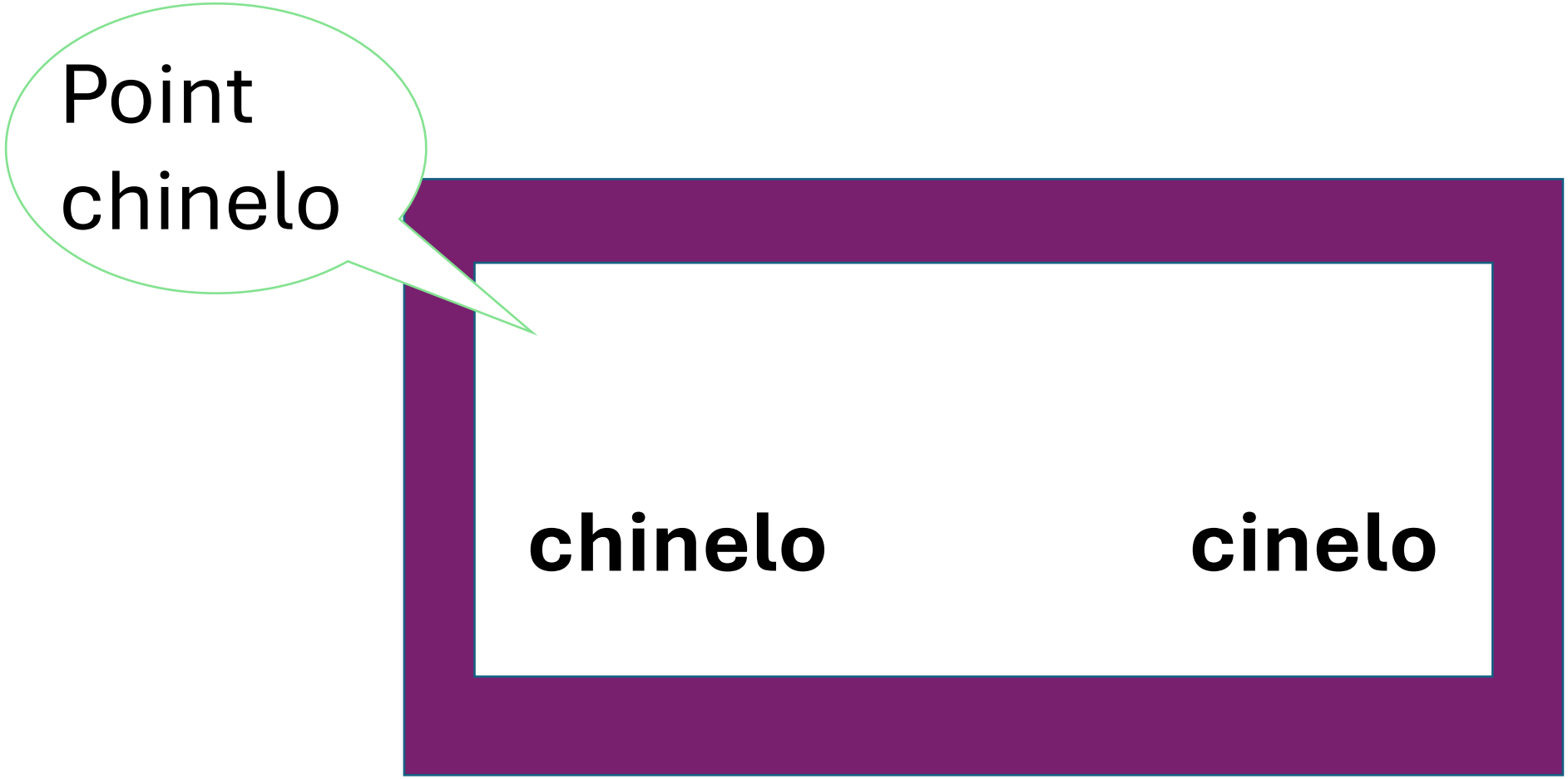
Example: **CH**



Example: **CH**



Example: **CH**



PROBE: TEXTUAL

Which word is this?

