Cognition

PSYC 2040

L6: Information Processing

Part 1

logistics: midterm + monthly quiz

practice assessment 1	monthly quiz	review sessions	midterm
• multiple-choice + short answers • available on Canvas • will post answer keys next week	• available from Friday (Feb 23) to Tuesday (Feb 27) midnight • open-book, Canvas • 1 hour time limit	• Monday (Feb 26), 7-9 pm • Thursday (Feb 29), 8-10 pm • Kanbar 200	• March 1 • in-person • Canvas quiz + handwritten short answer • closed-book

recap

- what we covered:
  - precursors to behaviorism
  - flavors of behaviorism (Watson, Tolman, Skinner, Hull)
  - associations and behaviorism today
- your to-dos were:
  - *finish:* L5 quiz + writing assignments
  - *read:* L6 (information processing) chapter

today's agenda

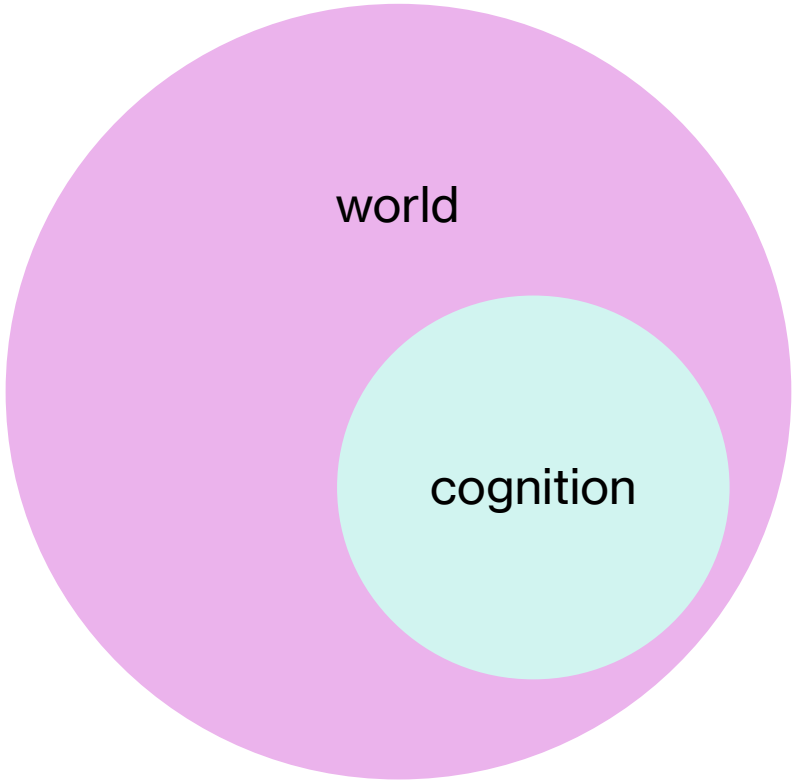
- the four R(evolution)s
- Donders' processing stages
- PRP effect

behaviorism's aftermath

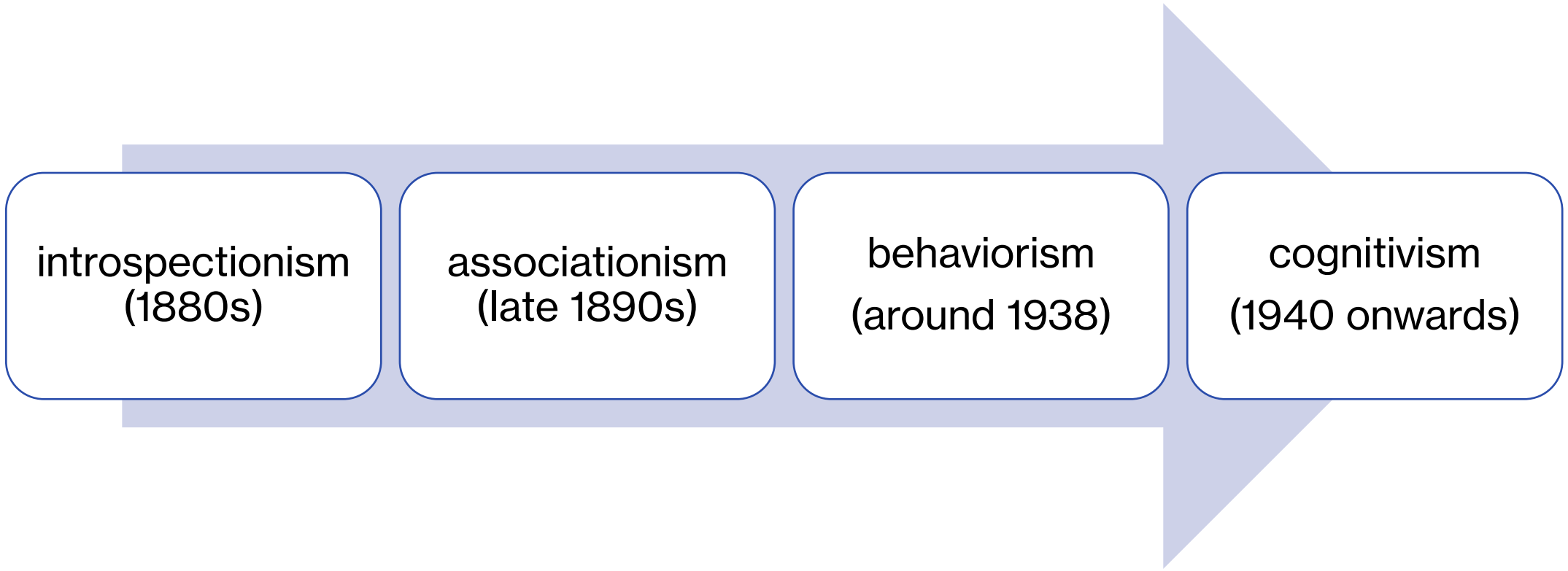
- behaviorism emphasized the relationship between stimulus and response, with the goal of controlling and predicting behavior
- the emphasis was more on how different stimuli directly lead to specific responses and less on the internal processes that bridge that gap
- not all behaviorists thought the same way...Tolman argued that internal drives and representations were critical to understanding behavior
- the "radical" form of behaviorism slowly started to fall out of favor, and more and more scientists began to embrace "cognitive" aspects of behavior

cognition and the four Revolutions

- the study of cognition has a bidirectional relationship with the world and its events
- several important events shaped how we think/thought about cognition
  - industrial revolution
  - technological revolution
  - digital revolution
  - “cognitive” revolution



