

# Seeing hands, seeing objects, seeing words


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EMCO - EMbodied COgnition lab


ROSSI

www.rossiproject.eu

**Philadelphia, October 1, 2009**

# OUTLINE

Simulation
while observing objects and hands:
- Hand primes and objects (grip)

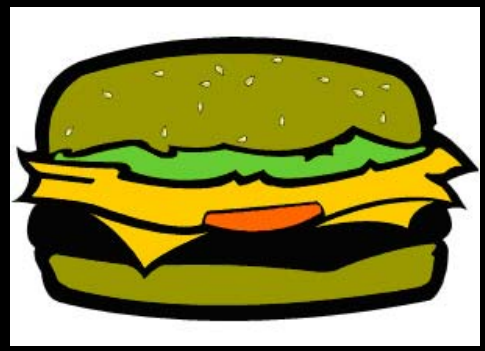
Simulation
during language comprehension while observing objects:
- Object grip and orientation
- Object weight

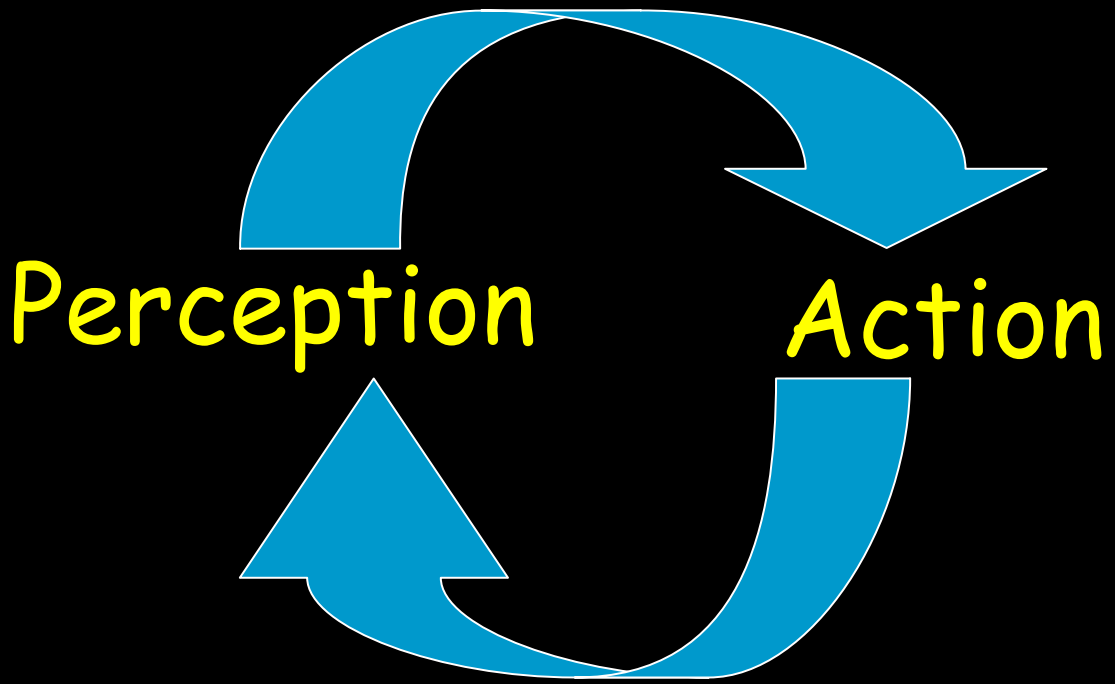
Simulation
during language comprehension:
- Part location
- Action effectors
- Action goals

Flexibility

# FRAMEWORK: EMBODIED AND GROUNDED COGNITION

Action
Cognition
Perception






Traditional view:

- Perception and action peripheral
- Linear relation between perception and action
- Perception independent from the kind of motor response (oculomotor, manual etc.)

# FRAMEWORK: EMBODIED AND GROUNDED COGNITION

- Object concepts are:

  - "Grounded" in sensorimotor processes, not arbitrary (Barsalou, 2008)

  - Multimodal, not amodal (Gallese & Lakoff, 2005)
  - Dynamical: they vary depending on context, goals etc.
- Object concepts as **simulators** (Barsalou, 1999), as patterns of potential actions (Glenberg, 1997).
- Function = activating on-line **simulations** that support interaction with objects, even when there is no specific task-requirement.

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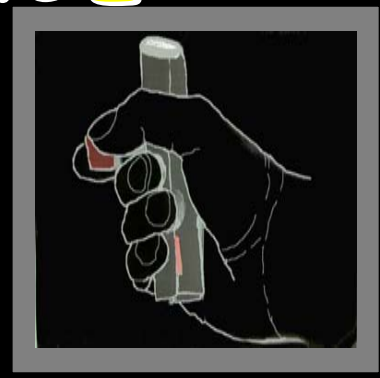
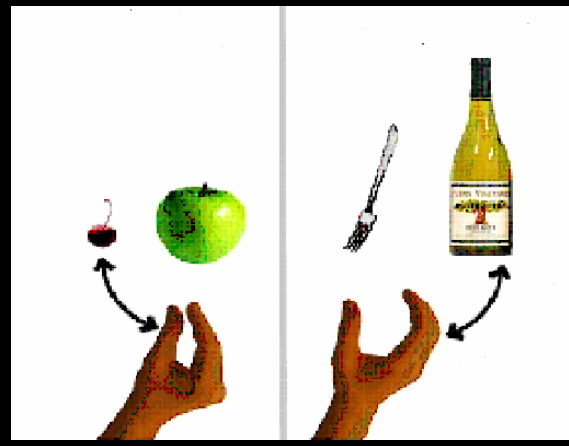
# FROM VISION TO ACTION: BEHAVIORAL EVIDENCE

**tucker & ellis, 2001**



**task:** categorization of objects into natural objects or artifacts. Participants respond mimicking either a precision or a power grip.



**results:** compatibility effects between the object size (not relevant for the task) and the kind of grip used to respond.

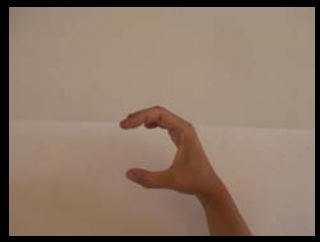
**explanation:** seeing an object activates motor information and potentiates the **affordances** linked to past visuomotor interactions with that object.

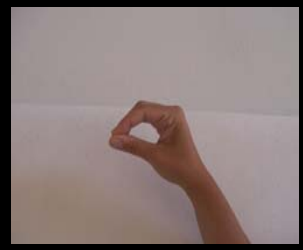
# HAND PRIMES AND OBJECT AFFORDANCES (GRIP)

Prime:
precision vs.
power grip

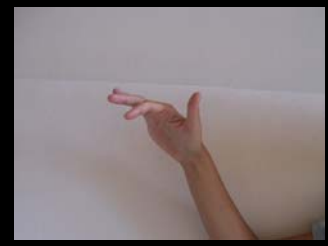
+

Visual prime





catch-trial



No answer

Target objects
graspable with
a precision vs.
a power grip

Categorization task: Artefact or natural object?