Example: **CH** (trained)

PROBE: TEXTUAL

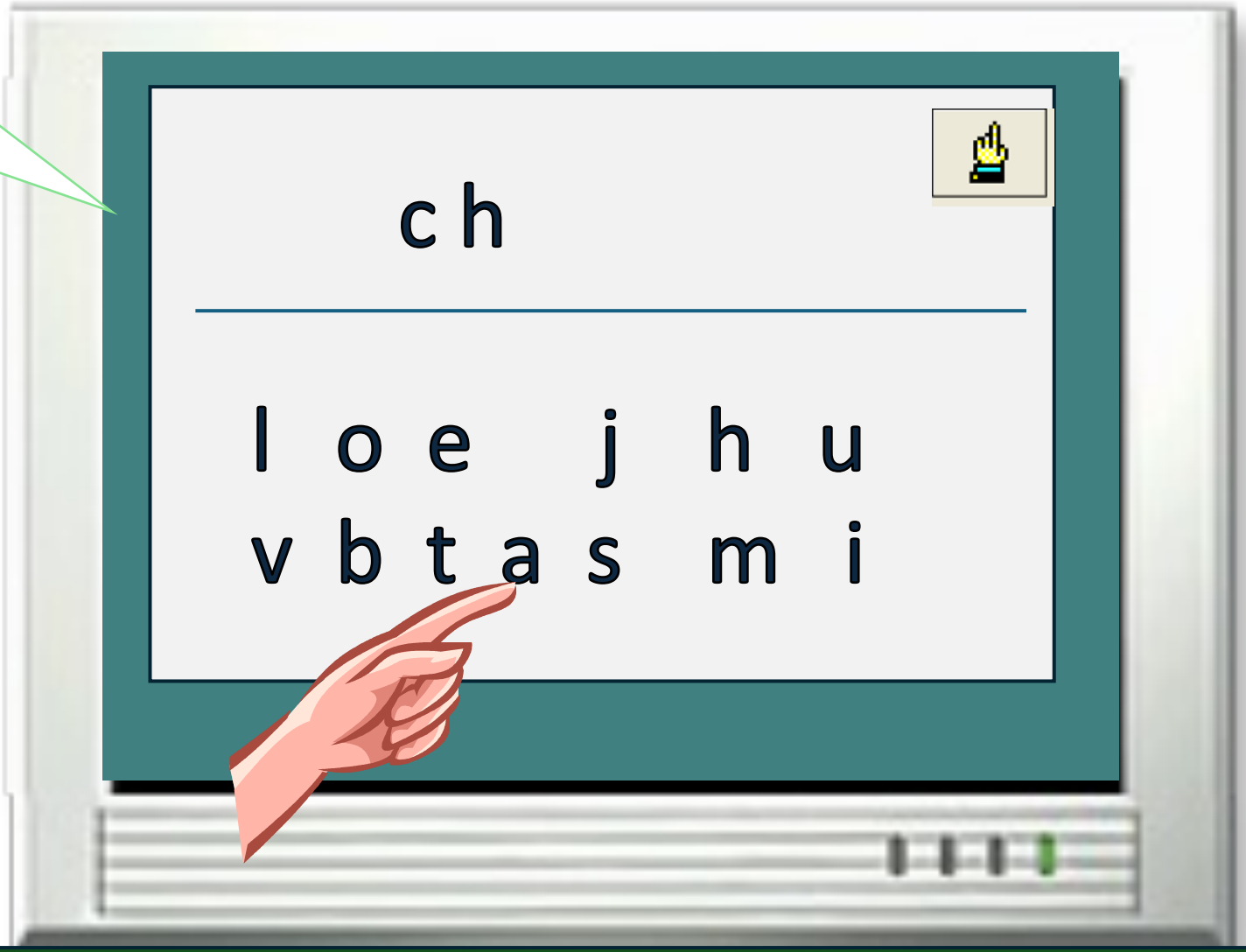
Which word is this?