the timeline so far



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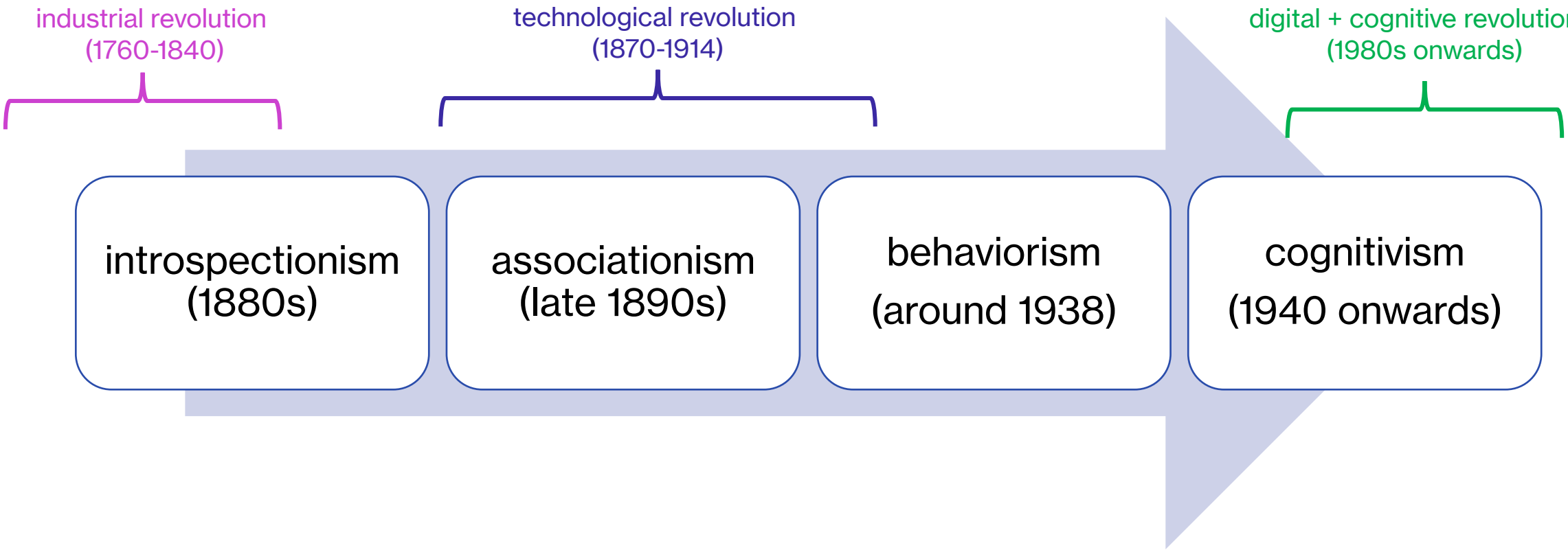
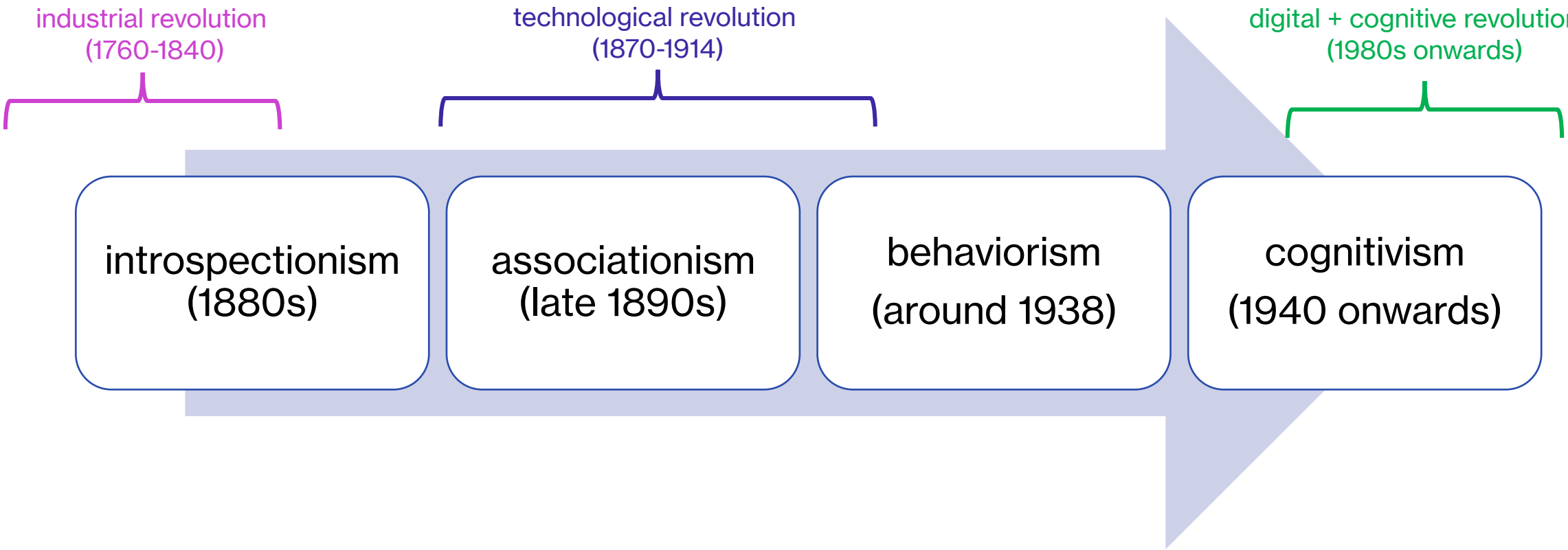


cognition and metaphors

- metaphors have been used as a tool to explain cognition
  - what are some metaphors we've already encountered?
- the revolutions brought along newer metaphors
  - industrial: cognition = assembly line
    - Donder's processing stages
  - technological: cognition = telephone network
    - Shannon's information theory
  - digital: cognition = computer
    - highly prevalent even today
  - broadly: cognition = machine
    - possibly reductive, but also extremely useful

the timeline so far



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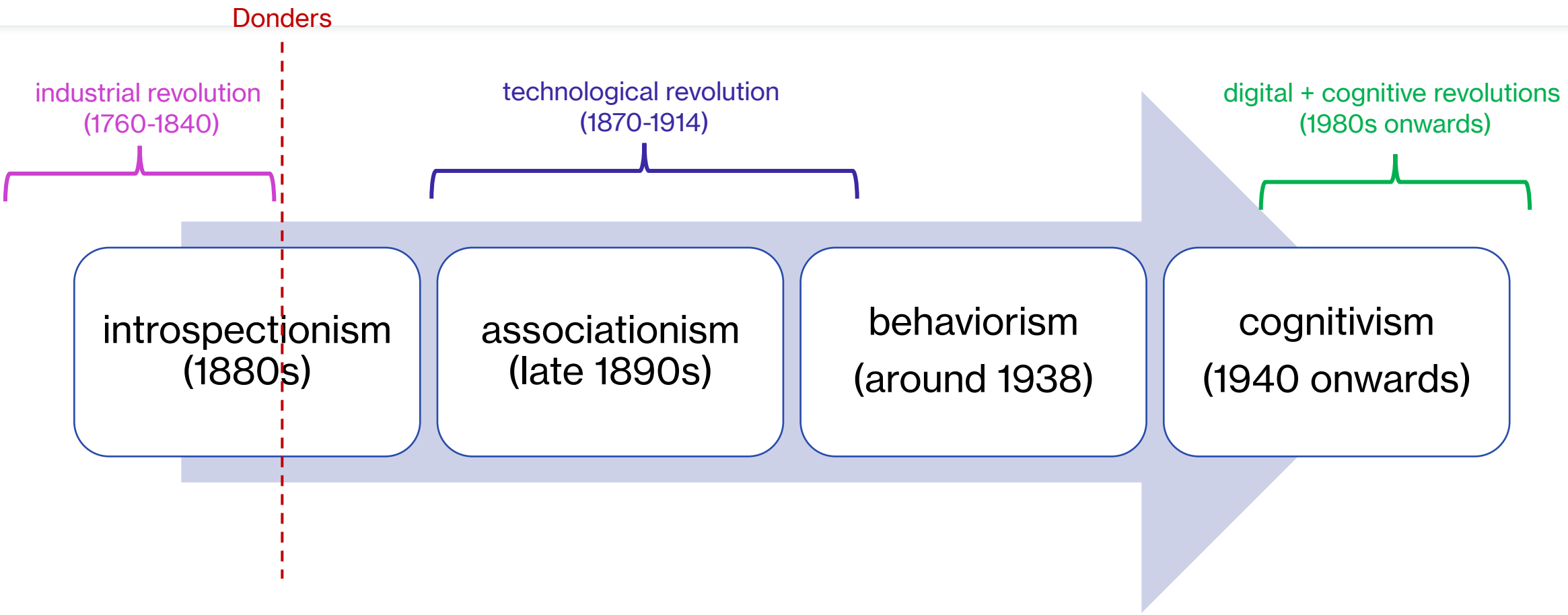
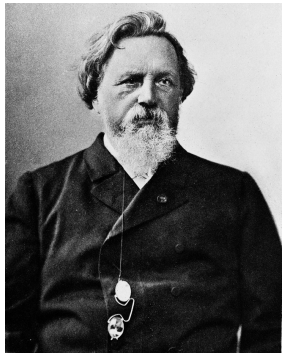


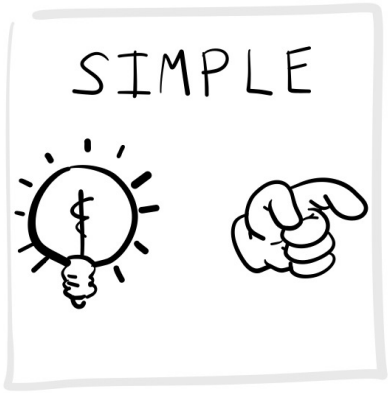
Donders' processing stages

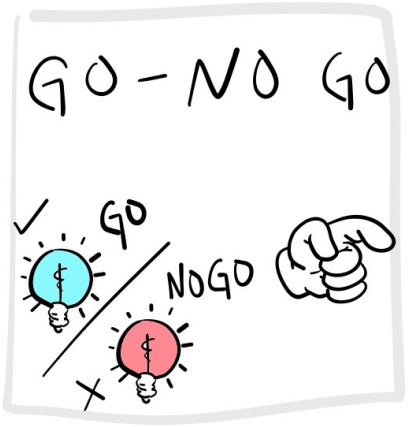


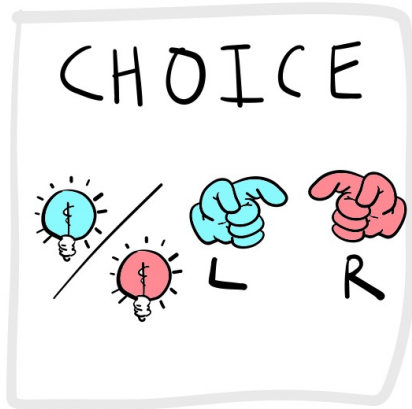
- key idea: there are individual stages of cognitive processing
- Donders attempted to identify these stages and estimate the time to complete each stage
- Donders used mental chronometry for this work:
  - where else have we seen this before?
- he conducted reaction-time experiments with various types of stimuli
- two main questions
  - do different sense organs have different "physiological times"?
  - do more complex tasks require additional "mental time"?