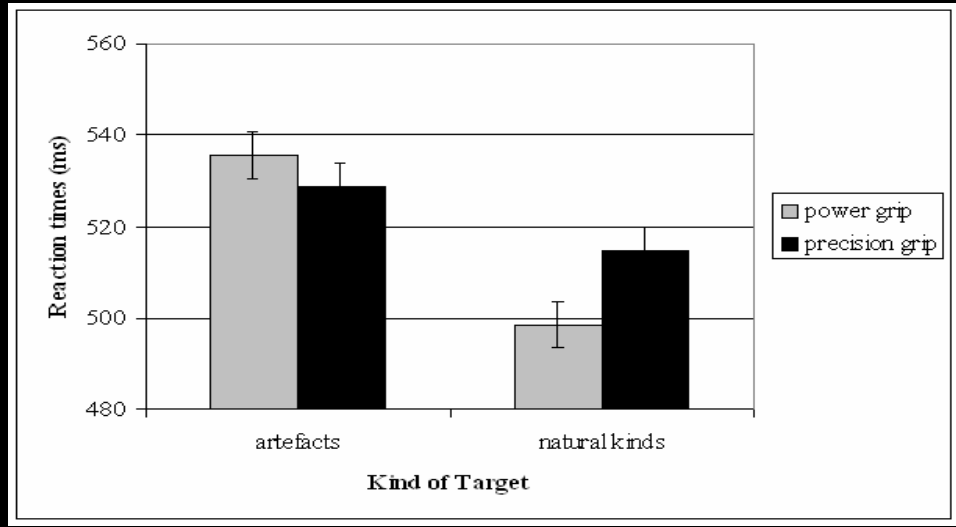
**Borghi, Bonfiglioli, Lugli, Ricciardelli, Rubichi & Nicoletti, 2007**

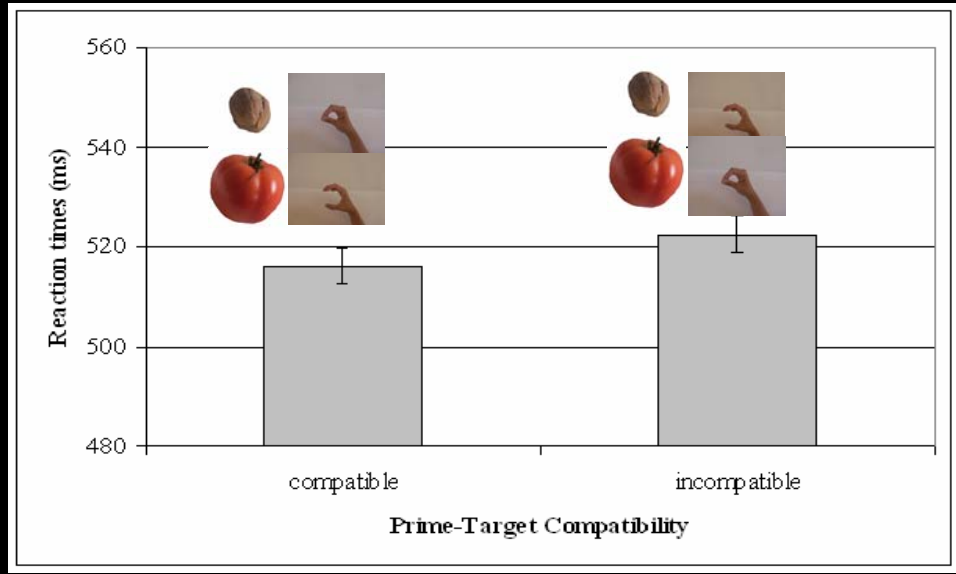
# RESULTS

- Natural objects graspable with a power grip are faster than all other objects. Manipulability vs. function? (e.g., Boronat et al., 2005; Buxbaum & Saffran, 2002; Buxbaum et al., 2000)

- Prime-target compatibity effect, but only if the experiment was preceded by a motor preparation phase

  Explanation: motor training can have led participants to match their own actions with the actions they saw, thus becoming sensitive to the different motor programs triggered by the two primes (Hommel et al., 2001)

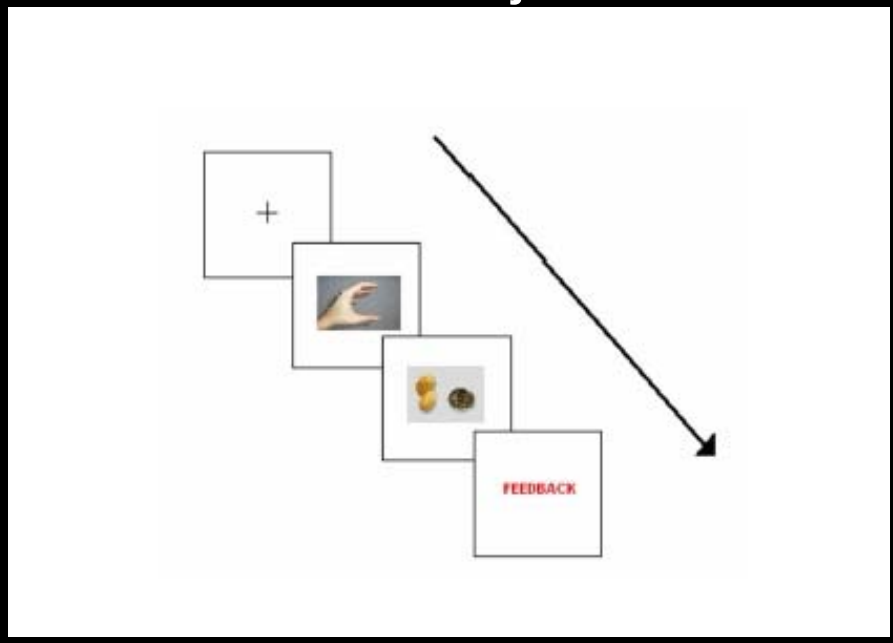


# EXPERIMENT: DIRECT AND SEMANTIC ROUTE

Which is the role played by online, visual information, and by information stored in memory, in categorization?

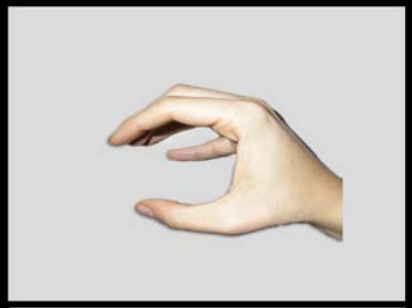
Categorization task, i.e. task implying access to semantic information: artifact-natural object.

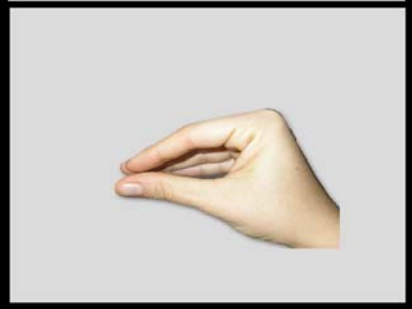



Bazzarin, Borghi, Tessari & Nicoletti, Proc. CogSCI, 2007;

Borghi, Bazzarin,Tessari & Nicoletti, in prep.