Example: **CH** (novel)

PROBE: DICTATION TACKING

Example: **CH** (trained)

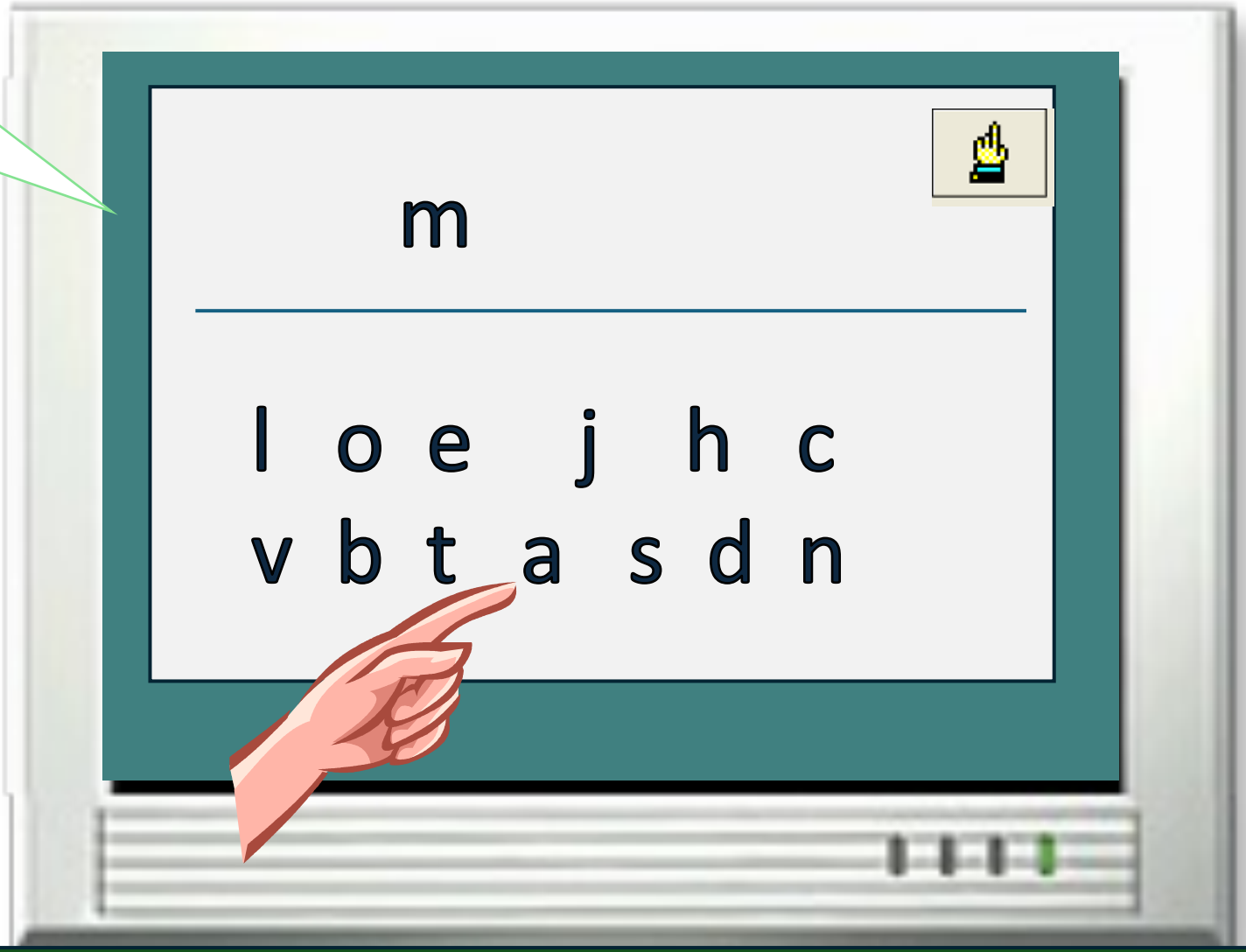
Write CHAVE



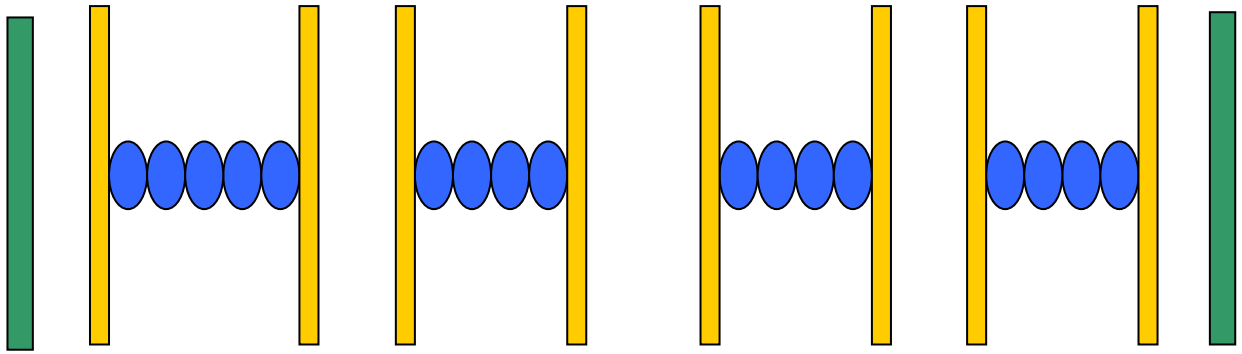
PROBE: DICTATION TACKING

Example: **CH** (novel)

Write
MACHADO



Schematic representation of the sequence of lessons and assessments of Module 1



Blue: Teaching lessons)

Yellow: Pre-and Post-tests of teaching UNITS (training and novel words)

