Cognition

PSYC 2040

L6: Information Processing

Part 1

logistics: midterm + monthly quiz

practice assessment 1

- multiple-choice + short answers
- available on Canvas
- will post answer keys next week

monthly quiz

- available from Friday (Feb 23) to Tuesday (Feb 27) midnight
- open-book, Canvas
- 1 hour time limit

review sessions

- Monday (Feb 26), 7-9 pm
- Thursday (Feb 29), 8-10 pm
- Kanbar 200

midterm

- 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
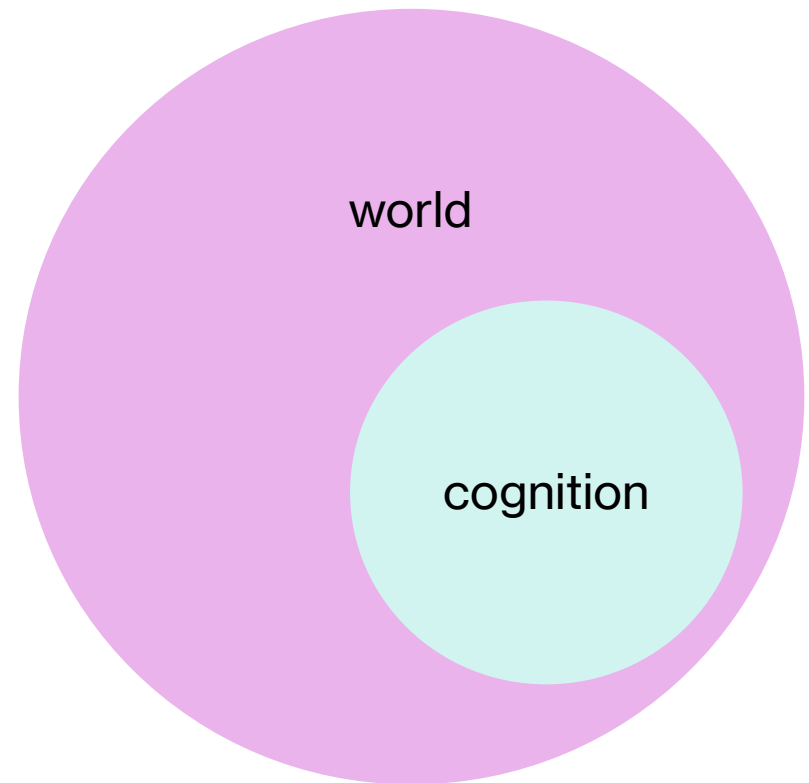
world

cognition

the timeline so far
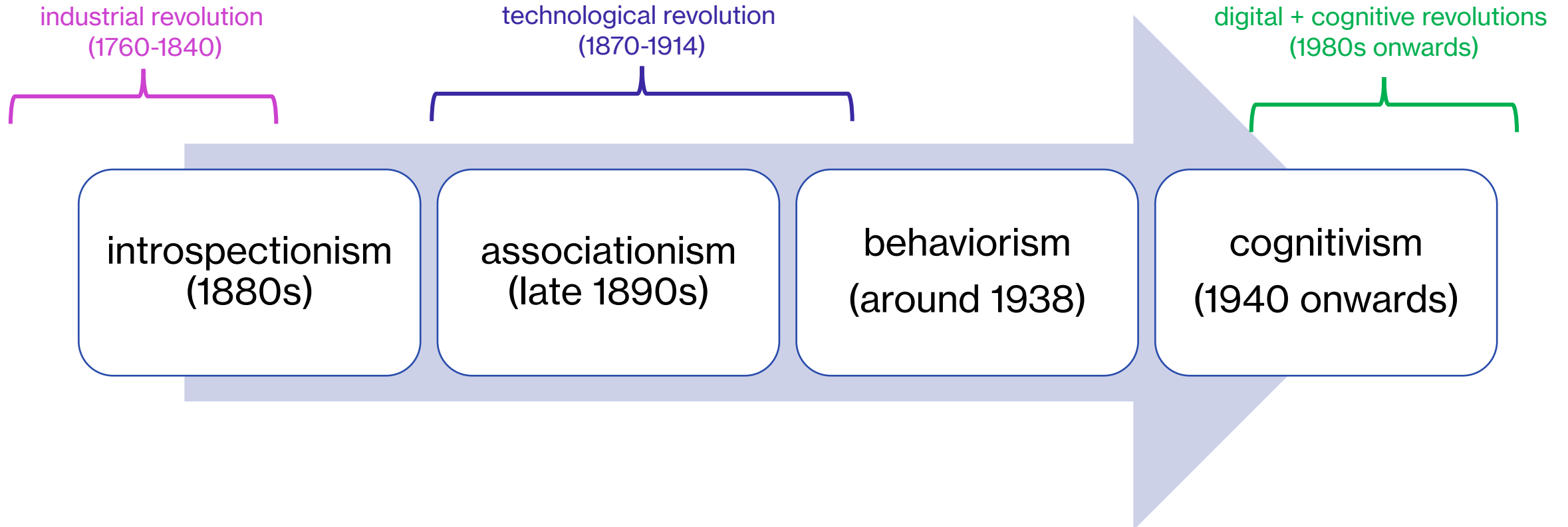
introspectionism
(1880s)

associationism
(late 1890s)

behaviorism
(around 1938)

cognitivism
(1940 onwards)

the timeline so far

introspectionism
(1880s)

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cognitivism
(1940 onwards)