# MATERIALS

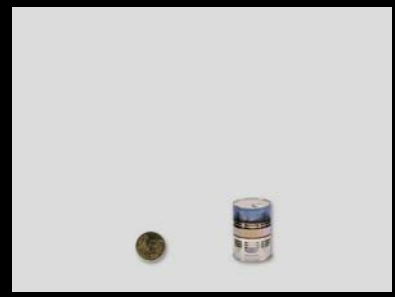


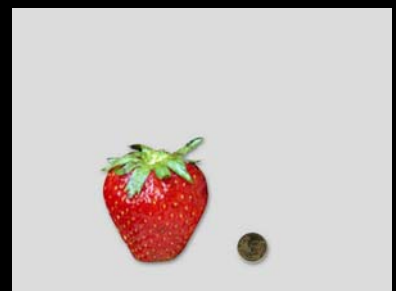


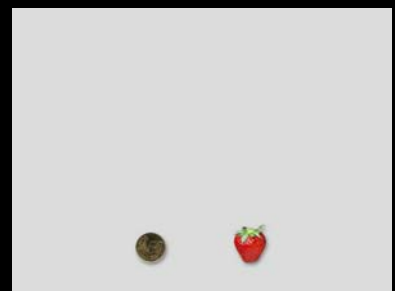
Catch-trial:
do not
respond

Task: Artefact or natural object?

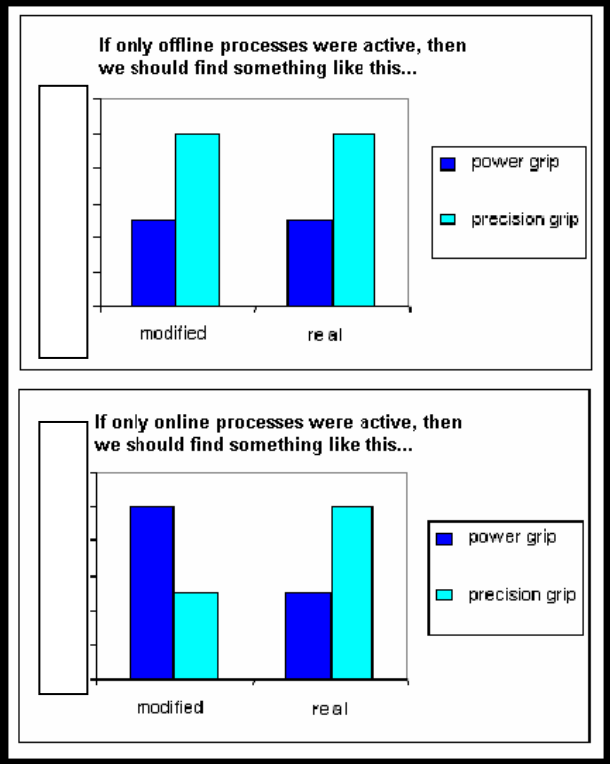
- Hand posture: power vs. precision prime
- Object kind: artefact vs. natural object
- Object grip: precision vs. power grip
- Object size: real vs. modified size

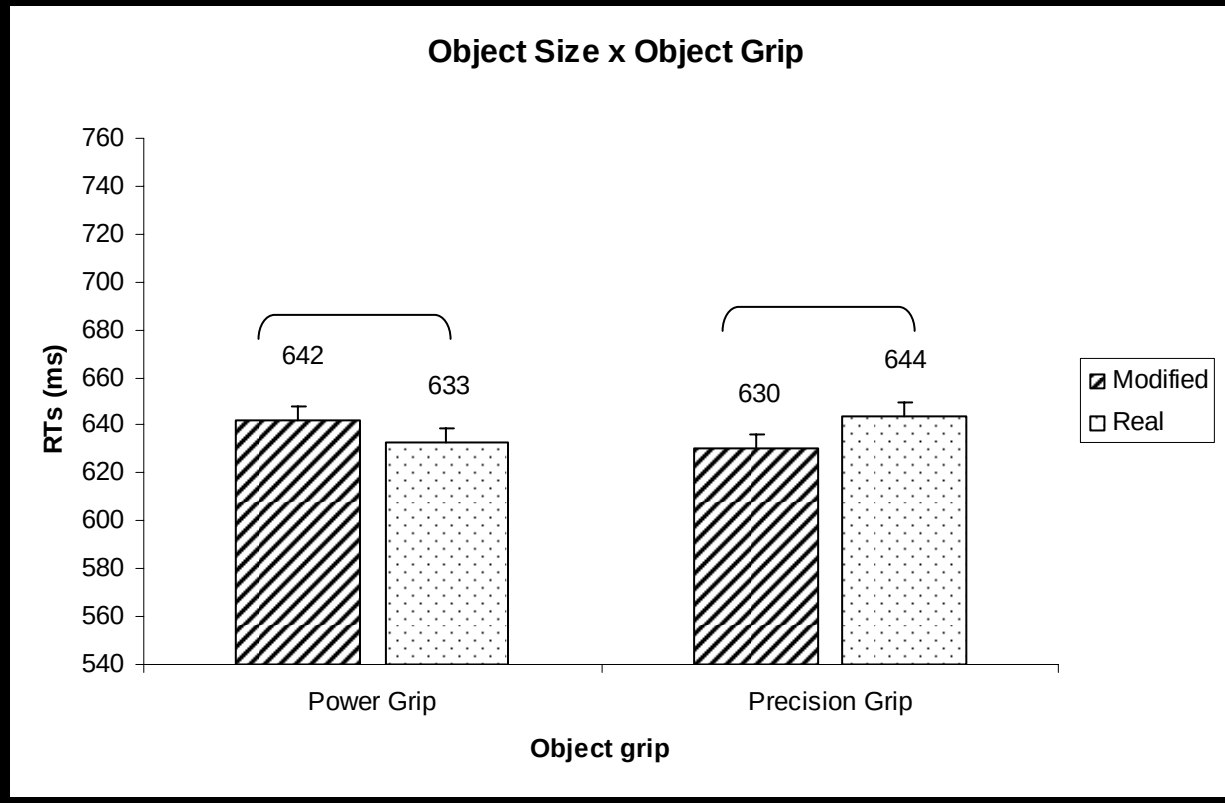






# RESULTS




Interaction SIZE (real vs. modified) X GRIP (power vs. precision): e.g. large cherries faster than small cherries, small apples slower than large apples

influence of online visual information on object size, not on information in memory

# DISCUSSION

The results reveal a strong influence of visual on-line information (thus of the dorsal system) in categorization.

