Unifying Negative Priming Theories

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Outline

1. Negative Priming
2. Negative Priming Theories
3. The General Model
4. Implementation of Theories
Aging Effects in Selective Attention

- Behavioral Experiments
- Theoretical Psychology
- EEG Recordings
- Computational Modeling
- ERP Analysis
- Advanced Averaging
- Single Trial ERPs
- Biology of Aging
Unifying Negative Priming Theories

Aging Effects in Selective Attention

Behavioral Experiments

Theoretical Psychology

EEG Recordings

Computational Modeling

ERP Analysis

EEG Recordings

ERP Single Trial

Advanced Averaging

See Poster #64 by Matthias Ihrke

Biology of Aging
Aging Effects in Selective Attention

Behavioral Experiments

EEG Recordings

ERP Analysis

Advanced Averaging

Theoretical Psychology

Computational Modeling

Single Trial ERPs

Biology of Aging
Introduction

Main Question:

How do we filter out irrelevant information about our environment?

Negative Priming (NP)

- is a way to access mechanisms of selective attention.
- is a slowdown of reaction time when responding to previously irrelevant stimuli.
RTs vary with the order of subsequent stimuli.

NP2 > NP > CO > PP > PP2 in general.
Robustness of the NP effect

Variation of objects
- pictures
- letters
- numbers
- words
- nonsense shapes...

Reaction determination
- key pressure
- voice recording...

Different tasks
- identity priming
- location priming
- lexical decisions
- stroop tasks...
Oddities of Negative Priming

Time Course
- NP even after a month
- paradoxical effects

Presence of Distractors
- no NP if a trial obviously requires no selection
- NP if this is not predictable

Influence of Strategies
- while comparison sig. NP if the perceptual order is fixed
- no NP if both objects in focus
A Few Explanations of Negative Priming

Distractor Inhibition

- distractor representations are actively inhibited
- inhibitory rebound pushes distractors below baseline
- neural rate code model of distributed representations


Adaptive Thresholding

- adaptive threshold for action decision
- forced decay of representation strength while conflict
- phenomenological model of representation activation

A Few Explanations ctd.

Episodic Retrieval

- response generation by direct computation vs. retrieval
- automatic retrieval of former episodes by similarity
- a change in response to similar stimuli causes NP


Dual Mechanisms

- inhibition as well as retrieval processes are present
- direct computation by distractor inhibition
- depending on the paradigm, they contribute more or less

Unifying all Theories

How to concretize the theories for comparison?

Construct and implement a computational model ...
... to quantify, integrate and cross-test negative priming theories.

Main Problems
- Most theories give no quantification
- Many different components are necessary
- Integration of different paradigms
- Cope with inconsistencies between theories
The General Model

Overview
- rate code model
- exponential dynamics
- adaptive thresholds
- no synaptic delay
- feature decomposition
- feature binding
- semantic representation
- decaying memory
- weighted recall
- action decision
Feature Layers

Background
- feature decomposition in the visual pathway
- input only to perceived features
- number and topology of feature layers paradigm specific

Realization
- distinct feature layers, here Color, Shape and Word
- every layer holds one variable for each feature instance
- feature present → input = 1, otherwise input = 0.
Feature Binding

Background
- the brain has to track object entities
- features have to be bound together in a flexible way
- objects are represented by bindings without perception, bindings decay

Realization
- a vector holds indices of feature instance variables
- the binding has a certain maximum synaptic strength
- feature instances balance their activation via bindings
- slow decay of synaptic strength in absence of input

Semantic Layer

Background
- paradigms like object naming and comparison rely on semantic classification
- language evokes semantic representation
- action initiation by comparing semantic activations to a threshold

Realization
- feature layers with semantic matter project to the semantic layer
- words and shapes with the same semantic meaning converge
- a threshold adapting to a global mean divides the representations into sub- and superthreshold for action decision
Unifying Negative Priming Theories
The General Model

Action Layer

Background
- only one action at a time
- possibility to hold action initiation
- concurrence of different actions

Realization
- input by superthreshold semantic representations
- additionally activation for *no response* contributing to threshold
- action initiation by crossing an adaptive threshold
Episodic Memory

Background
- every finished episode is memorized
- the memory decays with time
- similarities between percept and memory trigger a retrieval
- the more similar the percepts, the stronger the retrieval

Realization
- After a reaction, the entire actual state of the model is stored.
- A scalar product of percept and memory determines retrieval.
- Every variable receives the memorized value weighted with the retrieval strength as additional input.
Central Executive

**Background**
- organization of layer interplay has to be adapted to the task
- by a control instance external to the model

**Realization**
- target color (green) is amplified
- paradigm specific binding of (semantic) representations to actions
Simulation

NP Sim: Word–Picture Comparison

Color

Shape

Word

Binding

Semantic

Episode

Action

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The General Model

Simulation
Houghton’n’Tipper

Essence of the theory
The distractor is inhibited. When the input is switched off, persisting inhibition pushes the distractor below baseline. Activation of the former distractor first has to surmount this rebound.

Position in the Model
- feature decomposition
- rate code model
- switch between target amplification and distractor inhibition
- effect of amplification in a specific feature instance
- But no negative activations.

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Implementation of Theories

Imago-Semantic Action Model

Essence of the theory
Decisions about actions are triggered by only one semantic variable being superthreshold. Negative priming is produced by a forced decay of activations if two similar but nonmatching representations clash.

Position in the Model
- adaptive threshold in semantic layer
- the number and identity of superthreshold variables trigger actions
- residual bindings produce a flow of activation from perceived objects to complementary variables

Episodic Retrieval

Essence of the theory

The onset of a new trial triggers a retrieval of the last episode from memory. Conflicts produce a slowdown in reaction time. Recently: Perceptual similarities trigger mainly a retrieval of the prime response.

Position in the Model

- Episodes are memorized.
- Perceptual similarity determines retrieval strength.
- Individual retrieval effects to switch between classical and modern episodic retrieval.

Conclusion

Take Home Message
- We have implemented a general model for selective attention that produces negative priming effects
- The model concretizes NP theories for direct comparison
- The model can be applied to all NP paradigms

Outlook
- To account for all theories still requires a lot of reading
- Determination of theory-specific set-screws
- Inclusion of aging effects
- Application to perception based action selection in robotics
Thanks ...

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... and to You!