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
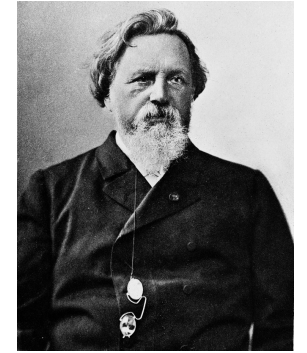
the timeline so far

industrial revolution
(1760-1840)

technological revolution
(1870-1914)

digital + cognitive revolutions
(1980s onwards)

introspectionism
(1880s)

associationism
(late 1890s)

behaviorism
(around 1938)

cognitivism
(1940 onwards)
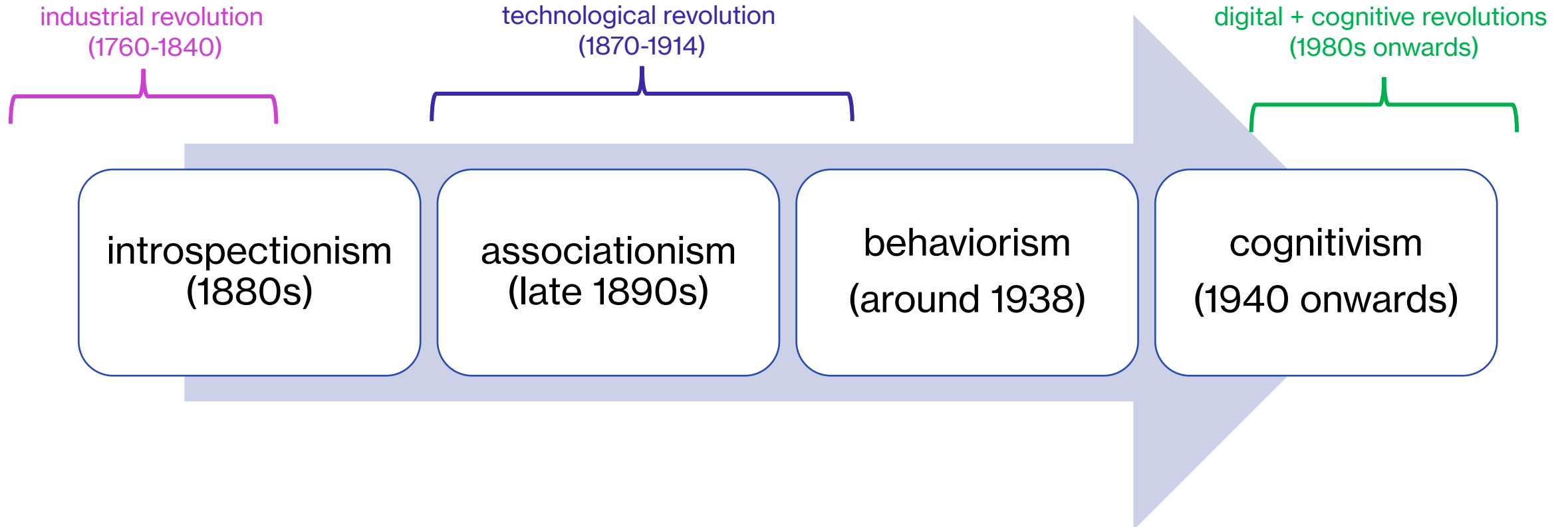
the timeline so far
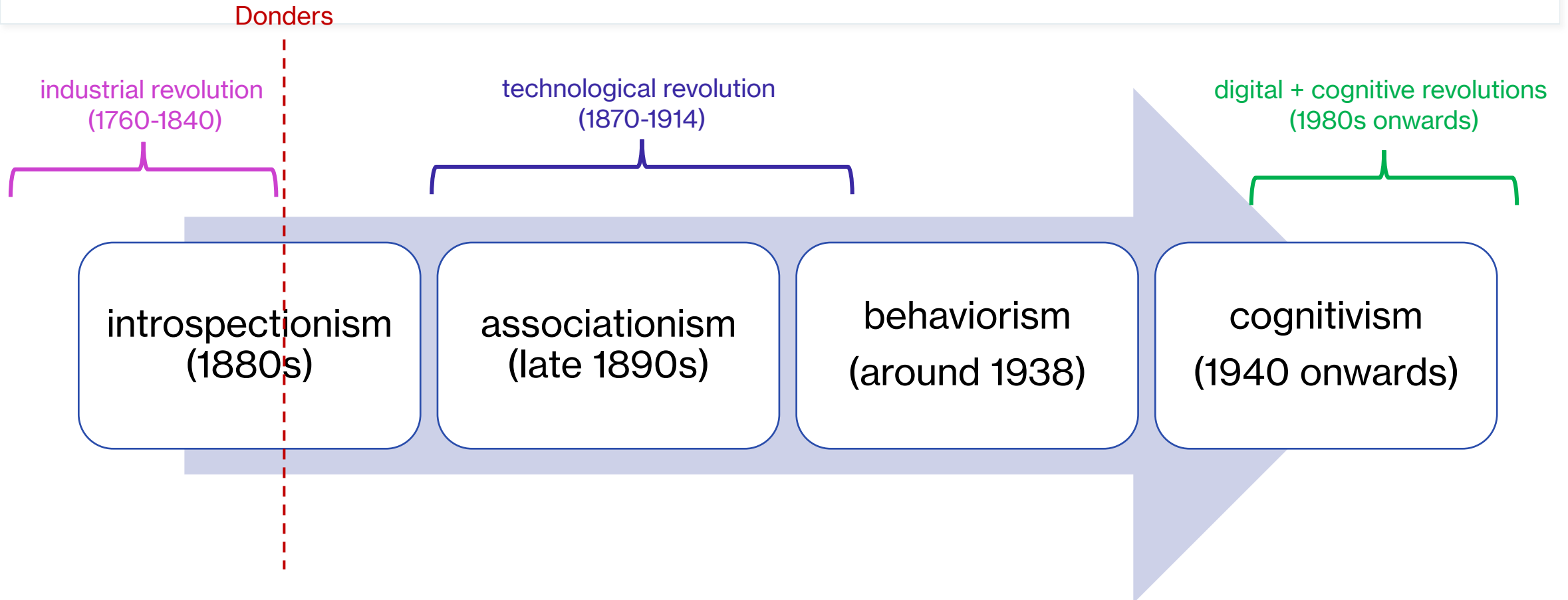
Donders' processing stages