Striking because

- ∞ It was found with a task (categorization) that necessarily involves the semantic system
- ∞ It concerns a dimension (size) that was not relevant to the task

**BUT FURTHER EVIDENCE IS NEEDED.**

POSSIBLE IMPLICATIONS

- ❍ Distinction between dorsal and ventral route too dichotomous? (Derbyshire, Ellis & Tucker, 2006; Gallese et al., 1999; Young, 2006)

- ❍ Differences between dorsal-dorsal and dorsal-ventral routes? (Gentilucci, 2003, Rizzolatti & Matelli, 2003)

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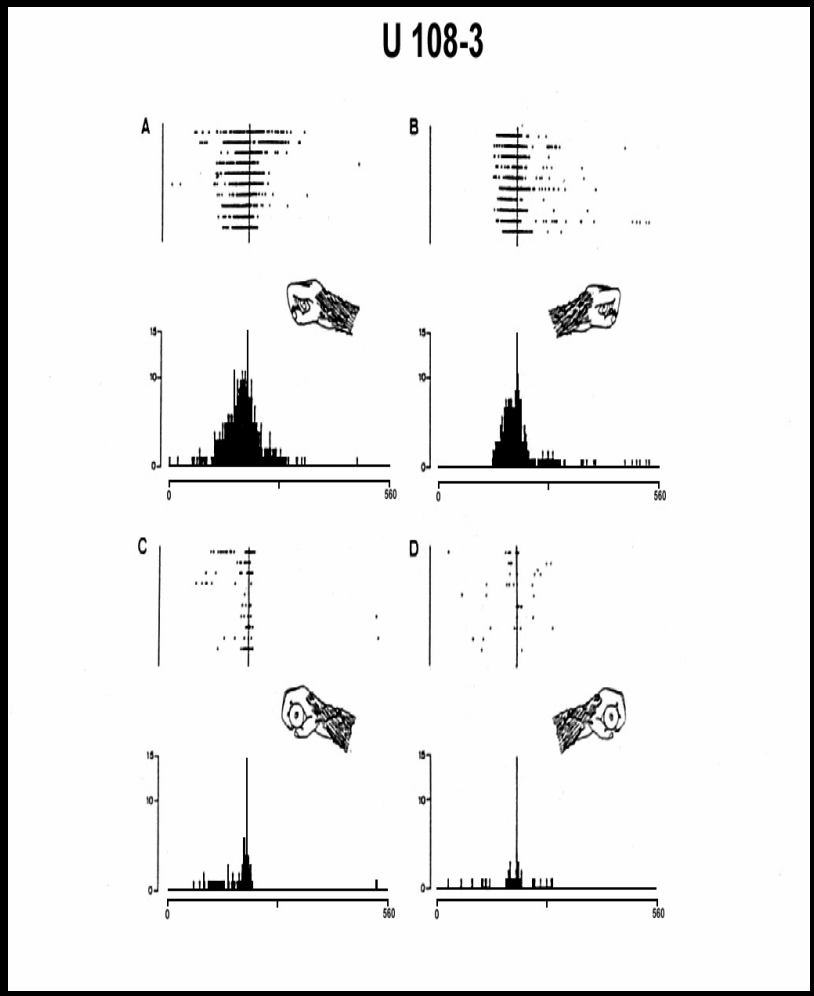
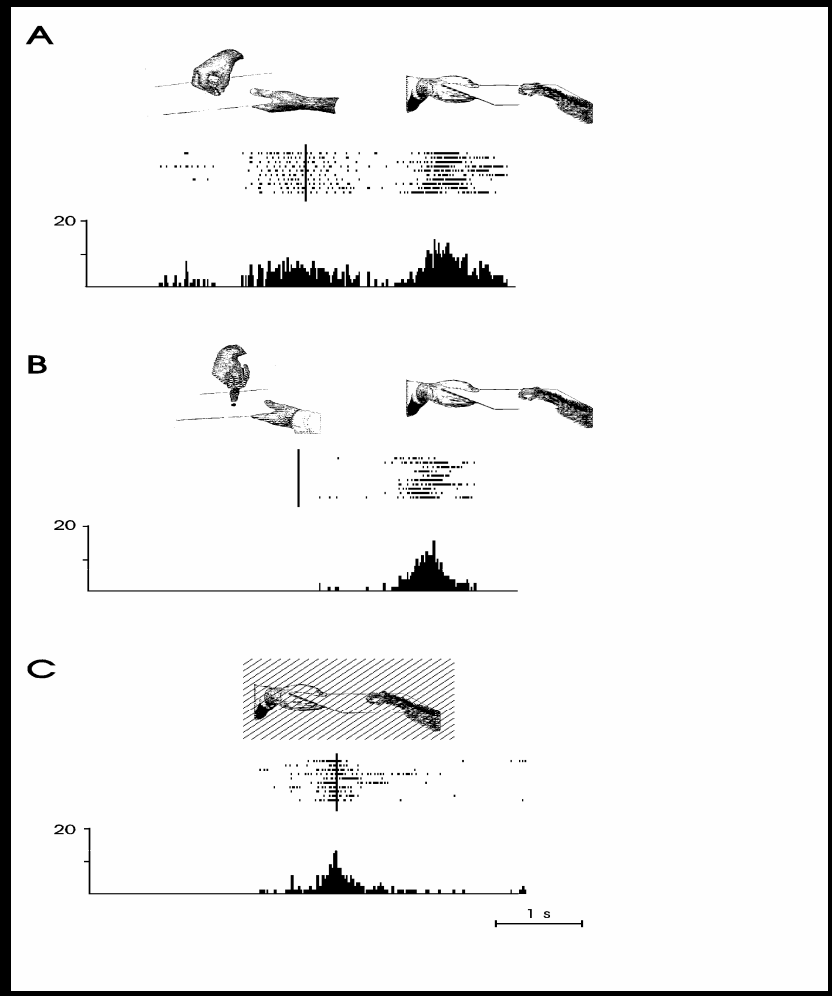
# EMBODIED THEORY OF LANGUAGE COMPREHENSION

- if visual objects activate affordances, also the words that refer to objects should evoke affordances.
- understanding a sentence regarding an action with an object would entail a mental **simulation** of the situation the sentence describes.
- during language comprehension activation of the **same perception, action and emotion systems** recruited during **perception** and **interaction** with objects (barsalou, 1999; 2008; barsalou, simmons, barbey, & wilson, 2003; fischer & zwaan, 2008; gallese & lakoff, 2005; glenberg, 1997; glenberg & robertson, 2000; pecher & zwaan, 2005; pulvermüller, 2005; zwaan, 2004).

# NEURAL BASIS: CANONICAL AND MIRROR NEURONS




Affordances - nouns




verbs

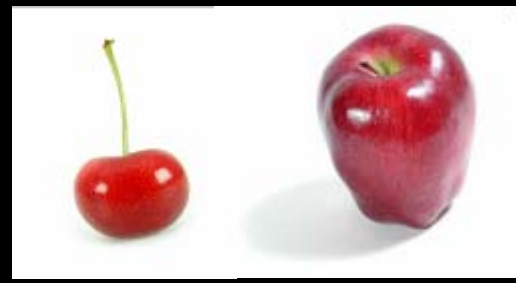
# EMBODIED THEORY OF LANGUAGE COMPREHENSION

Evidence obtained with:

- response times
- kinematics measures
- eye tracking
- brain imaging

# SENTENCES AND OBJECTS AFFORDANCES

affordances can be:



- "stable" / permanent – they are based on long term visuomotor associations, i.e. on information in memory. Emerge from rather stable / invariant properties of objects. e.g., size

- "temporary"/variable – they are based on visual online information. e.g. current object orientation: extrinsic property, depending on both the observer and the observation conditions (graf et al., 2004)

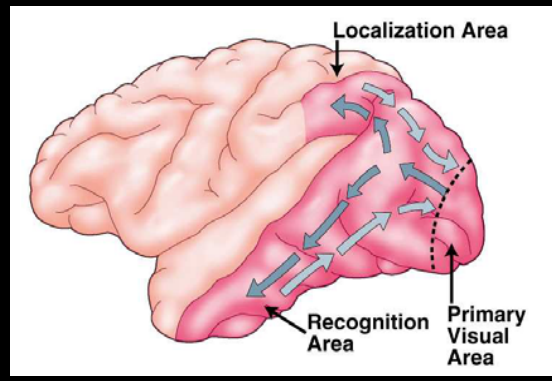
- not dichotomy: e.g., canonical orientation

# SENTENCES AND OBJECT AFFORDANCES

- can different kinds of affordances be subserved by different neural pathways (online vs. offline)?

