Semantics

Weighting: 2/17

Dehaene, S., Naccache, L., H, G. L. C., Koechlin, E., Mueller, M., Dehaene-Lambertz, G., … Le Bihan, D. (1998). Imaging unconscious semantic priming. *Nature*, *395*(8 October), 597–600.

# Agenda

* What is knowledge/semantics?
* The article: Imaging unconscious semantic priming
* Motivation and hypothesis
* Method
* Results
* Authors’ conclusion
* Criticism
* Grand perspective™

## Semantics

**semantic memory**

Declarative memory that refers to general knowledge about the world, including knowledge of language, facts, and the properties of objects. Compare *episodic memory*.

**semantic priming**

A form of indirect priming in which the prime and the target are semantically related. Compare *conceptual priming*.

# The article: Imaging unconscious semantic priming

This article is overall about:

* Priming effects: activation of cognitive processing by masked primes that do not reach consciousness
* Semantic understanding: subconscious semantic processing
* Subconscious processes

### Hypothesis

“Here we use a combination of behavioural and brain-imaging techniques to estimate the depth of processing of masked numerical primes.” (p. 597)

Masked primes can initiate a measurable but unconscious processing of prime stimuli – both semantically and motorically

### Method

#### Preexperiment: Determining duration of the prime (table 1)

Task 1 (n = 6):

* Shown trails with and without primes (in variating durations), asked to discriminate between them

Task 2 (n = 7):

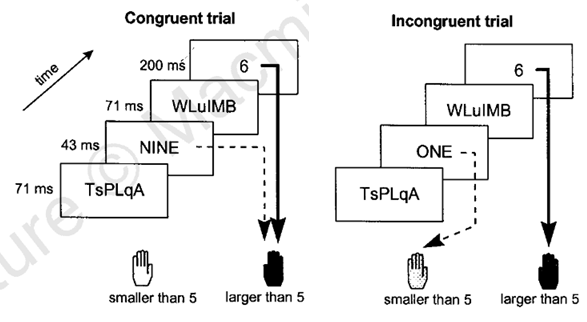
* Shown numerical and letter string primes, asked to discriminate between them

#### Pre-experiment results

* 43 ms were chosen as the masked prime interval, since this is the highest exposure duration which couldn’t be significantly discriminated (discrimination of stimuli is significant at 57 ms)
* “At the prime duration used in the main experiments (43 ms), subjects consistently reported not seeing the numerical primes (task 1), did not respond differently to prime-absent and prime-present trials (task 1) and were unable to discriminate numerical primes from letter strings (task 2).”

#### Main experiment

*N* = 12, training sessions before each trail



**Counterbalancing within-subjects** between which hand is used to indicate answers smaller or higher than 5

**Congruent trials**: prime and probe same side of 5

**Incongruent trials:** prime and probe on opposite sides of 5

Researchers investigate how prime and target congruency affect RT, ERP and fMRI

## Results: main experiment

*N* = 12, 2x256 ERP trails

##### Figure 2: Response times in congruent vs incongruent trails

* All 12 subjects showed a positive priming effect, ranging from 2-43ms (avg. 24 ms)
* **Prime-target congruity effect:** incongruent responses are slower (24 ms) -> **response competition**
* **2B**: Response time distribution was shifted by ~24 ms in incongruent trials compared with congruent trials.
* Effect is seen regardless of prime notation (letters/Arabic)
* **Authors conclude that primes are processed to a semantically meaningful level**

##### Figure 3: Lateralized readiness potential (LRP)

ERP results

* **3A**: Shows prime-target congruity effect: incongruent responses are 24ms slower
* **3B Upper:**
  + Synchronized according to keypress to suppress effect of response delay
  + Shows lateralized readiness potential (LRP); indexing of activation in motor networks in both left and right side
  + Positive voltage deflections indicate response preparation, negative deflections indicate inhibition of a particular response
    - -> Unconscious processing of prime-stimuli
  + In both hemispheres we see an early covert motor-response
  + Activity in C3 (controls right hand) when response is given with left hand can “only” be due to incongruent primes. It is therefore earlier than activity in C3 when response is given with right hand (half of these responses have been “delayed” because of incongruent prime)
  + Conversely, activity in C4 (controls left hand) on right responses can “only” be due to incongruent primes (therefore it is earlier than C4 activity on left hand responses)
  + C3, **bold** line is incongruent (early activity due to prime)
  + C4, slim line is incongruent (early activity due to prime)
* **3B Lower: to make sense of this, think of it as activity for just left or right hand**
  + **Congruent vs incongruent:** Deflections before “response hump” shows the covert motor activity due to the prime. It can be seen that the prime (the shaded part) either initiates or inhibits the overt motor response.