- 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)
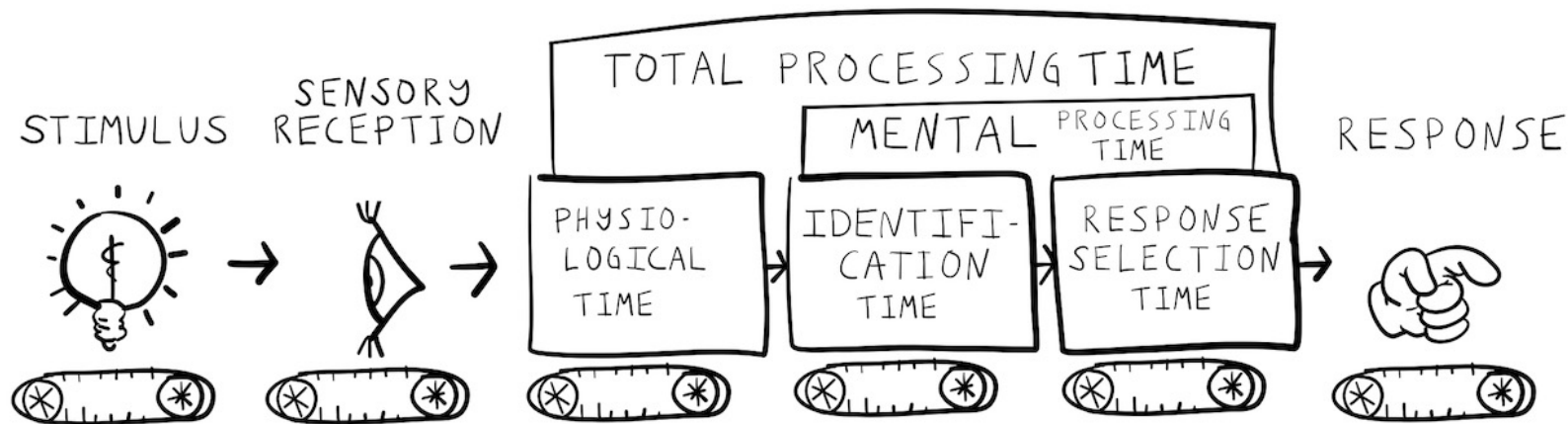 - record time taken to respond
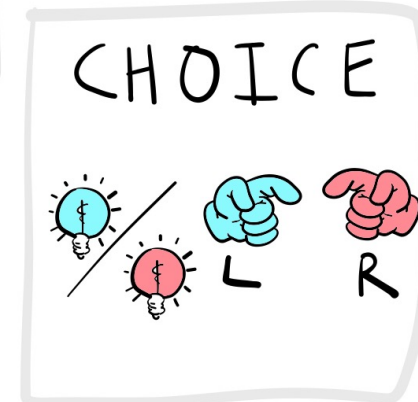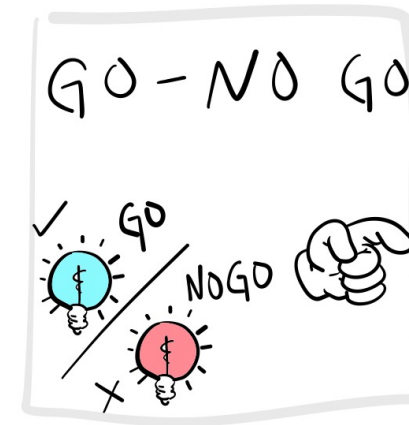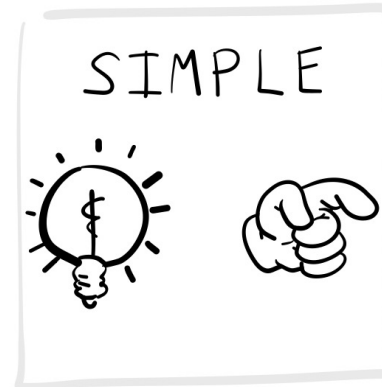
activity: classify the tasks!

- 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
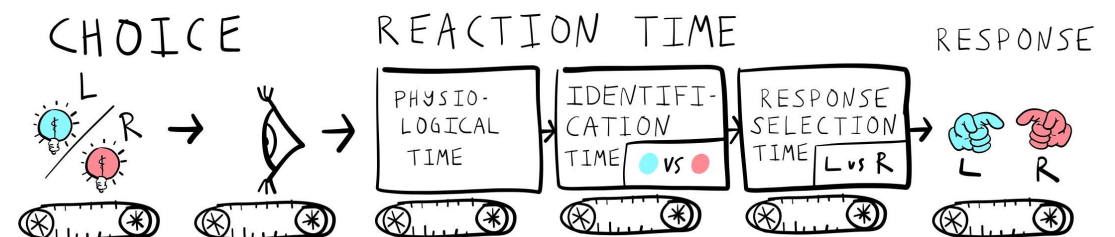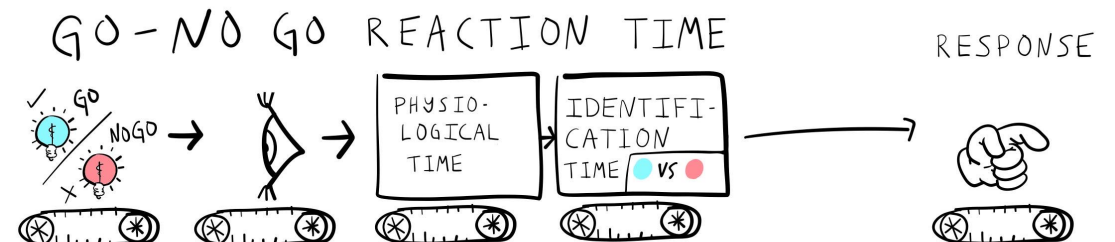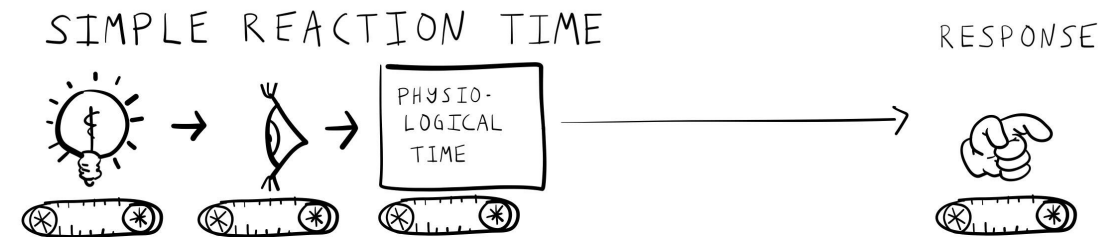
Donders: subtractive logic