**Unconscious?**

**HOW**




**Conscious?**

**WHAT**

**zwaan, stanfield, & yaxley (2002).**

task: sentence, then picture – decide whether the object in the picture is the same as the one mentioned in the sentence.


materials:
*sentences*: e.g. “the ranger saw the eagle in the sky / in its nest”
*pictures*: e.g., bird with the wings stretched out / drawn in.

results: advantage in the congruent condition.

# MATERIALS

- action sentences (grasp the brush) vs. observation sentences (look at the brush) (kind of sentence). **Point** is a catchtrial: partecipants have to refrain from responding

- followed by everyday objects with canonical affordances presented either in the upper or lower object part (affordances: up-low), presented either in the upper or lower visual field (visual field: upper-lower)

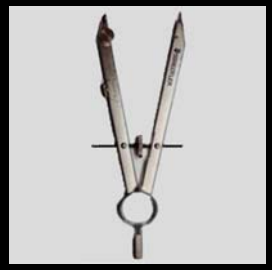
- graspable either with a precision / power grip (grip)

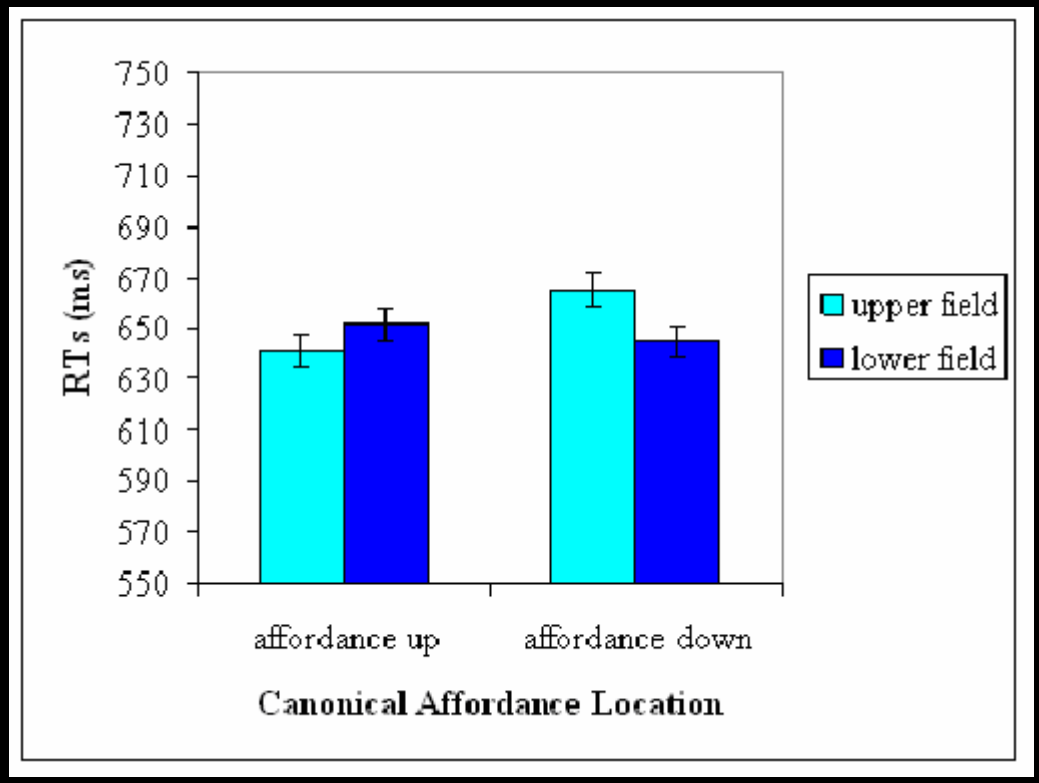
task; Is the object in the picture the same as the object mentioned in the sentence?

# RESULTS: MAIN EFFECTS

- **action** sentences faster than observation sentences
- objects graspable with a **power grip** faster than those graspable with a precision grip

# RESULTS



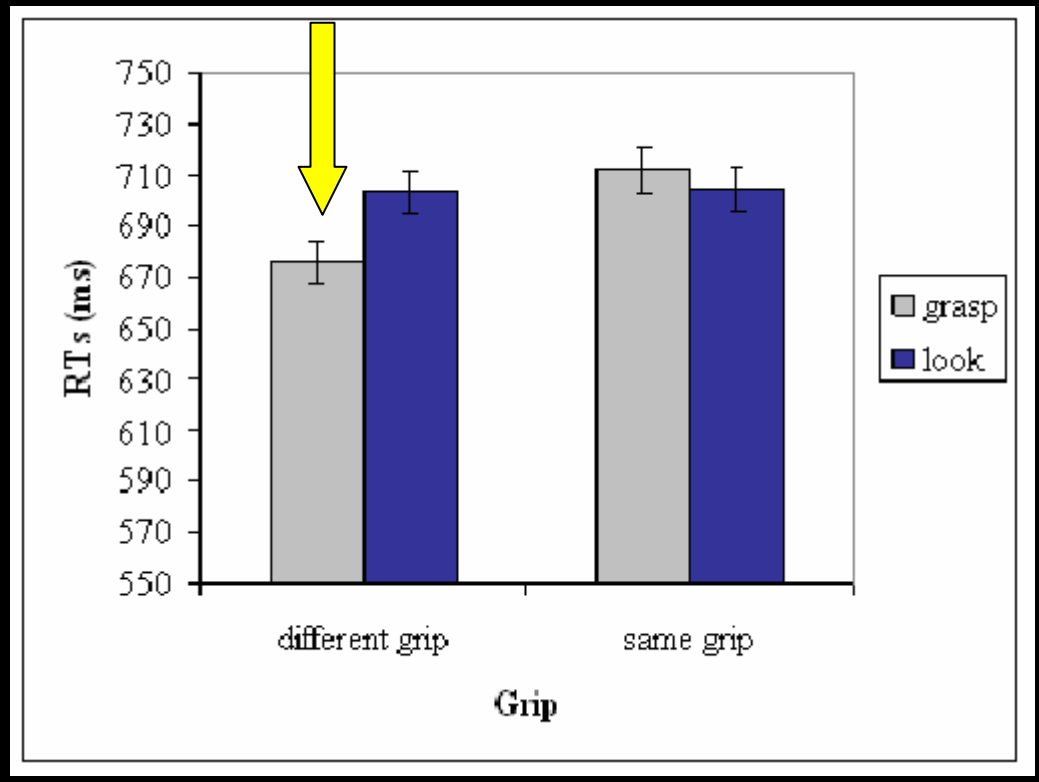



RTs were faster in case of correspondence between the canonical affordance location (up, down), and the field in which it was presented (upper, lower).