##### Figure 4: ERP scalp topography for prime and target related potentials

* Red box: priming effect, ERP related to prime, covert motor priming
* Green box: response effect, ERP related to target, overt motor response
* Prime-related activity is smaller and earlier, but similar in topography to target-related activity
* Authors conclude that they are processed similarly, only to a lesser extent (sub-action threshold for primes)
* Difference from 0 is the covert motor priming effect and over motor response effect, respectively

##### Figure 5: Exp. 2: Using fMRI to gain higher spatial resolution and confirm that activity is in motor cortex

*N* = 9, 2x64 fMRI trails

* ERP has lower spatial resolution -> cannot distinguish covert and overt activity -> fMRI
* Reasons that signal change % is equal to sum of overt and covert activity
* Highly significant positive peak in lateralized BOLD response (LBR) following motor response
* LBR smaller in incongruent trials -> only actual response effect *or* priming effect rather than sum of both
* Correct side response activity is smaller on incongruent trials, because prime response is on opposite side: congruent trials show 9% more activity on correct side than incongruent trials
* LBR is similar to LRP (Fig. 3)

## Authors’ conclusions

* Masked primes are processed to a semantic level (ERP results)
* This processing happens not only in sensory areas but also in motor areas (fMRI results)
* As a number of processes can occur without conscious awareness, we can exclude these processing areas in the search for consciousness

## Criticism

* Can the unconscious be operationalized and measured upon? Doubtful, since consciousness is a distributed emergent property. Most likely it is nowhere and everywhere at the same time.

## Grand PerspectiveTM

* Levels of processing (Craik & Lockhart), in the experiment there is no difference whether the prime is in Arabic or verbal, hence the effect must be the due to the semantic meaning
  + Craik & Lockhart: Four levels of processing; Structural, phonemic, categorical, semantic
* Response inhibition/conflict: Stroop, ACC, stop-signal task
* SNARC effect: Spatial-Numerical Association of Response Codes. Numbers are thought of as on a scale going from left to right. Judgments of smaller numbers is faster when using the left hand, and judgments of larger numbers are faster when using the right hand.
* Binocular rivalry: unconscious processing of scary faces produces measurable but unnoticed effect
  + Whalen et al (2005): Scary eyes vs. happy eyes (17ms) masked by neutral face -> Greater signal change in amygdala following fearful eyes
* **Models for organization of knowledge**
  + **Classical theory (defined properties/features)**
    - Each category defined by a set of features which are necessary and sufficient
    - If an object matches enough features, it is deemed a member of the category
    - Objects have all-or-nothing memberships in a category
  + **Prototype theory**
    - Categories are defined by a prototype
    - Each category has a “most central member” to which all objects are compared
    - If an object is sufficiently similar it is deemed part of the category
    - Couch is more central to the “furniture” category than wardrobe
    - Categories are “graded” -> members near the “edge” can be part of several overlapping categories
    - A prototype can be an averaged version of all members of a category
  + **Exemplar theory**
    - Categories are based on all previously experienced objects which fit in them
    - New objects are compared to exemplars in a category and deemed a member if sufficiently similar
    - Some objects in a category are more typical and share more characteristics with other members -> these may be used as exemplars when making quick judgements or recalling the first few items in a category (fruit: apples and bananas mentioned before figs and dragon fruit)
  + **Explanation-based theory**
    - Categorizing is problem solving: people develop explanations for *why* something is in a category
    - Categories are used and created to explain the world
    - Categories are not just lists of properties but relations between them – birds have
    - Very flexible categories
    - Psychological essentialism: a painted horse is not a zebra – category members are believed to share common essence