- 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!
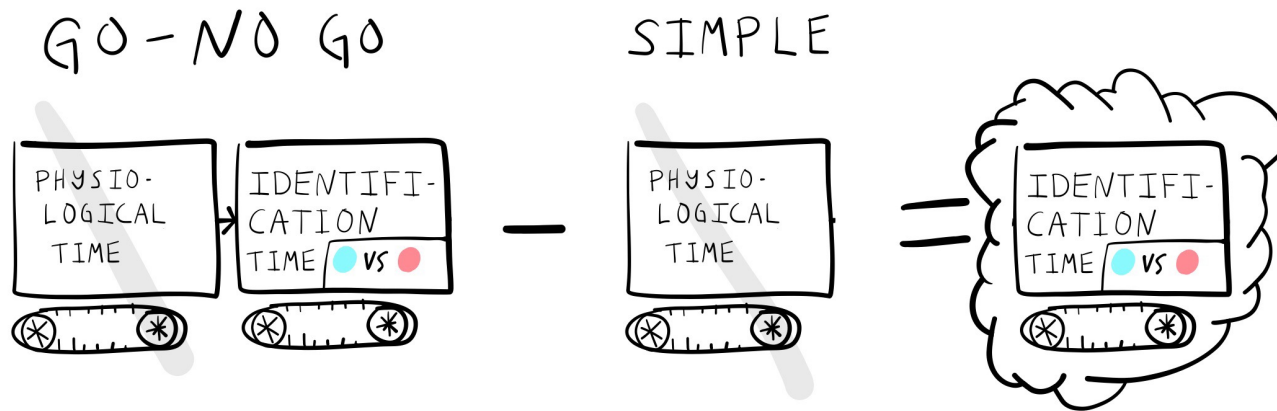
Donders: subtractive logic

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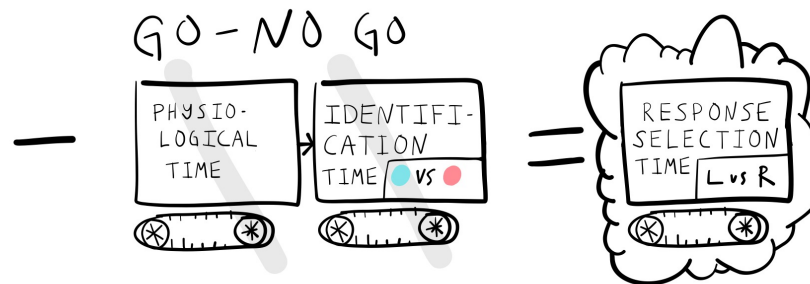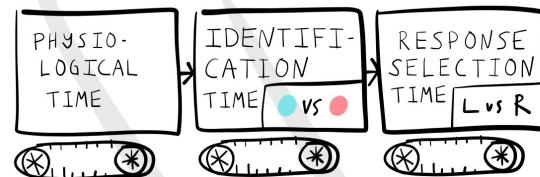
subtractive logic: processing stages

- 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

positive set

7 9 1 8 5

negative set

0 2 3 4 6

7

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

positive set

7 9 1 8 5
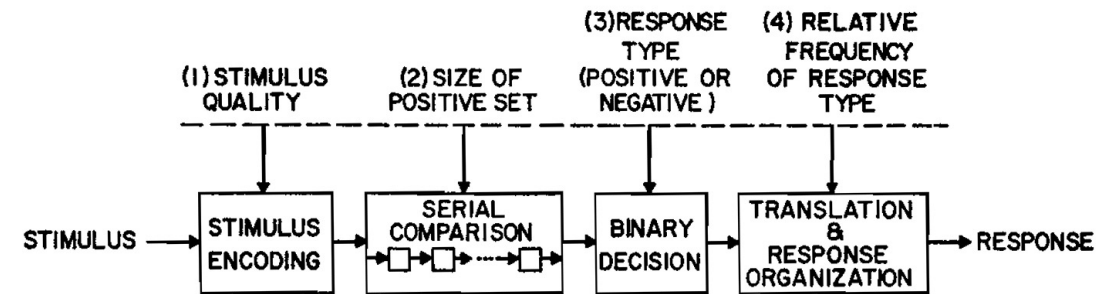
negative set

0 2 3 4 6

7

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

mean
RT

intact   degraded

s=4
s=2
s=1

(3)RESPONSE   (4) RELATIVE
TYPE   FREQUENCY
(1)STIMULUS   (2) SIZE OF   (POSITIVE OR   OF RESPONSE
QUALITY   POSITIVE SET   NEGATIVE)   TYPE