# RESULTS: FALSE ITEMS

Factors:

- o Sentence (action – observation),
- o Grip (same – different),
- o Orientation (upright – reversed)




- the advantage of the **action** sentences over the observation sentences was limited to objects graspable with a **different grip.**

- with action sentences RTs were slower with objects graspable with the same grip than with objects graspable with a different grip

# DISCUSSION 1

simulation theory:

- explains the faster responses with action than with observation. This does not mean that no simulation occurs with observation sentences, but:
  - the task is a manual one and the action verb is related to hand action, probably determining a priming effect for the hand / convergent evidence: Warren, Bub & Masson (2008).
- different neural circuits are probably activated by the 2 verbs: only canonical neurons with the observation sentences / mirror + canonical neurons with the action sentences.

# DISCUSSION 2

- possibility: comprehending sentences leads to the activation of a MOTOR PROTOTYPE including stable affordances, (size), and the "canonical" aspects of temporary affordances, such as the canonical object orientation. Longer RTs when mismatch visual stimuli – motor prototype:
  - **upright** objects faster than reversed objects (canonical affordance)
  - objects graspable with a **power grip** faster than objects graspable with a **precision grip (stable affordance)**.

**This does not mean there is no variability or contextual dependency! It only suggests that the most frequent ways to act with an object are accessed first.**

# DISCUSSION 2

- there could be different kinds of affordances subserved by different neural pathways (Young, 2006).
  - temporary > dorso-dorsal route (online),
  - stable and canonical > dorso-ventral route (offline)? (Rizzolatti & Matelli, 2003)

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Flexibility

# SIMULATION, WORDS and WEIGHT

- participants listened to sentences referring to the lifting of light or heavy objects (e.g., pillow or chest, respectively).
- then they lifted one of two boxes that were visually Identical, but one was light and the other heavy.
- focus on the kinematics of the initial lift (rather than reaching) which is mostly shaped by proprioceptive features derived from weight that cannot be visually determined.
- **Results:** Participants were slower when the weight suggested by the sentence and the weight of the box corresponded.

**Scorolli, Borghi & Glenberg, *Exp. Brain Res.*, 2009**

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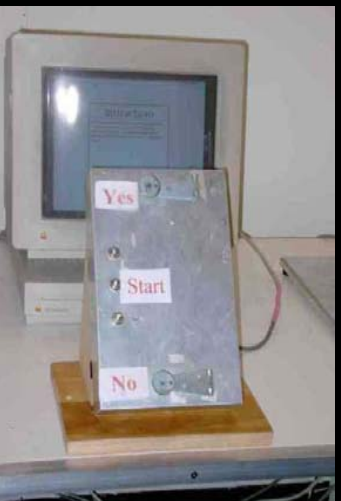
# SIMULATION, WORDS and OBJECT PART LOCATION

participants saw sentences describing objects

E.g.: *There is a doll standing on the table in front of you*

followed by nouns

**task:** decide whether the noun refers to a part of the object. move to yes or no button to respond.




**Response direction** **Yes-is-Up** or **Yes-is-down**

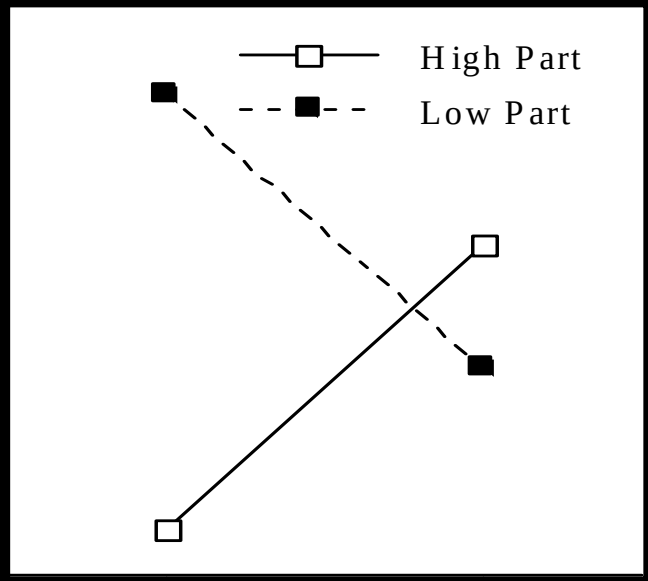
**Part location** Upper vs. lower parts

*hair – ankle YES – kindergarten – baby NO*

Borghi, Glenberg & Kaschak, *Memory & Cognition*, 2004

# SIMULATION, WORDS and OBJECT PART LOCATION

Interaction Part Location – Response direction: not predicted by models based on word associations in a semantic network (e.g., Latent Semantic Analysis, Landauer & Dumais, 1997).




Not only real stimuli or pictures but also **words** referring to objects activate motor information.

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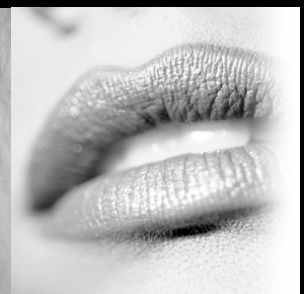
# SIMULATION and EFFECTORS

are actions encoded in terms of GOALS (v. Hommel, 2001)

or also (and to what extent) in proximal terms (e.g., which EFFECTOR do we use) ?



# SIMULATION and EFFECTORS

"Kick the ball"

"Throw the ball"

Buccino, Riggio et al., 2005

Aziz-Zadeh & Damasio, 2008

Hauk, Johnsrude & Pulvermüller, 2004

many others….

# SIMULATION and EFFECTORS

**task:** decide whether noun-verb combinations made sense or not. responses by using a microphone or a pedal. 'hand sentences' used as a baseline.

**material:** verbs that referred to 'hand actions' and 'mouth actions: (e.g., to unwrap the sweet – to suck the sweet) - verbs that referred to 'hand actions' and 'foot actions': (e.g., to kick the ball – to throw the ball)

**results: modulation of the motor system** in case of congruency between the effectors involved in the motor response and in the sentence.

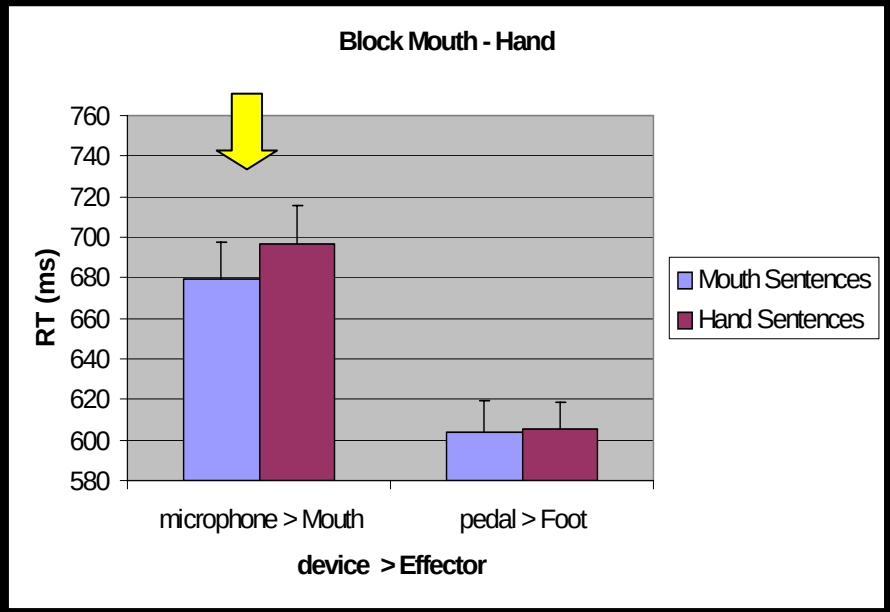
**Scorolli & Borghi, *Brain Research*, 2007**

