PSI 428
Attentional Processes

Central Processing Limitations in Sensorimotor Tasks

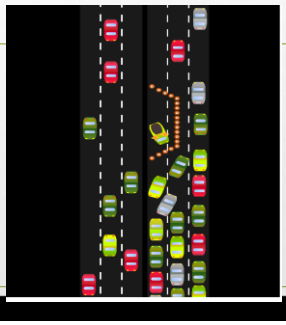
Learning Objectives

- Where is the central bottleneck on the human brain?
- Effects of extensive practice on dual-task interference

Theories of Central Attentional Limitations in Sensory-Motor Tasks

- Dual-task interference:
- When people do two things at the same time, sometimes interference might arise
- Performance on task A and/or task B is impaired when they are conducted at the same time, compared to when they are conducted separately

Bottleneck Theories



Bottleneck Theories

- Central mental operations are carried in parallel
- There is a discrete processing bottle neck
- Processing is queued at some stage of information processing
  - at the memory retrieval, decision, response selection, response initiation, or response execution stage

Psychological Refractory Period

- To understand dual-task interference at a mechanistic level more fine-grained analysis is necessary
  - People perform two tasks periodically (not simultaneously)
  - Time to perform each task is measured

Psychological Refractory Period

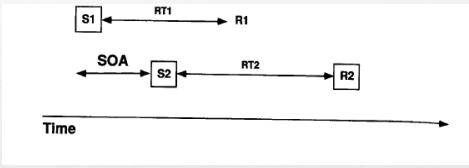
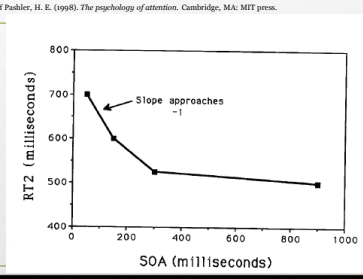


Figure 6.2 of Pashler, H. E. (1998). *The psychology of attention.* Cambridge, MA: MIT press.

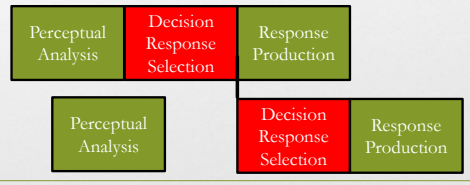
Psychological Refractory Period

Figure 6.2 of Pashler, H. E. (1998). *The psychology of attention.* Cambridge, MA: MIT press.

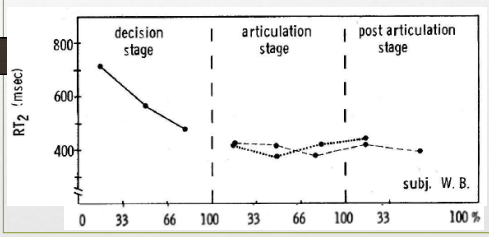


Central Bottleneck

- Does this theory assume serial or parallel processing?



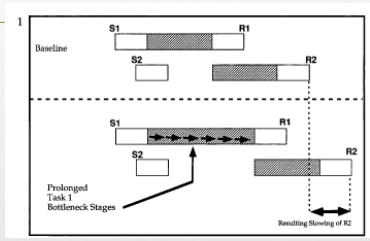
Van Galen & Hoopen (1976) Results



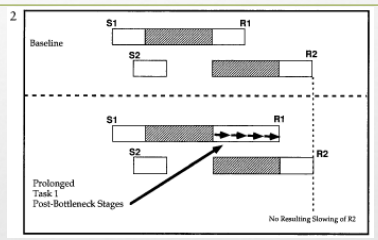
Van Galen & Hoopen (1976) Conclusion

- RTs were unaffected when S2 arrived during the articulation, but RTs were substantially elevated before the articulation (during the decision)
- Psychological refractory period is related with decision / S-R translation / response selection processes