STIMULUS → | STIMULUS | → | SERIAL | → | BINARY | → | TRANSLATION | → RESPONSE
            | ENCODING | | COMPARISON | | DECISION | | & |
                              | □→□···►□ | | RESPONSE |
                                                             | ORGANIZATION |
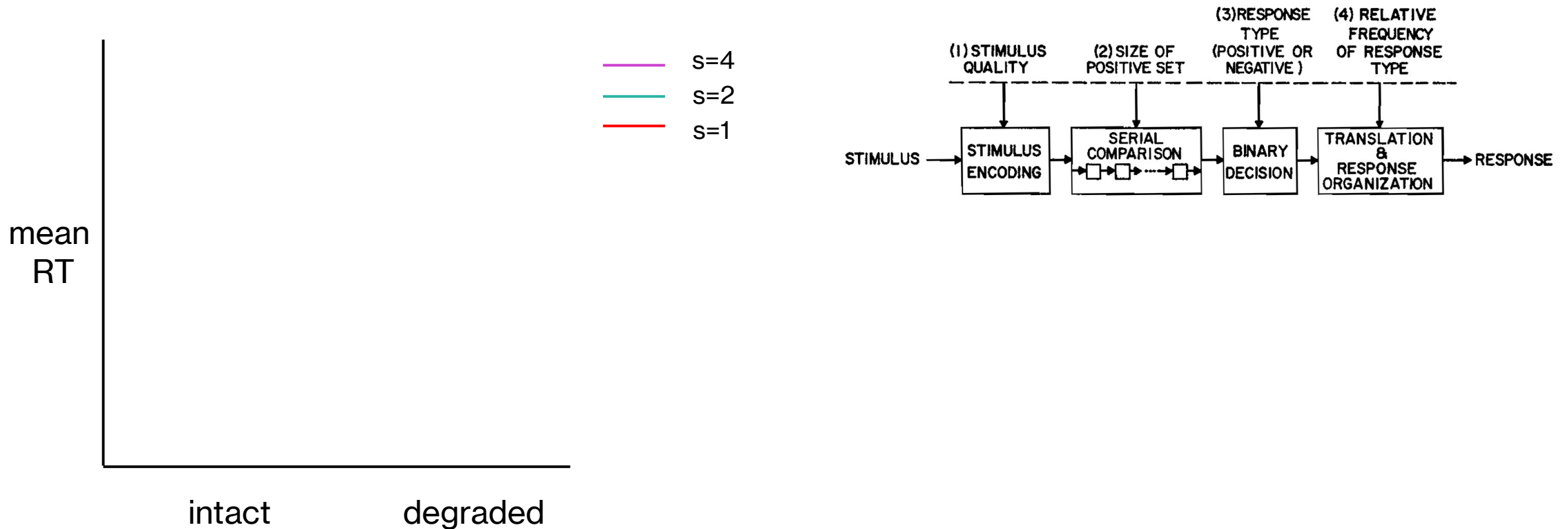
subtractive logic: findings
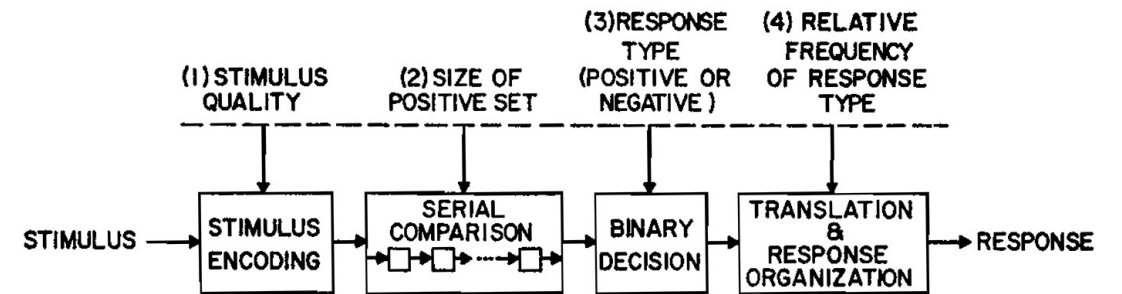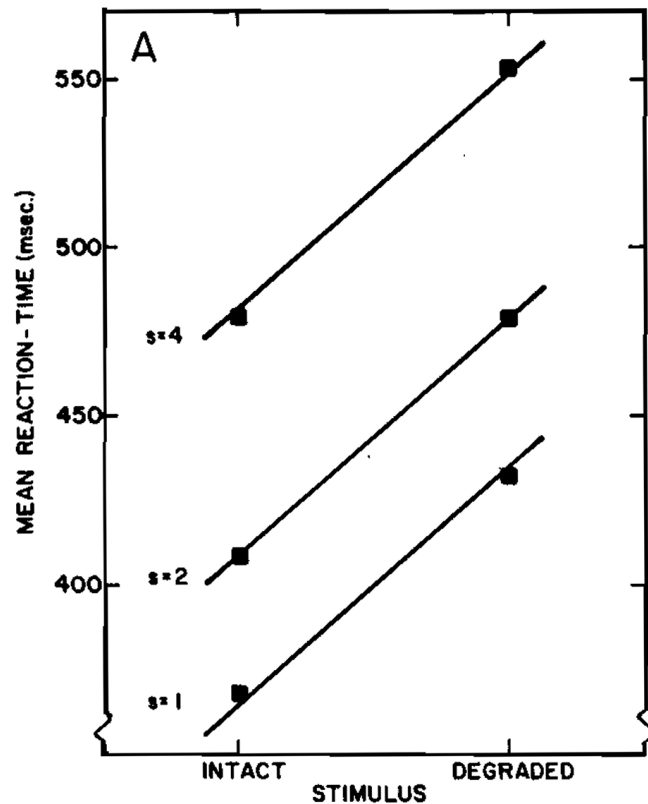
stimulus quality is additive with stimulus set