# SIMULATION, WORDS and EFFECTORS

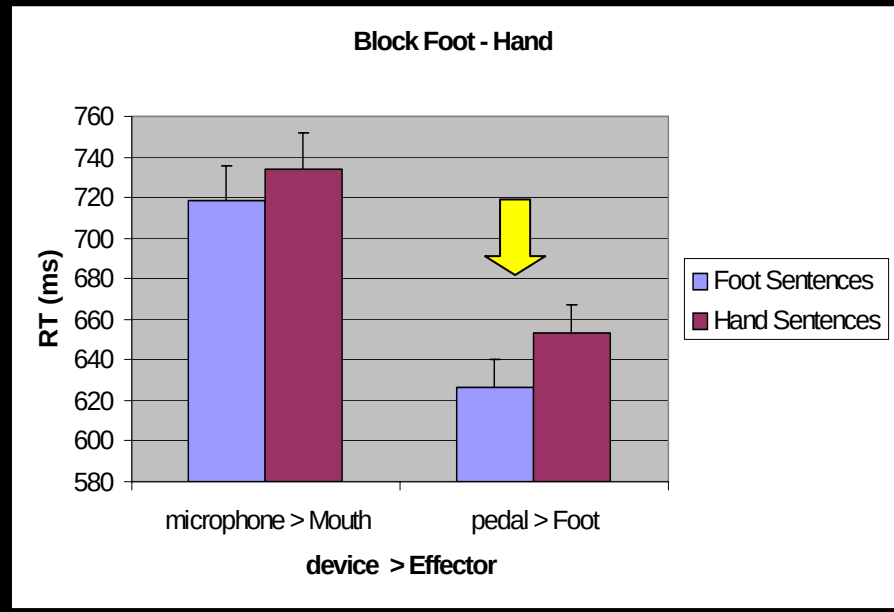
**RESULTS:** 'mouth sentences' were processed faster than 'hand sentences' when participants were responding with the microphone rather than with the pedal.

The same facilitation effect was obtained with 'foot sentences' compared to 'hand sentences' when participants were responding with the pedal rather than with the microphone.

*unwrap the sweet*
*suck the sweet*




*throw the ball*
*kick the ball*



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# SIMULATION, WORDS, EFFECTORS and GOALS

**task:** decide whether noun-verb combinations made sense or not. responses by pressing a key with the right or left hand.

**stimuli:** Hand, foot and mouth sentences.

**results:**

- advantage of the right hand with sensible hand sentences, not with not sensible sentences: simulation

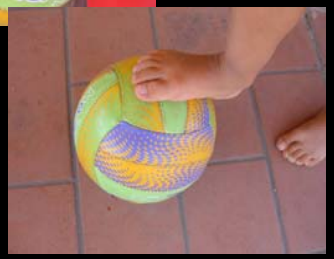
- same pattern of data with hand and mouth sentences: common goal? (e.g., unwrap, suck the sweet)

- different pattern of data with foot sentences: different goal

**Borghi & Scorolli, *Human Movement Science*, 2009**

# SIMULATION, WORDS, EFFECTORS and GOALS

- simulation sensitive to:
  - the involved effector: difference between foot and mouth sentences
  - the goal expressed by the sentence: advantage of the right hand with hand and mouth actions: common goal?



# SIMULATION, WORD VALENCE and GOALS

**Literature on approach / avoidance compatibility effects**

**Chen and Bargh (1999):** participants responded to the word's emotive valence (positive vs. negative) by pulling or pushing a lever towards or away from their body.

**Results:** RTs were quicker when participants had to pull something near to their body for positive words and to push something away for negative words.

Others: e.g., van Dantzig, Pecher & Zwaan, 2008

# SIMULATION, WORD VALENCE and GOALS

**task:** classify words as positive or negative.

focus not on the arm but on the hand posture. 2 conditions: open hand vs. hand holding a tennis ball.

**results:** with the empty, open hand, faster RTs when withdrawing negative objects from the body and approaching/reaching positive objects far from the body. When holding a tennis ball replication of Chen and Bargh's results.

| PosNear | PosFar |
|---|---|
| NegFar | NegNear |
| **953** | **836** |

| PosNear | PosFar |
|---|---|
| NegFar | NegNear |
| **872** | **949** |

**Freina, Baroni, Borghi & Nicoletti, *Memory and Cognition*, 2009**

# SIMULATION, WORD VALENCE and GOALS

Simulation sensitive also to the **specific posture of the hand** (clench-closed hand vs. palm-open hand; see Klatzky et al., 1987; Klatzky et al., 1989).

But relevance of the hand posture only **if it influences the** more general action goal, and induces the participant to assign a different meaning to the whole movement (Bekkering et al., 2000; Hommel, Müsseler, Aschersleben & Prinz, 2001)

Hand open: far positive (reach), near negative
Hand holding something: near positive, far negative

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Simulation
Flexibility

# SIMULATION and FLEXIBILITY

Not only **seeing an object** but also processing **words** referring to manipulable objects activates the motor system. Support for the embodied view.

But: concept / words are not simply blueprints that tell us how to act

- Evidence
  - Studies showing that object concepts are represented as potential action patterns but are **flexible** and vary depending on the simulated situation
  - Studies suggesting that objects are differently represented depending on the adopted **perspective**

# CATEGORIZATION AND PERSPECTIVE

Have you ever been <u>inside</u> a _____? (yes/no)

VS

Have you ever been <u>outside</u> a _____? (yes/no)

- a watch
- a nail
- a skyscraper (list properties*)
- a needle
- a train
- a car (list properties*)
- a library
- a hammer
- a lamp
- a jail (list properties*)
- a page

* "What characteristics are typically true of a _____?"

7 critical items

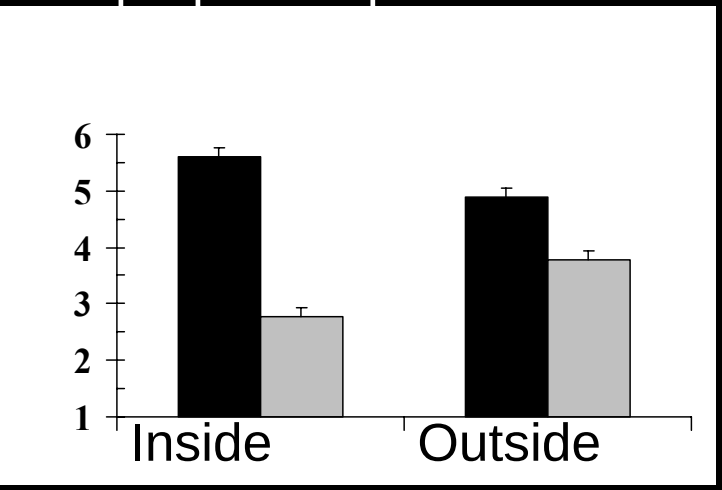
14 fillers

Borghi & Barsalou, in prep.