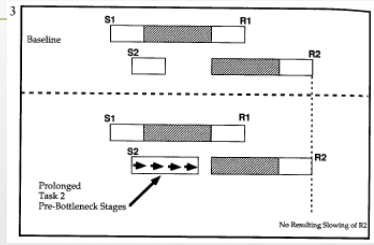
Strategy 1



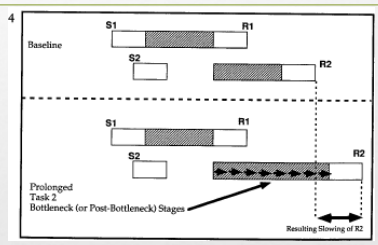
Strategy 2



Strategy 3



Strategy 4



Learning Objectives

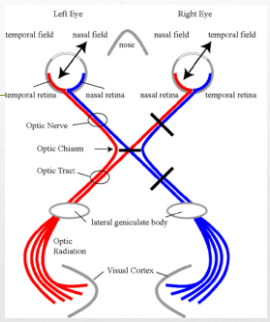
- **Where is the central bottleneck on the human brain?**
- Effects of extensive practice on dual-task interference
- Article presentation

Pashler, H., Luck, S. J., Hillyard, S. A., Mangun, G. R., O'Brien, S., & Gazzaniga, M. S. (1994). Sequential operation of disconnected cerebral hemispheres in split-brain patients. *Neuroreport*, *5*(17), 2381-2384.

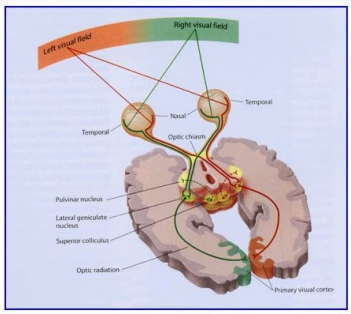
Where is the Central Bottleneck

- What are the neural substrates of dual-task interference?
- Dual-task interference is observed even with tasks involve different hemispheres.

http://humanphysiology.academy/Vision/Vision%202b.html

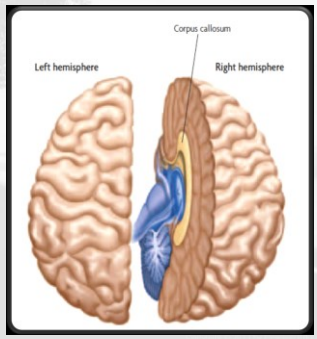


http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/V1/LGN-V1-slides/Slide4.jpg



Richard Gerrig, Psychology and Life, Figure 3.19, page 71

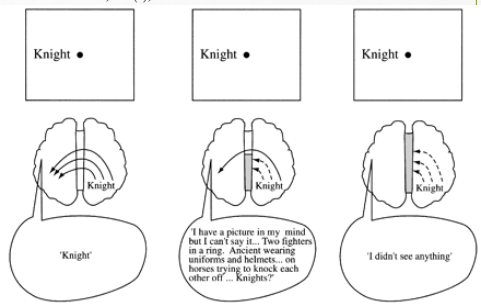
Corpus Callosum



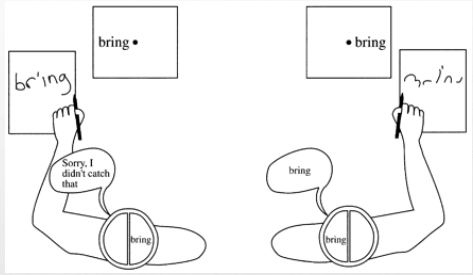
PSYCHOLOGY AND LIFE • RICHARD J. GERRIG

PEARSON

Gazzaniga, M. S. (2000). Cerebral specialization and interhemispheric communication. *Brain*, *123*(7), 1293-1326.



Gazzaniga, M. S. (2000). Cerebral specialization and interhemispheric communication. *Brain*, *123*(7), 1293-1326.



Pashler, H., Luck, S. J., Hillyard, S. A., Mangun, G. R., O'Brien, S., & Gazzaniga, M. S. (1994). Sequential operation of disconnected cerebral hemispheres in split-brain patients. *Neuroreport*, *5*(17), 2381-2384.

Where is the Central Bottleneck

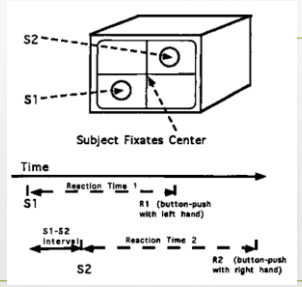
- What are the neural substrates of dual-task interference?
- Dual-task interference is observed even with tasks involve different hemispheres.

Pashler, H., Luck, S. J., Hillyard, S. A., Mangun, G. R., O'Brien, S., & Gazzaniga, M. S. (1994). Sequential operation of disconnected cerebral hemispheres in split-brain patients. *Neuroreport*, *5*(17), 2381-2384.