subtractive logic: findings
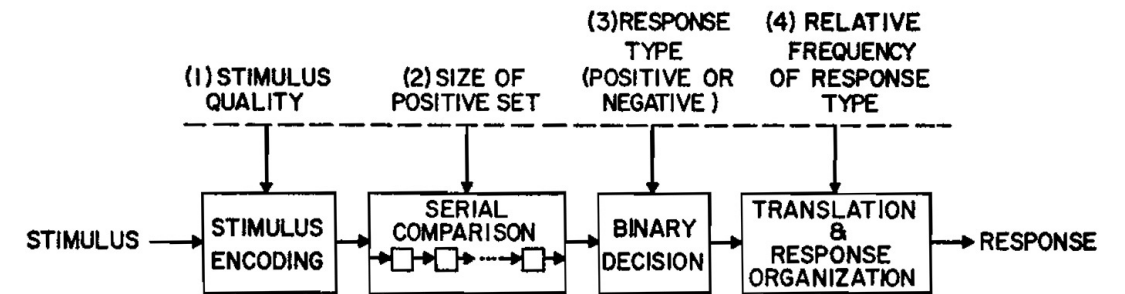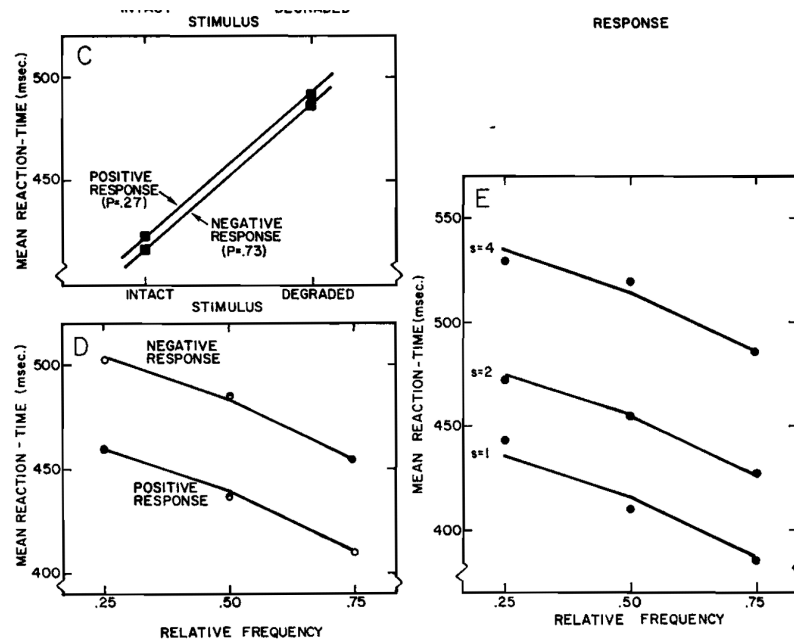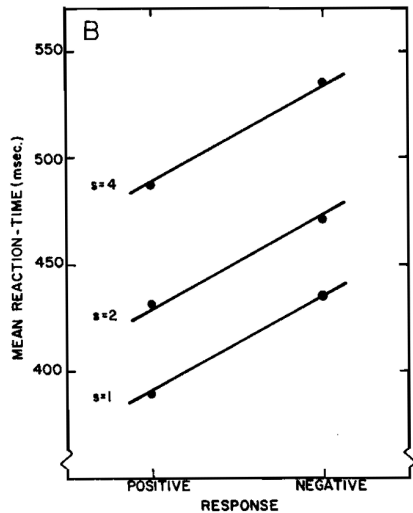
several other additive patterns were also found

subtractive logic: inferences

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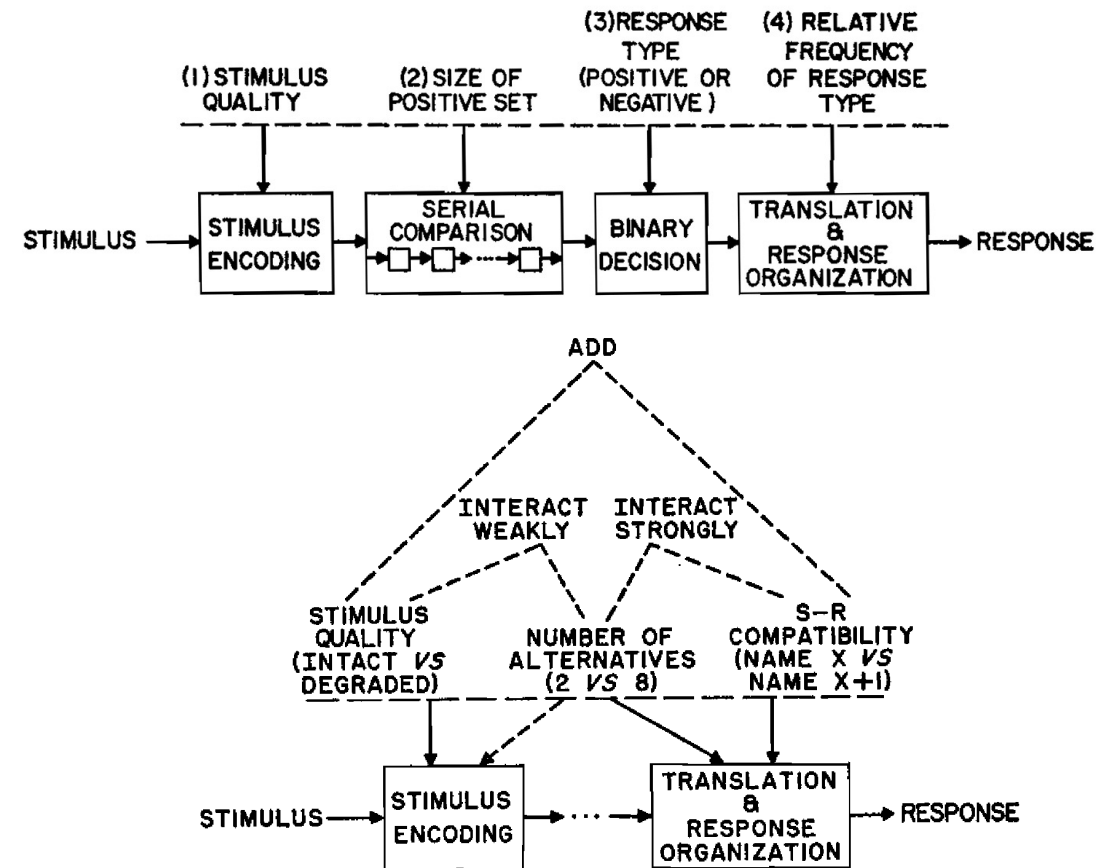
subtractive logic: neuroimaging