# RESULTS

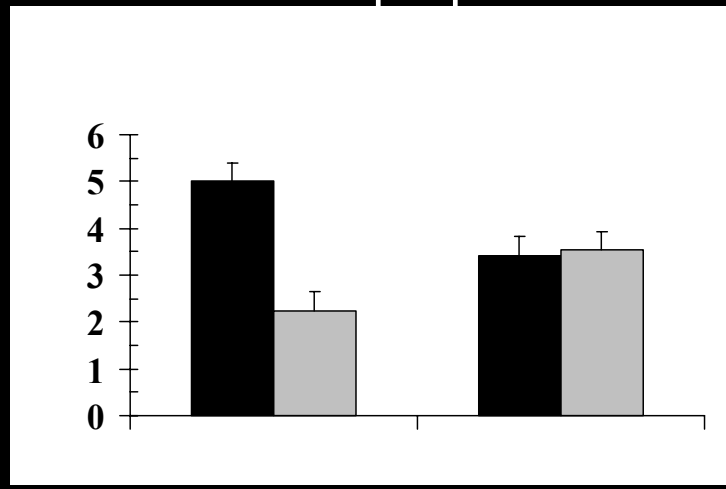
■ Inside ■ Outside

Average rating of properties produced




Rated perspective

Average frequency of dominant properties




Dominant examples
Inside: *SKYSCRAPER–elevator*
Outside: *SKYSCRAPER–antenna*

- an inside perspective
  - relevant for situated action
- a situational effect (i.e., task x rating interactions)
  - the outside situation moderates the inside bias

# CATEGORIZATION and PERSPECTIVE

| Experiment | Entrenched Effect | Situational Effect |
|---|---|---|
| 1 | Towards | no |
| 2 | Near | no |
| 3 | Beside | yes |
| 4 | Inside | yes |
| 5 | Vision, Action | yes |

conclusions

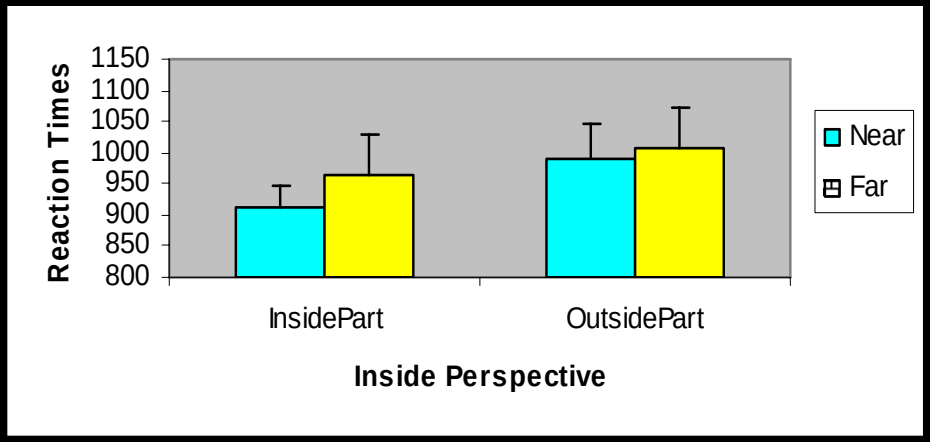
1. entrenched effects reflect an orientation to situated action
2. situational effects reflect ease of reverting to default perspectives
   - easy: back-to-front, far-to-near
   - difficult: above-to-beside, outside-to-inside, dark-to-light

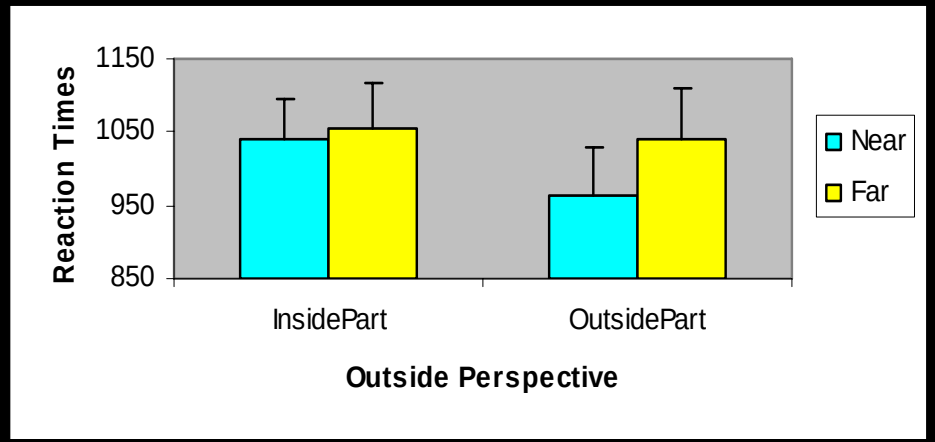
# SIMULATION, WORDS and PERSPECTIVE

Task: reading sentences – part verification

Variables: **Internal vs. External Actions, Internal vs. External Parts, Near vs. Far Parts**

IA - You are driving a car – IPN - horn, IPF - back seat
EA - You are painting a car – EPN - trunk, EPF - exhaust pipe




Borghi, Glenberg & Kaschak, Memory & Cognition, 2004

# SIMULATION, WORDS, AFFORDANCES and PERSPECTIVE

**Task:** part verification(Is the XXX part of the object mentioned in the sentence?)

**Materials**:

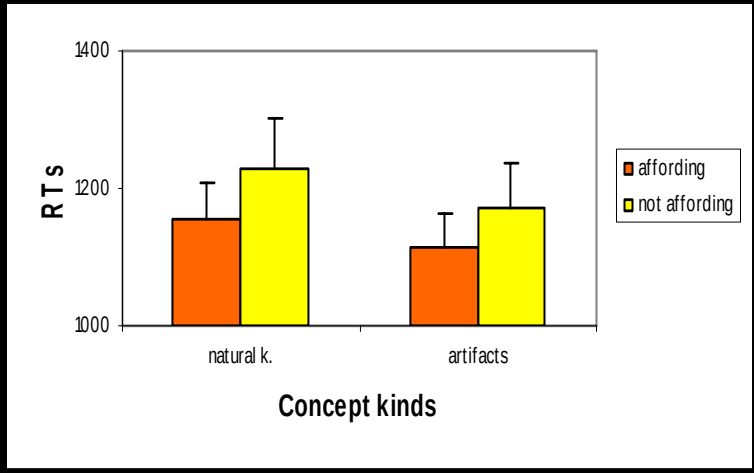
Sentences with **afforded** / ***not afforded parts***:

*The woman* **shares** *the orange-***slice** */* ***pulp***

*The boy* **extracts** *the book-***cover** */* ***page***

**Natural object**

**Artifact**




**Results:** depending on the simulated action different parts are activated: affordances

(Words controlled for lenght, familiarity, association degree)

Borghi, Acta psychologica, 2004

# CONCLUSION

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# OPEN ISSUES

- Affordances: Difference between stable and variable affordances (dorso-ventral vs. dorso-dorsal systems) = way to deal with the issue of automaticity? Stable affordances accessed first? (Motor prototype?)

- Words: blueprints that tell us how to act?

Sensitivity to means (effectors, hand postures), but also (and mainly) to goals

Flexibility, but also default perspectives: those which are relevant for situated action

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# Thanks

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