Donders: levels of complexity

- simple reaction time task
  - present stimulus (e.g., light) and record time taken to detect it
- go-no go task
  - present stimulus, ask to respond only for some trials (go) and not others (no go)
  - record time taken to respond on “go”
- alternative forced-choice task (AFC)
  - present many stimuli, respond with specific response (e.g., blue: left, red: right)
  - record time taken to respond





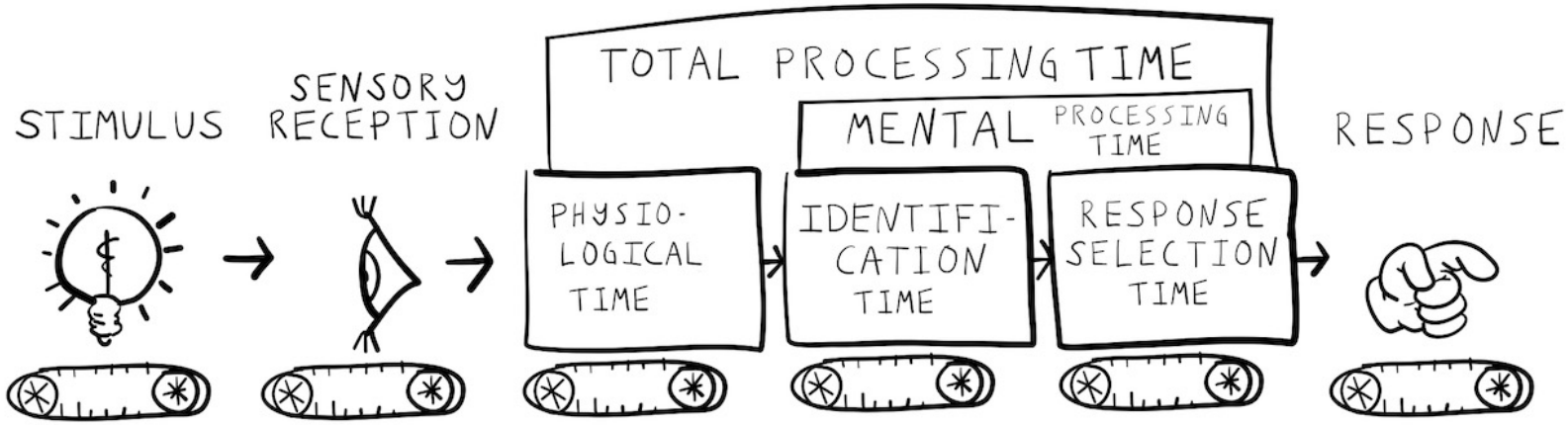


activity: classify the tasks!

- In groups, do the following tasks and classify them as simple reaction-time, go/no-go, or forced alternative choice
  - Group 1: Stroop task
  - Group 2: Impulsive response task
  - Group 3: Lexical decision task
  - Group 4: Sustained attention to response task
  - Group 5: Wisconsin Card Sorting task
  - Group 6: Self-paced reading
- debrief: describe the task to the class and how you classified it

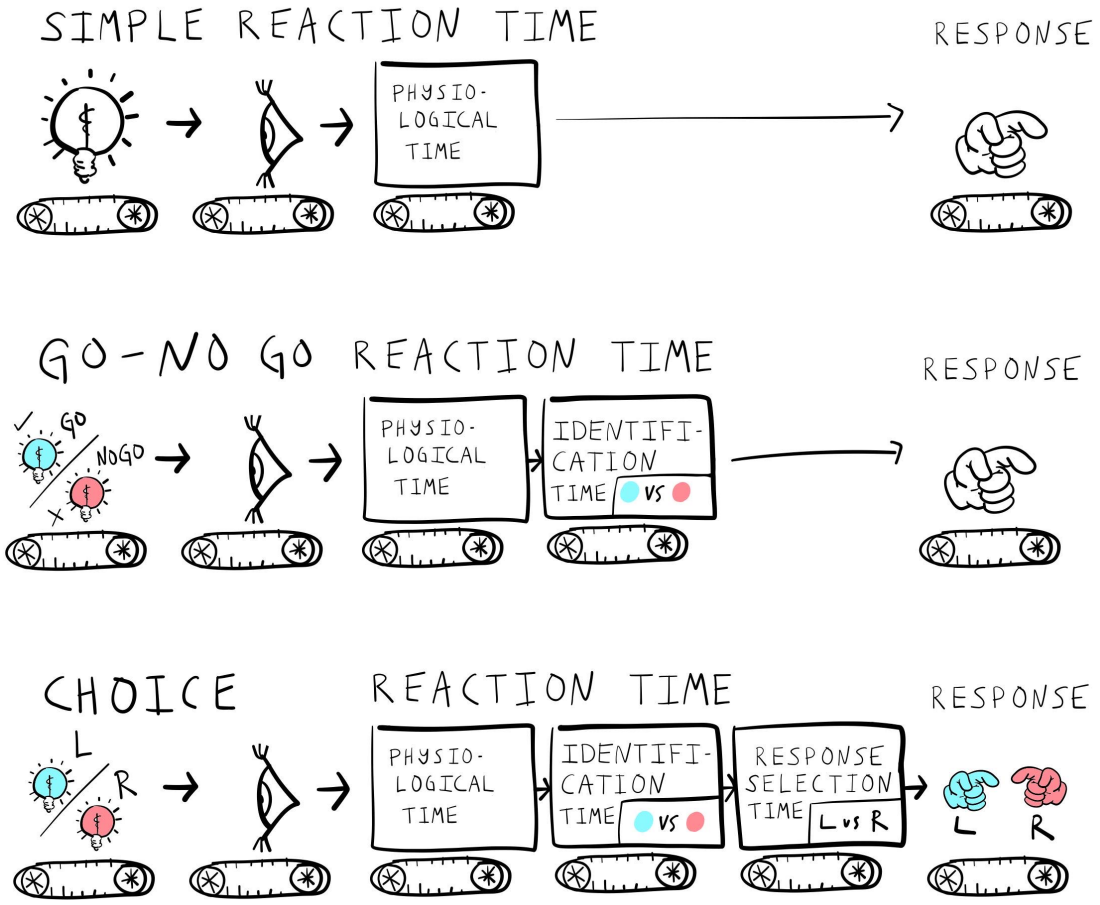
Donders: subtractive logic

- Donders assumed that mental operations occurred in successive stages, i.e., like an assembly line



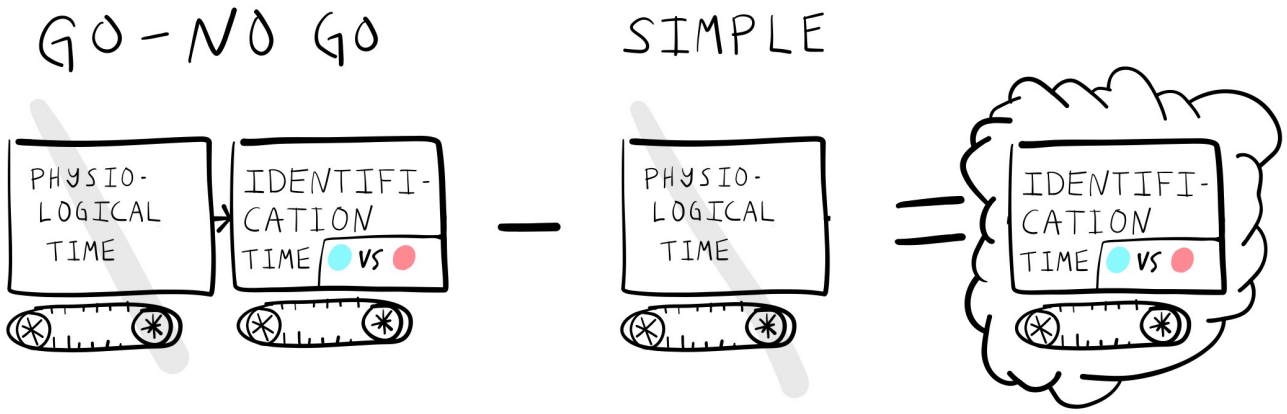
Donders: subtractive logic

- time taken to respond should depend on number of processing stages required to complete the task
  - simple tasks have fewer stages and are therefore performed quickly
  - complex tasks have more stages and therefore performed slower



Donders: subtractive logic

- the problem: we do not know how long each processing stage takes
- solution: subtract the times from two different tasks!