Where is the Central Bottleneck

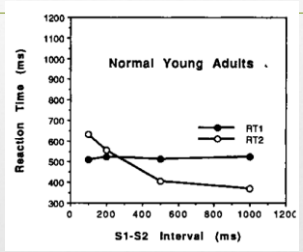
- If the dual-task interference depends higher-cortical functions
- Then this form of dual-task interference should be eliminated in split-brain patients

Pashler et al (1994) Method

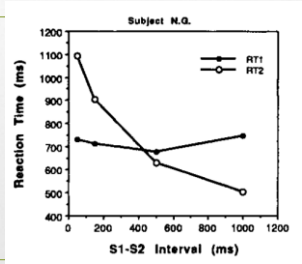


- Subjects responded to the location of the disk with their left hand (R1) and right hand (R2)

Pashler et al (1994) Method



Pashler et al (1994) Method



Pashler et al (1994) Conclusion

- The performance of the split-brain subjects was highly similar to that of the normal control group
- These results clearly demonstrate interference between the separated hemispheres, with response selection in one hemisphere delaying the response selection made by the other hemisphere.

Pashler et al (1994) Conclusion

- Intact **subcortical structures** mediate important aspects of behavioral integration

Learning Objectives

- Where is the central bottleneck on the human brain?
- **Effects of extensive practice on dual-task interference**
- Article presentation

Schumacher, E. H., Seymour, T. L., Glass, J. M., Fencsik, D. E., Lauber, E. J., Kieras, D. E., & Meyer, D. E. (2001). Virtually perfect time sharing in dual-task performance: Uncorking the central cognitive bottleneck. *Psychological Science*, *12*(2), 101-108.

Effects of Extensive Practice

- Dual task interference is observed when the S-R translation is not procedural
- Skilled performance use procedural knowledge in the form of condition-action production rules.
- Condition-action production rules can be executed in parallel
- There is no dual task interference for well-learned tasks

Schumacher et al (2001) Method

- **Audio Vocal (AV) Task:**
- Stimuli: Low, Medium and High Tones
- Response: Vocal Response 1, 2, 3
- **Visual Manual (VM) Task:**
- Stimuli: O-- -O- --O
- Response: Right index, middle and ring finger

Schumacher et al (2001) Method

- Dual-task: Both stimuli occur at the same time, participants performed two tasks simultaneously
- Heterogeneous single-task: One of the stimuli was presented, participants performed the respective task
- Heterogeneous single-task and dual task trials were interleaved

Schumacher et al (2001) Method

- Homogenous single-task: One of the stimuli was presented, participants performed the respective task
- There were different blocks of AV and VM trials for the homogenous single-task condition

Schumacher et al (2001) Method

- There were five experimental sessions
- By the end of Session 5 a participant had performed each task on 2064 trials.
- Participants were instructed to perform both tasks quickly and accurately

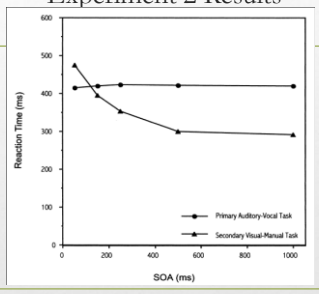
Schumacher et al (2001) Results

		Session			
Task	Trial type	2	3	4	5
Auditory-vocal	Dual task	725 (6.5)	566 (8.0)	507 (6.3)	456 (5.4)
	Heterogeneous single task	655 (5.3)	539 (7.7)	486 (4.0)	447 (3.3)
	Homogeneous single task	604 (3.5)	509 (5.2)	475 (2.2)	445 (3.1)
Visual-manual	Dual task	352 (2.4)	322 (4.0)	300 (3.5)	283 (5.6)
	Heterogeneous single task	338 (1.3)	310 (2.6)	292 (2.2)	282 (2.7)
	Homogeneous single task	306 (4.7)	294 (4.9)	287 (4.4)	279 (4.7)

Schumacher et al (2001) Experiment 2 Method

- The same participants participated in Experiment 2 after the Session 5
- A typical psychological refractory period manipulation was implemented
- The SOA between AV and VM task was manipulated
- Participants were instructed to perform both tasks quickly and accurately but treat the AV task as primary

Schumacher et al (2001) Experiment 2 Results



Schumacher et al (2001) Conclusion

- Psychological Refractory Period procedure produce dual-task interference
- But the source of interference is not a central bottle-neck
- The source of the interference is adaptive control of task schedules based on task instructions