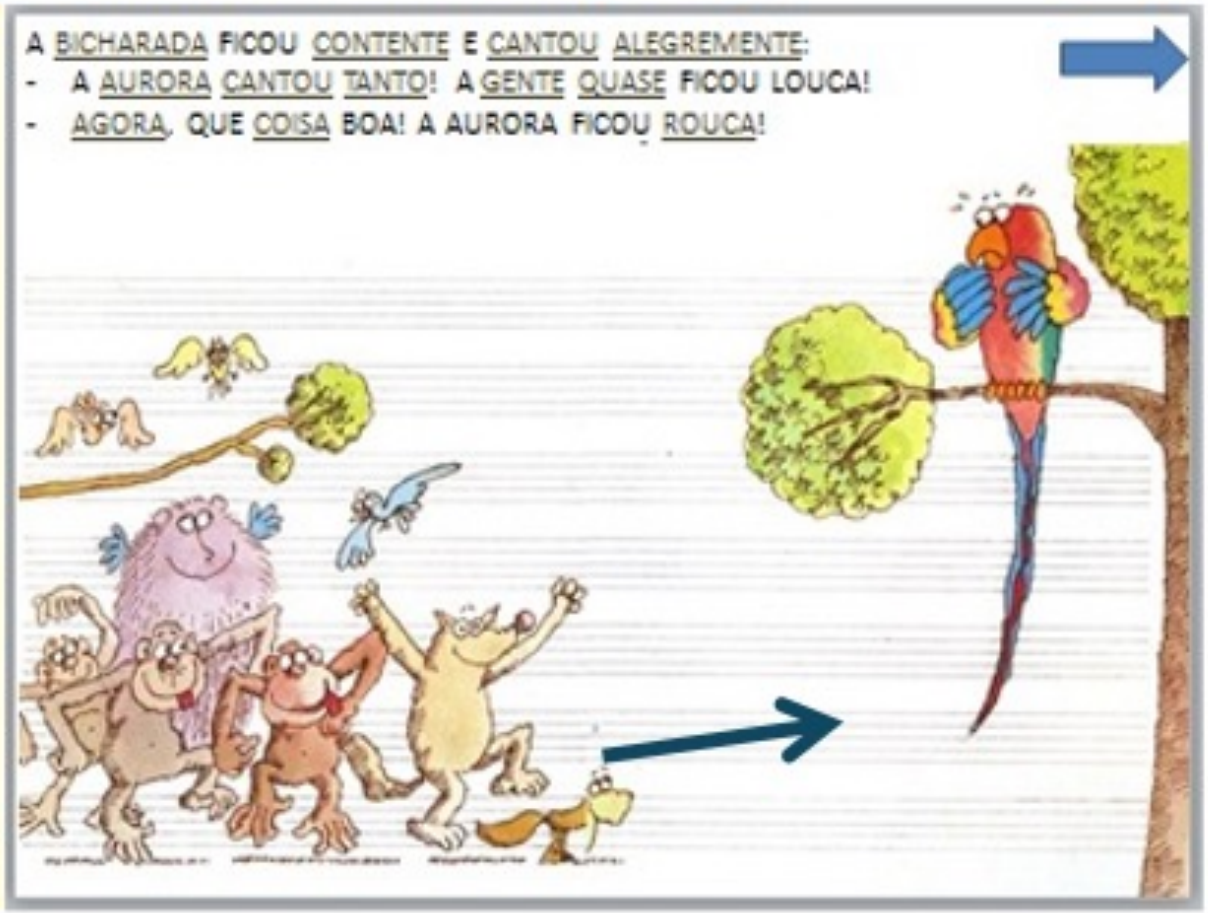
Green: Module's pre and post-tests

Criterion to proceed from one lesson/unit to another and to complete the module: 100% accuracy

MODULE 3
History books
Reading comprehension

Cover Page

Story Page



Question Page
What's the book title?

(a)	A Árvore Cantora
(b)	A Arara Cantora
(c)	A Aranha Cantora
(d)	A Ave Cantora

Question Page
How the animals felt when...

Como a bicharada se sentiu quando Aurora ficou rouca?

Help Page

A arara cantora

Aurora é uma arara.

Ela mora na floresta.

Aurora vive contente. Ela voa no meio das árvores.

Brinca no meio das flores. Come frutinhos gostosos.

E Aurora vive cantando: - Arara! Arara! Arara!

Um dia, Aurora resolveu: Vou ser cantora!

Question Page
What's the book title?

(a)	A Árvore Cantora
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Brinca no meio das flores. Come frutinhos gostosos.
E Aurora vive cantando: - Arara! Arara! Arara!
Um dia, Aurora resolveu: Vou ser cantora!

Incorrect response

(Try again)