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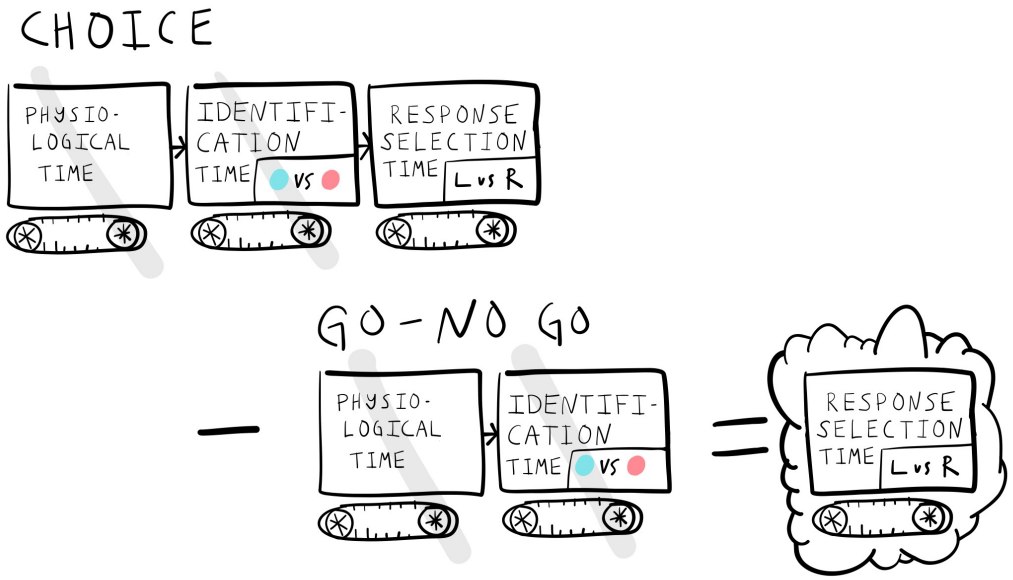
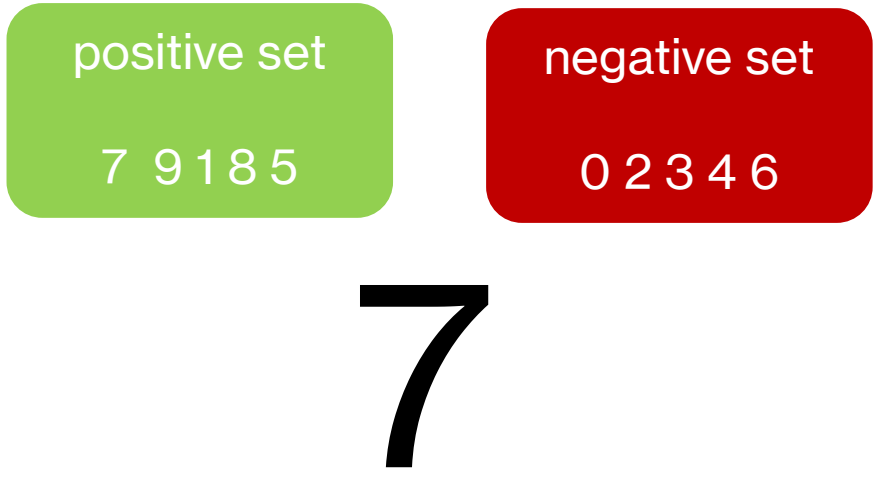


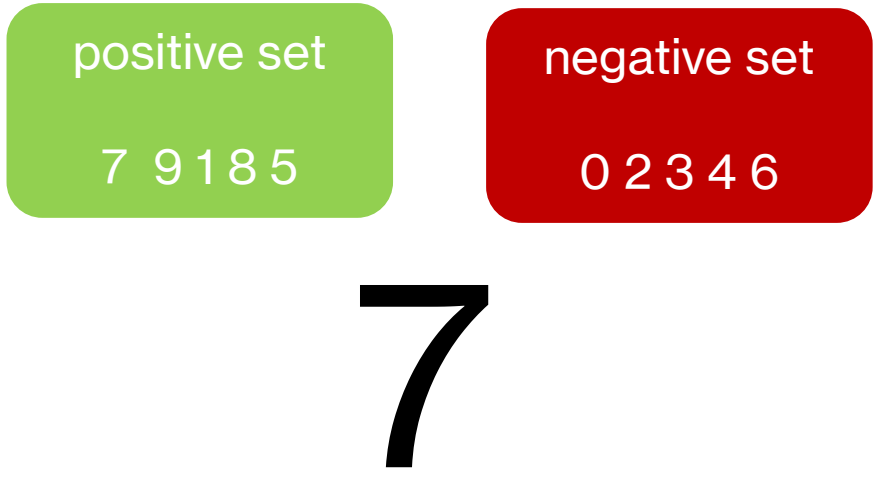
subtractive logic: processing stages

- Sternberg (1969) describes a binary classification experiment where a digit (0 to 9) is presented visually and participants decide whether the digit belongs to a pre-decided positive set or negative set



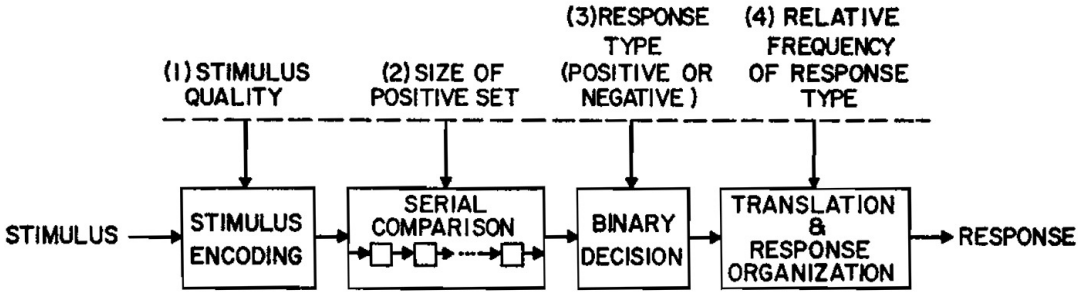
subtractive logic: processing stages

- factors varied in experiments
  - stimulus quality (intact vs. degraded)
  - size of the positive set
  - response type (positive / negative)
  - frequency of response type
- dependent variable
  - reaction time