- 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?

fixation

passive word presentation

repeat words

verb generation

subtractive logic: neuroimaging

OUTPUT TASK

MOTOR OUTPUT
MOTOR (ROLANDIC) CORTEX

ARTICULATORY CODING, MOTOR PROGRAMMING
SMA, INFERIOR PREMOTOR SYLVIAN AREAS, L. PREMOTOR

ASSOCIATION   TASK

GENERATE USES
COVERT MONITORING

SEMANTIC ASSOCIATION
AREA 47

SENSORY TASK   SENSORY TASK

PASSIVE WORDS
AUDITORY PRESENTATION

PASSIVE WORDS
VISUAL PRESENTATION

AUDITORY (PHONOLOGICAL) WORD FORM
TEMPOROPARIETAL CORTEX

VISUAL WORD FORM
EXTRASTRIATE CORTEX

EARLY AUDITORY PROCESSING
PRIMARY AUDITORY CORTEX

EARLY VISUAL PROCESSING
STRIATE VISUAL CORTEX

fixation

passive word presentation

repeat words

verb generation

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

Mouse-Click Spoken Response Silent Thought
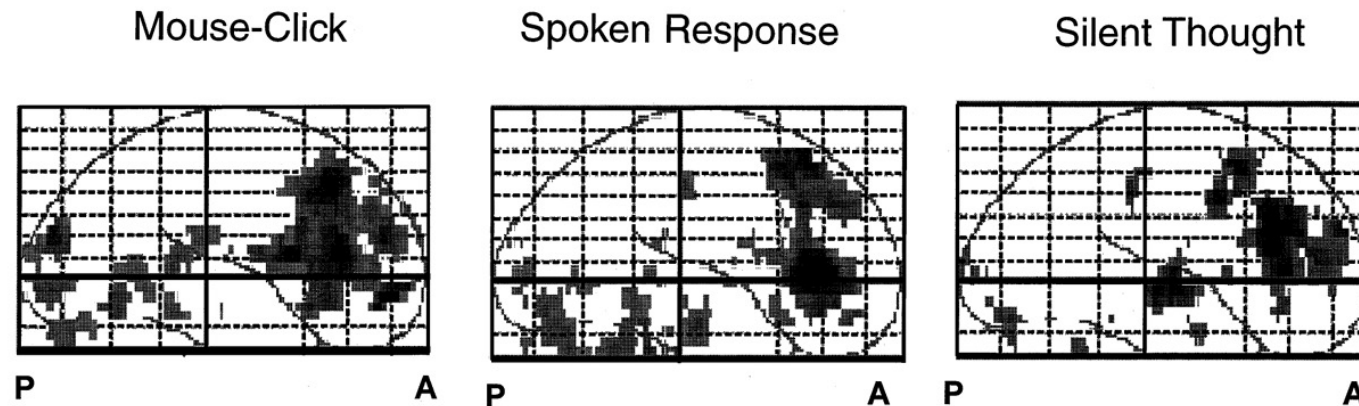
- some common brain areas were found but importantly, there were some brain areas uniquely activated in specific response modes

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
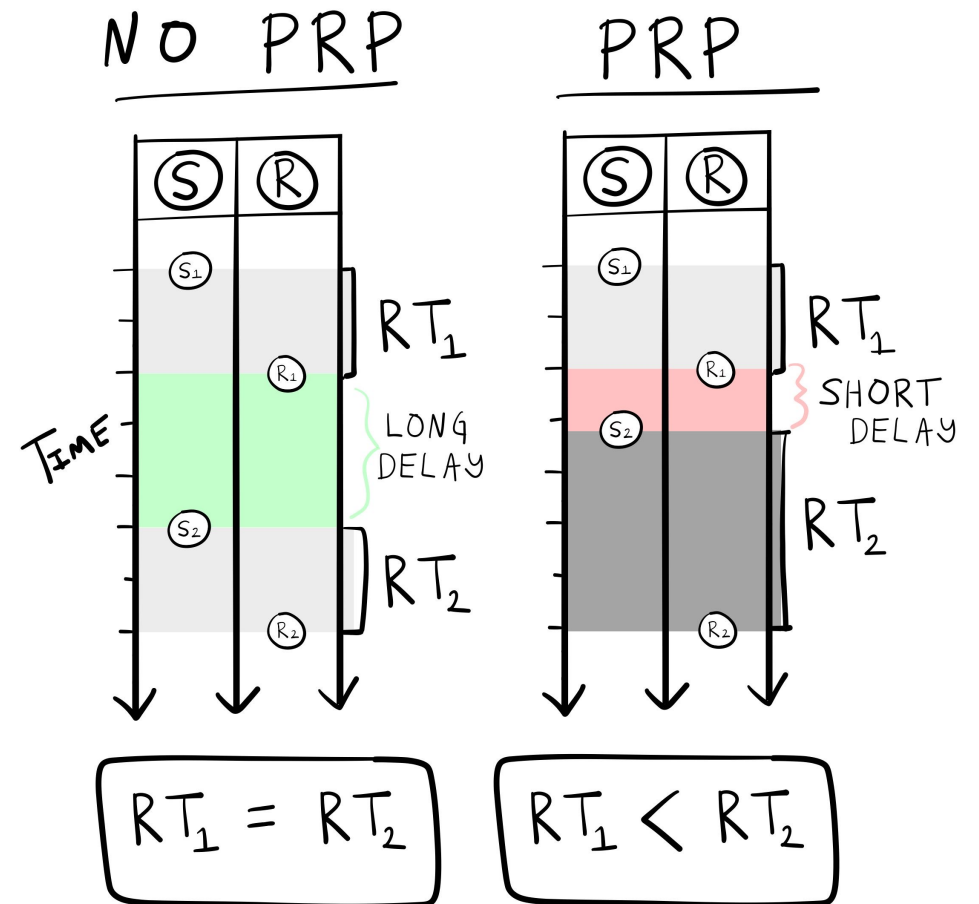 - meta-analyses
  - computational modeling