Tente outra resposta

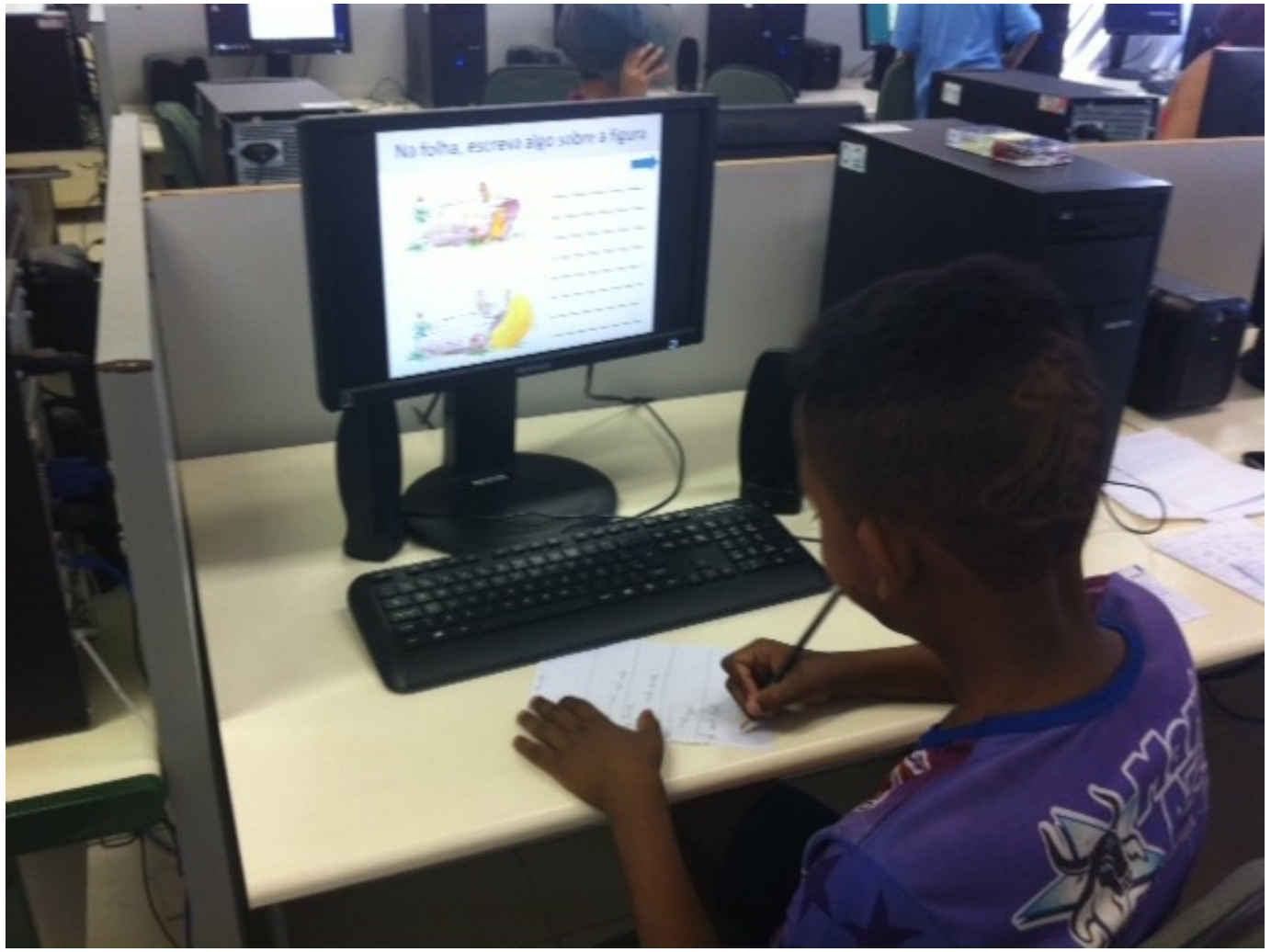
Correct response

Great!)

Isso!

Write about the picture

Na folha, escreva algo sobre a figura



After completing reading a book → Writing at least one sentence....

The curriculum incorporates procedures to encourage:

- (a) Learning arbitrary relations between spoken words, printed words and pictures
- (b) Including those types of stimuli in equivalence classes

  (S-S relations).
- (c) The stimulus control of vocal and written responses by the classes

  (network of stimulus equivalence → meaning and complexity)
- (c) The abstractions of auditory and textual units

  (recombinative responding – generalized reading and writing: the precise control of responses, when the units are recombined in novel words)