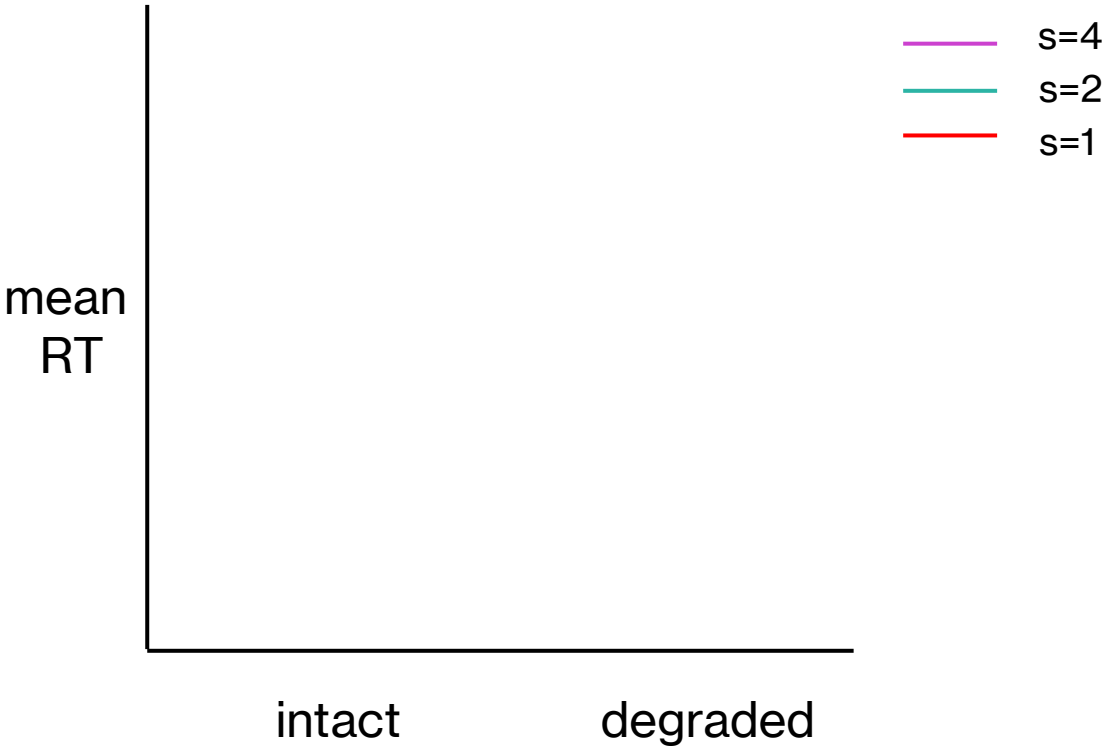


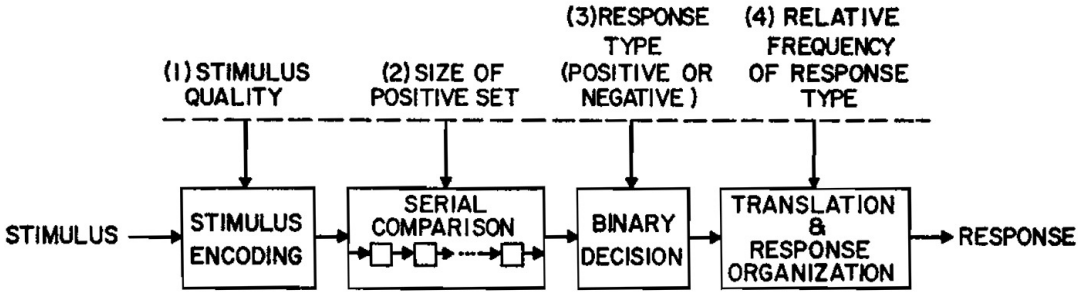
subtractive logic: predictions

- consider stimulus quality (intact/degraded) and size of positive set (s)
- if we assume that process of encoding the digit is independent and additive with the comparison process, what would we expect the plot of response times to look like?