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)
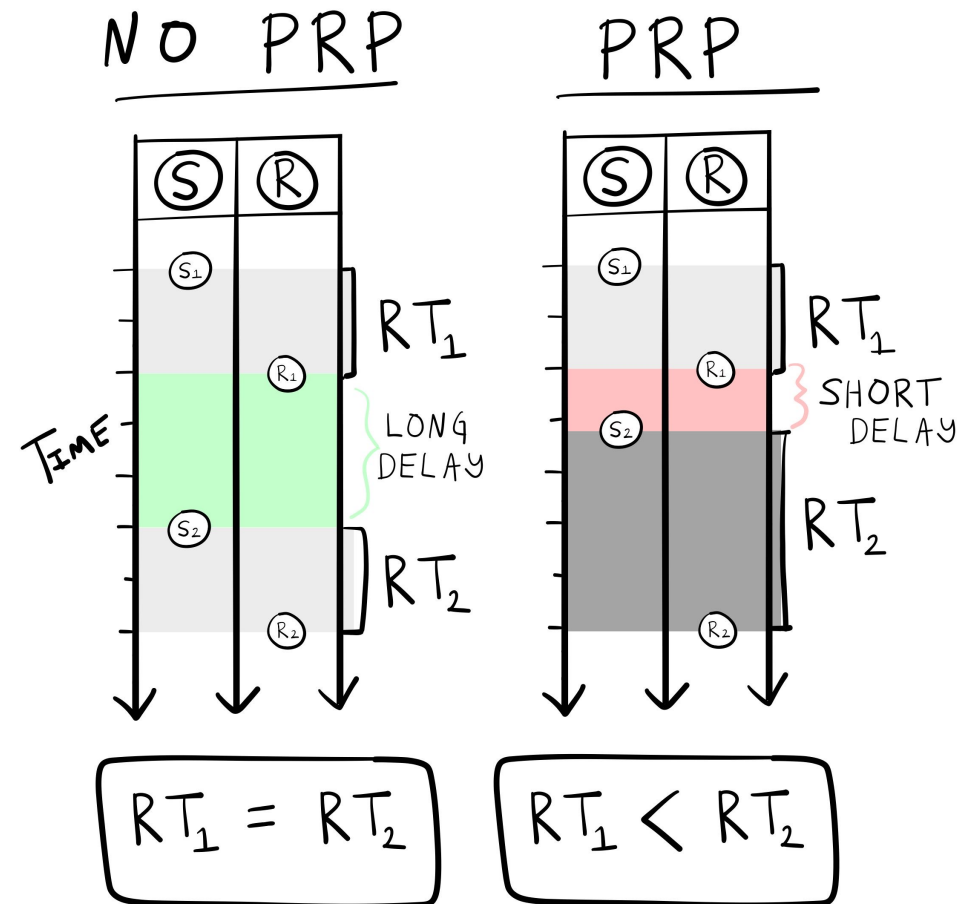
PRP effect: real-life **examples**

- 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"
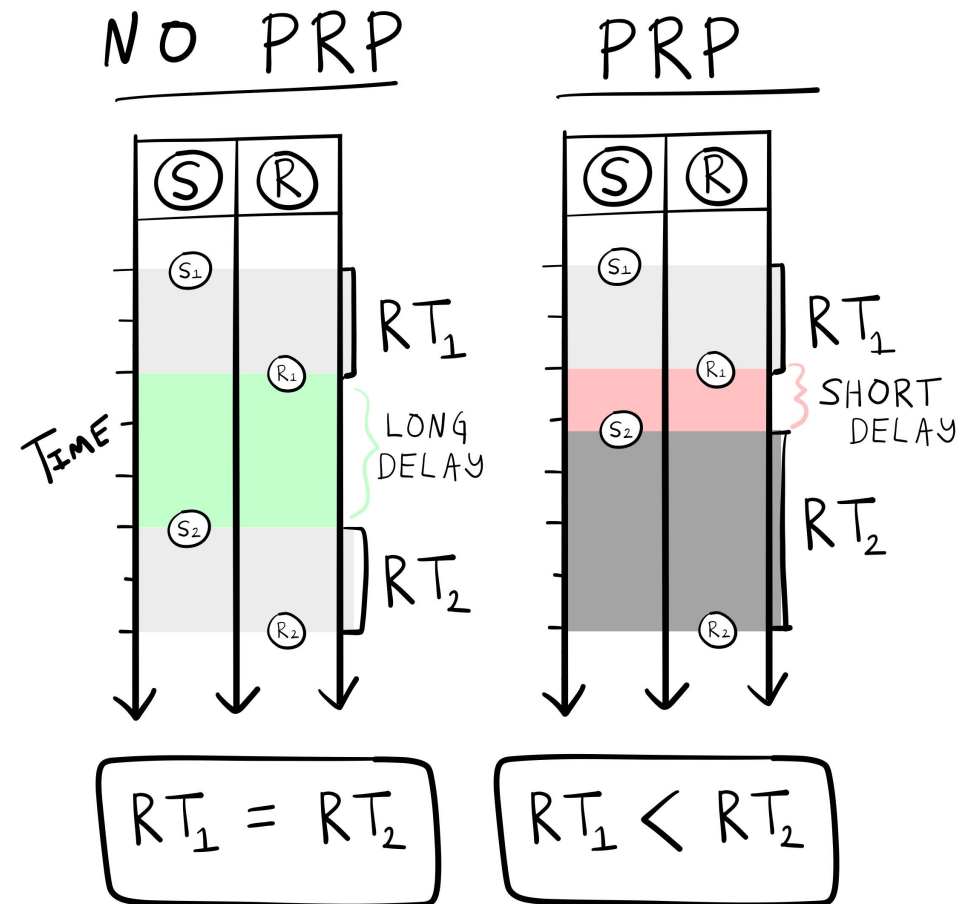
try a PRP experiment

- 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