- **Examples of results**

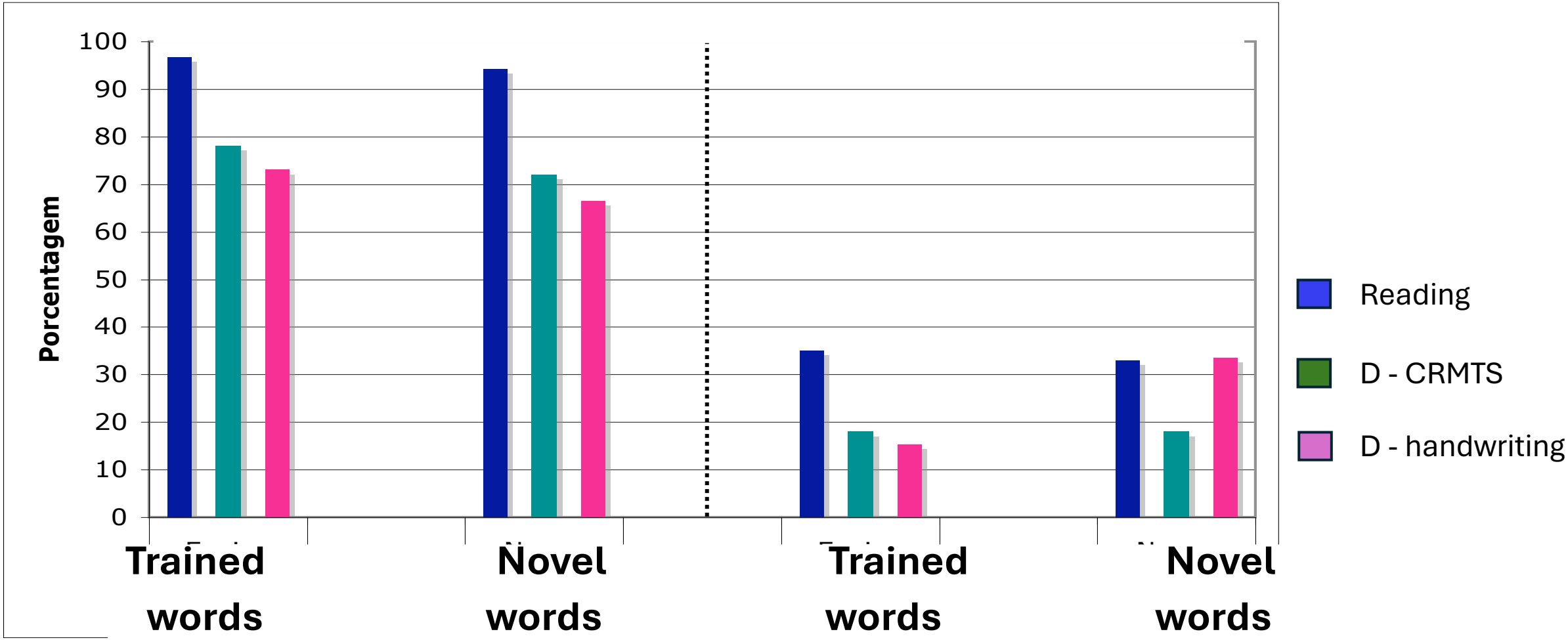
- **Module 1**

EMERGENT OPERANTS

	READING (Textual)	WRITING (Dictation-taking)
Taught words:	**98,2%**	**90,2%**
Novel words:	**90,4%**	**83, 3%**

Module 1 - Post-test results (Pre-test: < 13,3%)