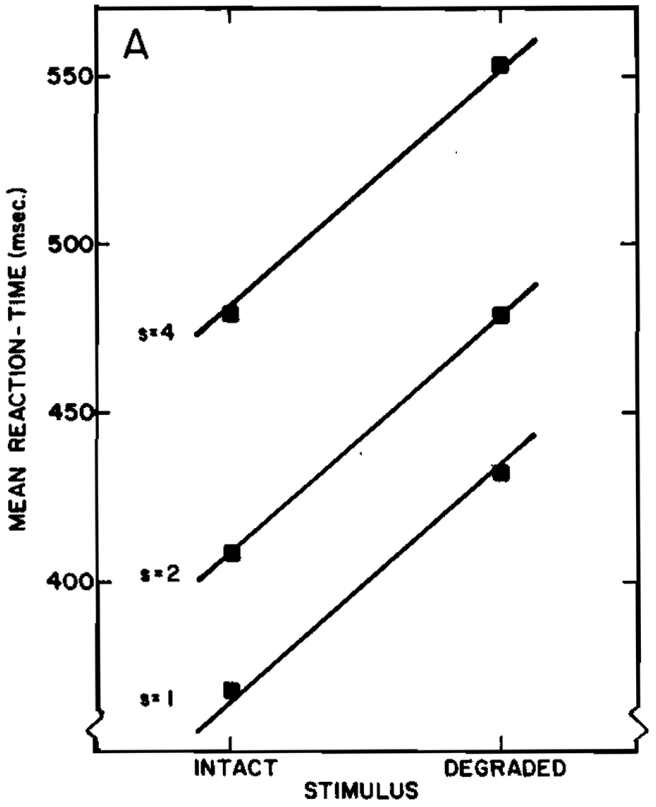


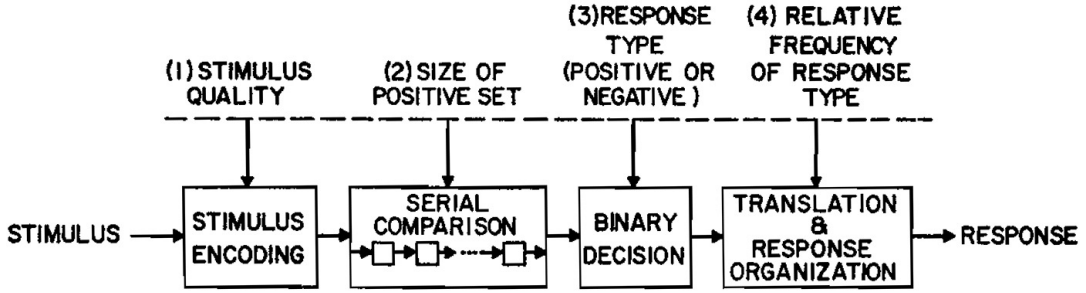
subtractive logic: predictions





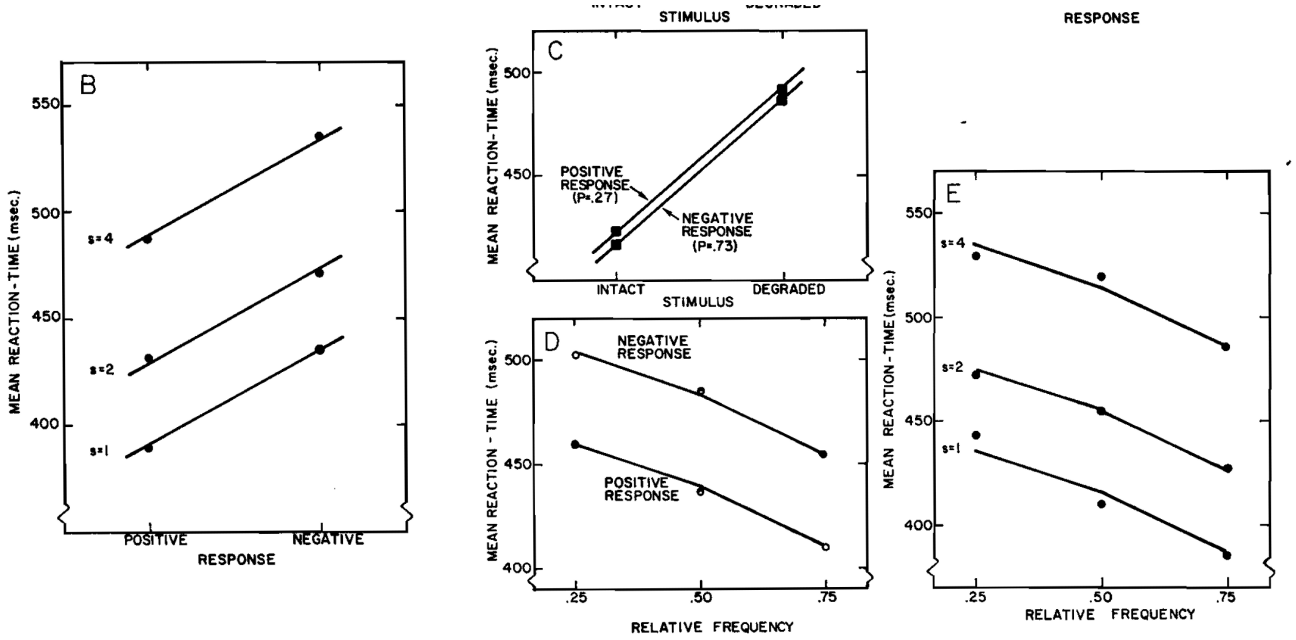
subtractive logic: findings

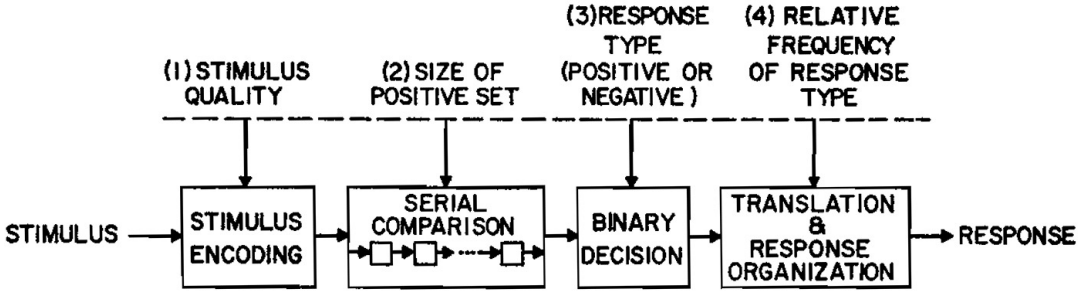




stimulus quality is additive with stimulus set

subtractive logic: findings

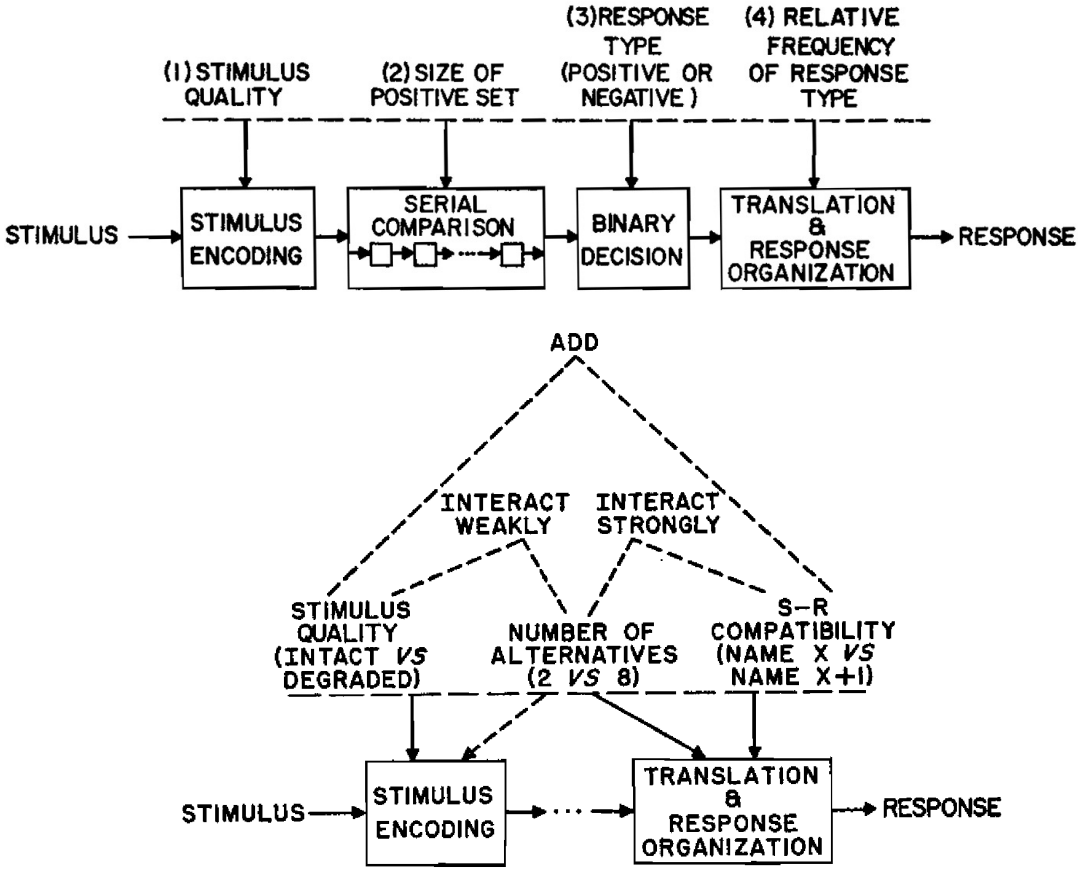




several other additive patterns were also found

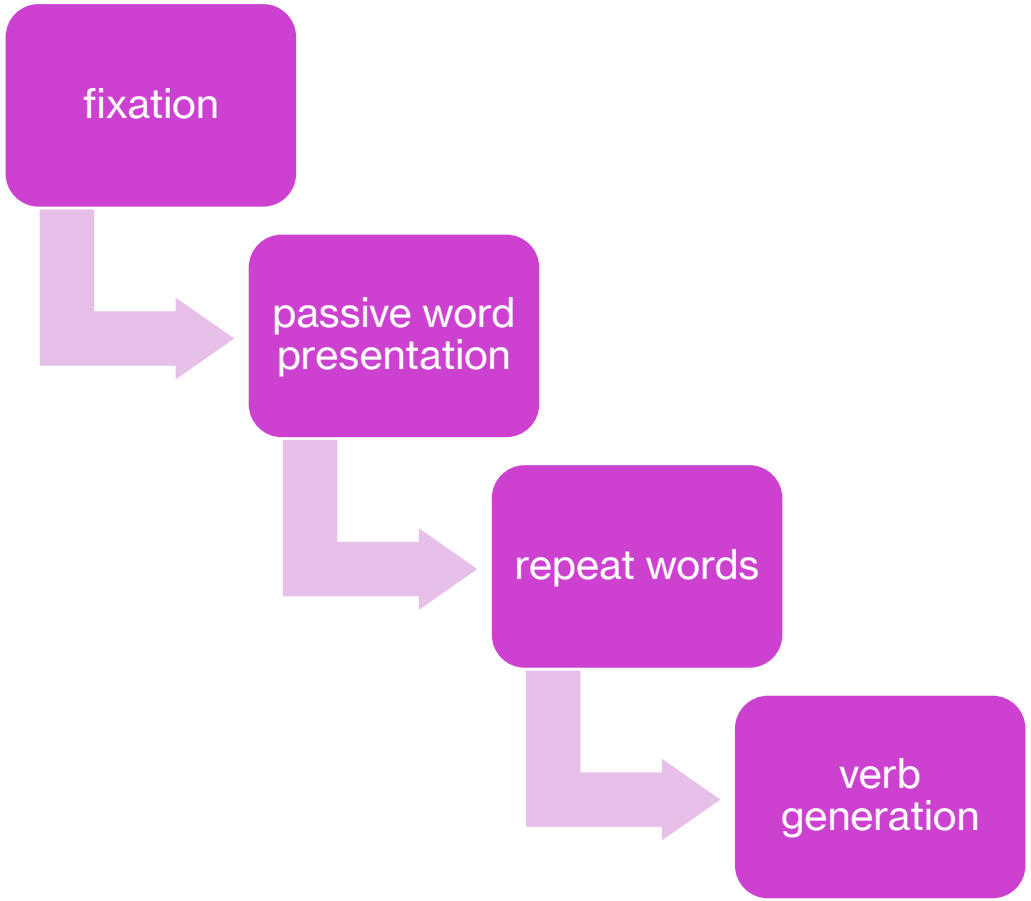
subtractive logic: inferences

- subtractive logic for processing stages in cognitive tasks can be verified using experimental manipulations that examine interactions between different factors

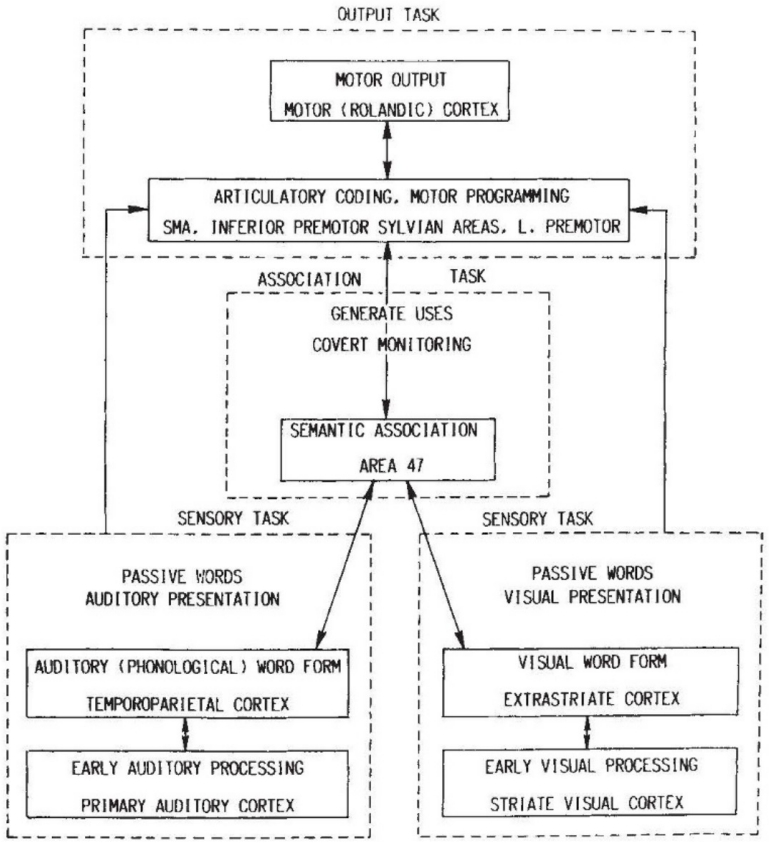


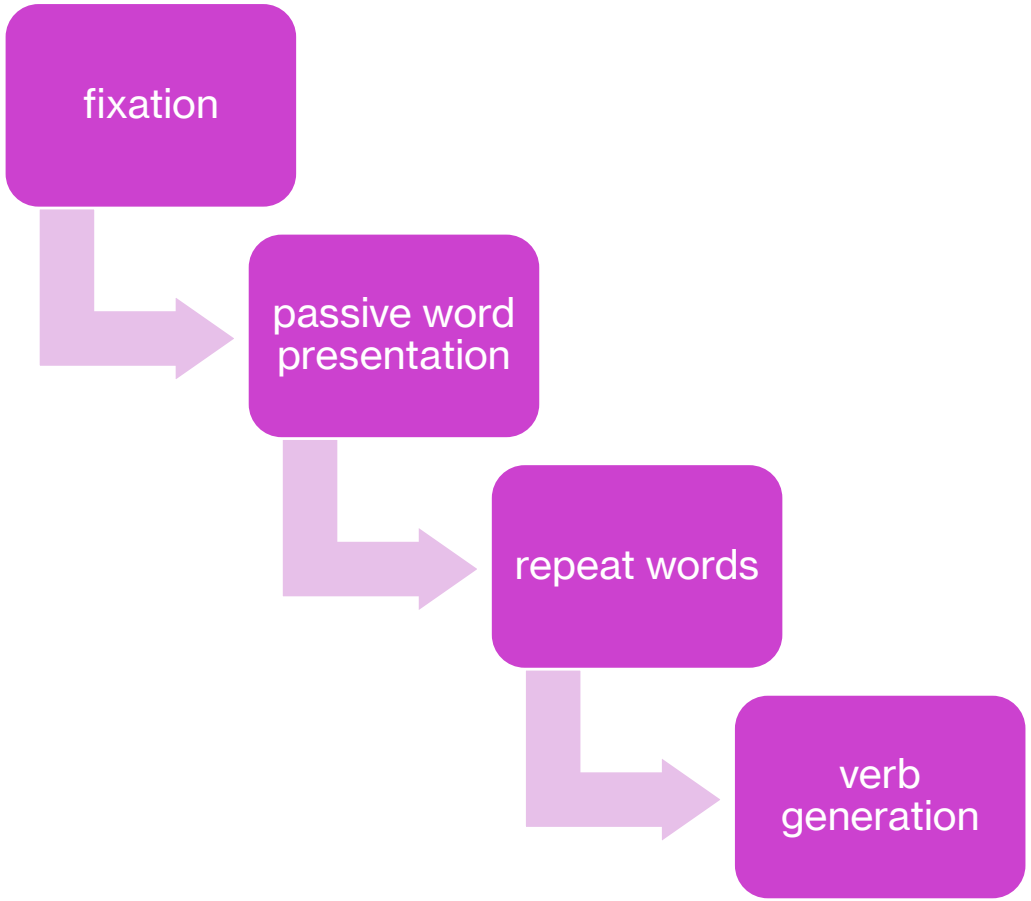
subtractive logic: neuroimaging

- Petersen et al. (1988) compared neural activity to a series of tasks with varying cognitive demands
- Positron Emission Tomography (PET) was used to generate images of blood flow in specific brain regions via subtractive logic to identify key brain areas
- assumptions? predictions?



subtractive logic: neuroimaging





subtractive logic: neuroimaging

- possible issues?
- “pure insertion” assumption
  - cognitive insertion: a single cognitive process is inserted
  - neural insertion: a single neural process is inserted
- neural pathways are highly nonlinear and interactive, so even if cognitive insertion can be verified, the leap to neural insertion may be difficult

subtractive logic: response modes

- Jennings et al. (1997)
- participants underwent six PET scans making semantic (would this be considering living?) or letter (does this word contain the letter “a”?) judgments in three modalities (mouse-clicking, spoken response, silent thought)
- compared semantic – letter activations
- what would the additivity assumption predict in this situation?

Experimental Design: Processing Crossed with Response Mode (Six Scans Total)

Processing task	Response mode
Semantic task	Mouse-click
	Spoken response
	Silent thought
Letter task	Mouse-click
	Spoken response
	Silent thought

subtractive logic: response modes

- semantic >> letter
- if the same cognitive processes are involved across different response modes (i.e., they are independent and additive), then the same behavioral and neural pattern should be observed
- if semantic processing and mode interact, different patterns may be observed
- no behavioral differences were found for response modes, i.e., no interaction between task and mode was found

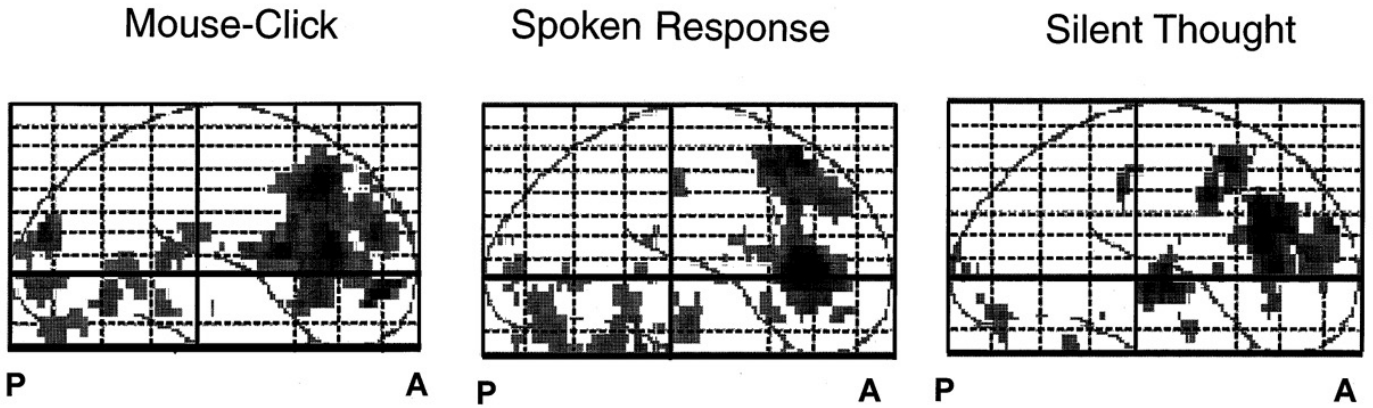
Experimental Design: Processing Crossed with Response Mode (Six Scans Total)

Processing task	Response mode
Semantic task	Mouse-click
	Spoken response
	Silent thought
Letter task	Mouse-click
	Spoken response
	Silent thought

Probability of Responding "Old" to Old and New Items on the Recognition Test for Each Response Mode

	Mouse-click		Spoken response		Silent thought	
Item	Semantic	Letter	Semantic	Letter	Semantic	Letter
Old	0.90	0.52	0.87	0.52	0.79	0.54
New	0.27	0.30	0.22	0.24	0.28	0.23

subtractive logic: interactions



- some common brain areas were found but importantly, there were some brain areas uniquely activated in specific response modes

TABLE 4

Areas of Increased rCBF Associated with Semantic Processing

x	*y*	*z*	Brodmann's areas	Mouse	Spoken	Silent
			Areas of increased rCBF common to all response modes			
−34	28	4	Left area 45	*	*	*
−24	28	−8	Left area 11	*	*	*
−16	−94	4	Left area 17	*	*	*
6	22	36	Right area 32	*	*	*
10	−76	−16	Right cerebellum	*	*	*
			Areas of increased rCBF common to two response modes			
10	−88	−28	Right cerebellum	*	*	
40	48	12	Right area 10/46	*		*
42	30	28	Right area 9	*		*
−8	16	40	Left area 6/8		*	*
−28	−22	−20	Fusiform gyrus		*	*
			Areas of increased rCBF unique to a single response mode			
10	54	−4	Right area 10	*		
−62	−36	8	Left area 22	*		
26	−88	20	Right area 19	*		
−42	44	24	Left area 46	*		
0	−26	36	Area 31		*	
38	24	24	Right area 9/46			*
44	10	40	Right area 6/8			*
30	−14	0	Right NL			*
46	−34	36	Right area 40			*