EXPERIMENTAL N=38 CONTROL N=26



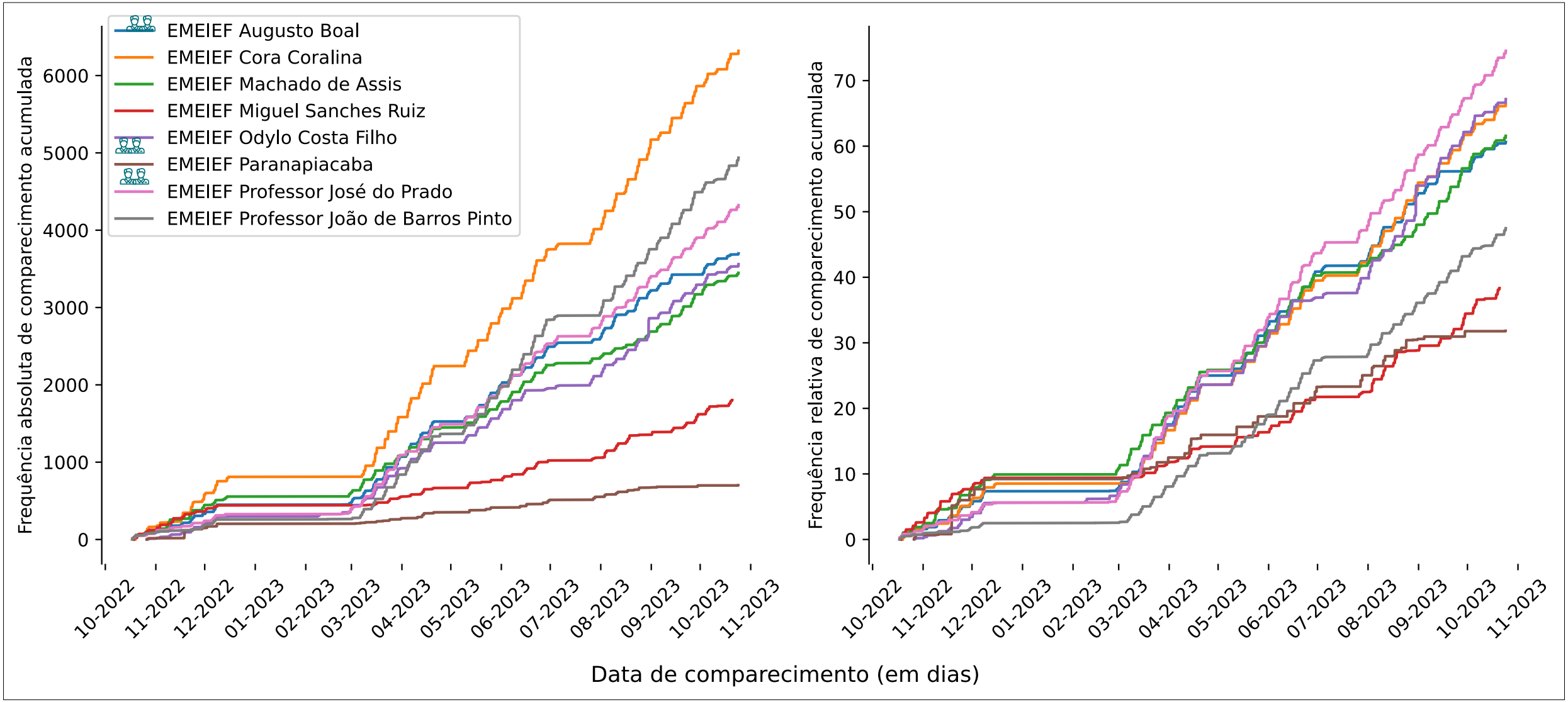
Reis, de Souza, & de Rose, 2009

- **Examples of results**

EMERGENT OPERANTS

	READING (Textual)	**WRITING** (Dictation-taking)
MODULE 1		
Taught words (N=51):	98,2%	90,2%
Novel words (N=42):	90,4%	83,3%
MODULE 2		
Taught words (N=40):	97,5%	87,5%
Novel words (N= 40):	90,0%	80,0%

APLICATION IN SCHOOL SETTINGS
Cumulative frequency of attendance



กรุณาทำซ้ำ

براه مہربانی دوباره

Prosím, opakujte

Lūdzu, atkārtojiet

Bitte wiederholen Sie

Ripetere per favore

Por favor, repita

REPEAT, PLEASE

Text: Stimulus ?

A continuum

No function... → Discriminative (textual) ...→ Simbol (equivalence

Ongoing applications

- **Children:**
  - Regular schools
  - Intelectual deficits (teachers; parents)
  - Auditory deficits (CI or AASI)
  - High functioning TEA

- **Illiteraty adults**


Time Enactus: Projeto Alfatech
COMEÇO


apit
e f q d
m l
x u c o

















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FUNDING: CNPq #564686/2014-1
CAPES #8887.136407/2017-00
FAPESP #2014/50909-8

Thanks!

ddgs@ufscar.br