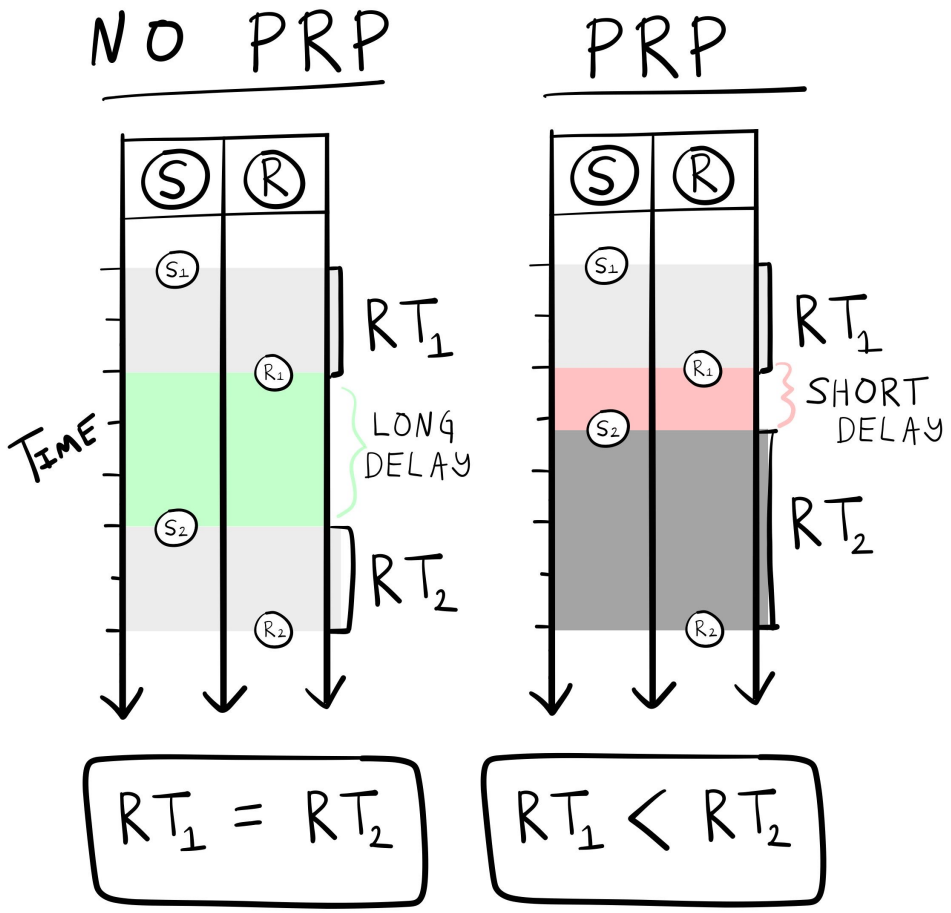
Note. Asterisks indicate regions that were active for each response mode.

subtractive logic: reflections

- metaphors are attractive but can be misleading
- subtractive logic came out of the assembly line metaphor
- potential issues:
  - what if multiple stages occur in parallel?
  - what if the stages don't have *constant* times?
  - can we assume similar processes at cognitive and neural levels?
- alternatives/checks for subtractive interpretations
  - multiple baseline conditions with varying levels of difficulty
  - meta-analyses
  - computational modeling

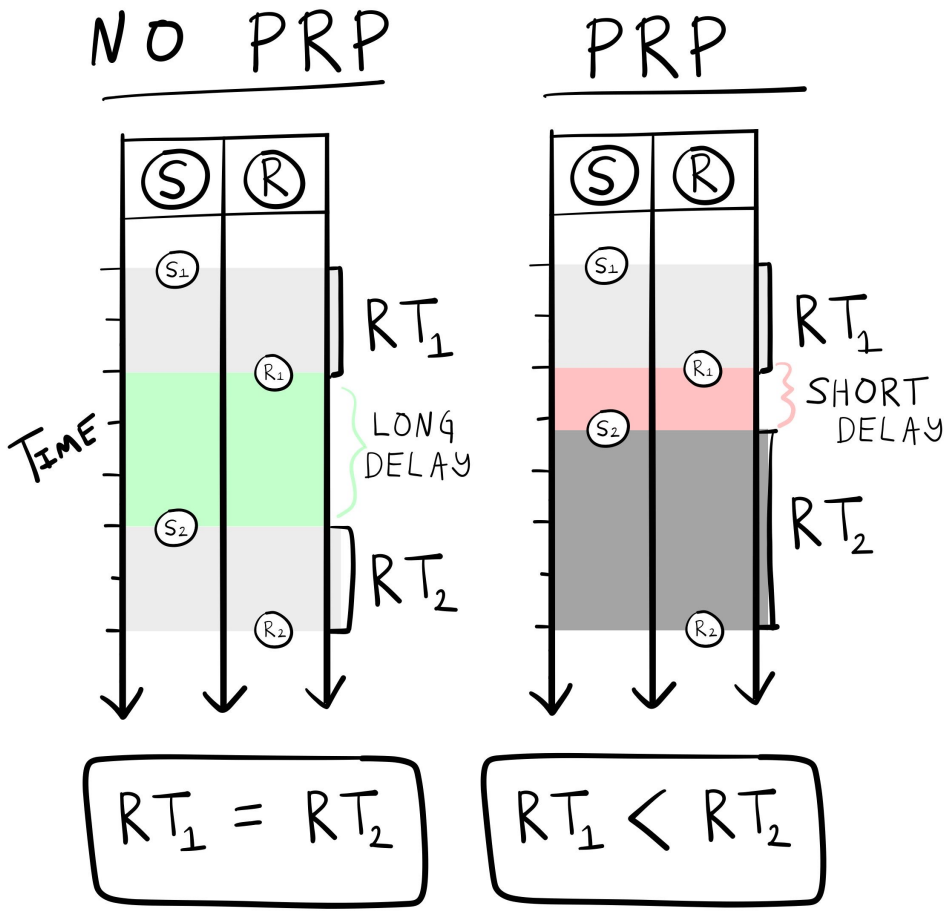
PRP effect

- the psychological refractory period (PRP) effect was documented by A.T. Welford
- the idea was that if two identical stimuli (S1 and S2) are presented with a short delay, then the time taken to respond to S2 is longer (RT2 > RT1)



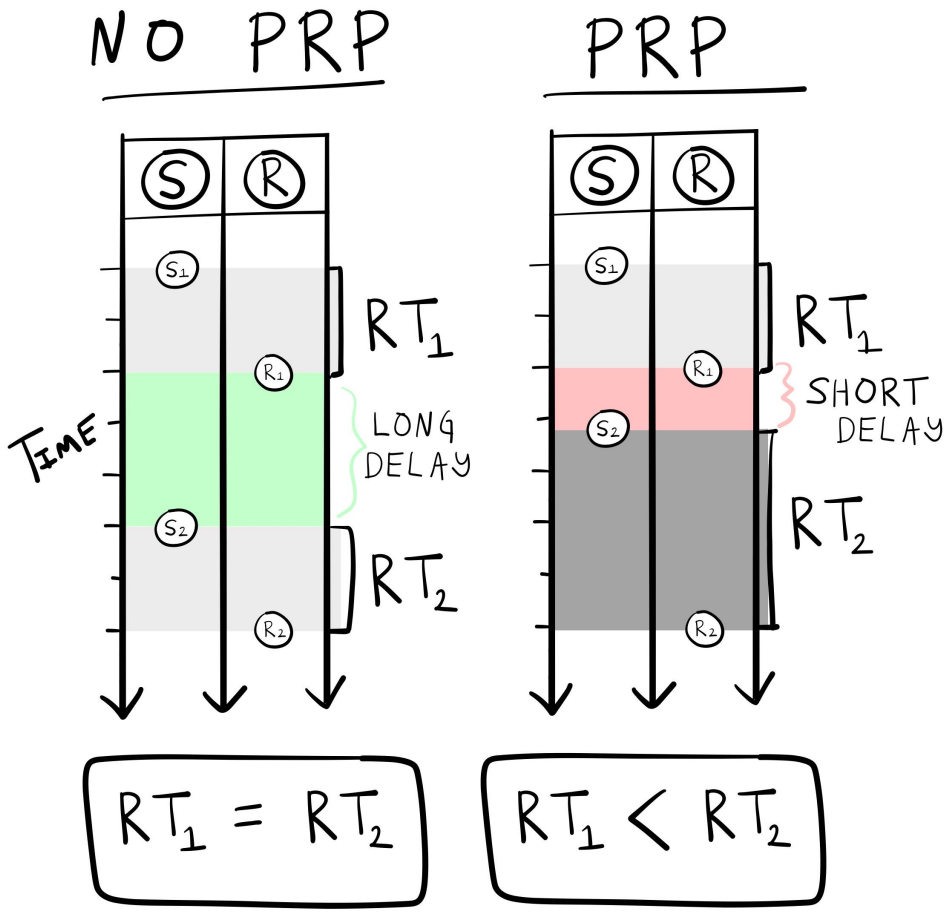
PRP effect: real-life examples

- groups of 2
- come up with a real-life example
- debrief



PRP effect: explanations

- properties of nerve fibers
- participant surprise: shorter delays produce more surprise which increases time
- limited-capacity single channel
  - inspired by the assembly line metaphor and how a bottleneck might be created if stimuli were presented quickly one after the other
  - also inspired by telecommunications...the idea of a “single channel”



try a PRP experiment

- https://www.psytoolkit.org/experiment-library/experiment_prp.html
- need headphones/speakers

big takeaways

- the study of cognition moved from introspectionism to associationism to behaviorism to “cognitivism”
- cognition was influenced by world events
- Donders’ processing stages are an example of the assembly line metaphor, inspired from the industrial revolution
- other world events also influenced cognition and led to a greater emphasis on mechanisms that influence how individuals react to stimuli and what processes lead to responses

next class

- **before** class:
  - *block out time*: practice assessment 1 / reviewing material
  - *explore*: L6 assignments
- **during** class:
  - the telephone metaphor of cognition
  - the rise of cognitivism via information processing