What are the basic concepts about attention that each paper has discussed? What does that mean in terms of key principles of attention?

- Selective attention: people can selectively focus on specific dimensions or features in their environment (e.g., Middlebrooks paper), which can facilitate information processing (remembering the high value items better, because they prioritized them over the distractions that they had in the task).
- Shared attention: people can share attention when doing a similar task or engaging with each other (e.g., Kang & Wheatley: pupils of a listener will dilate in sync with a speaker telling an engaging story). Other researchers have participants work together on tasks. Another example is of children pointing an image and looking back at their parent, drawing joint attention to where they pointed.
- Divided attention: people show behavioral deficits when their attention isn't focused on a single task (e.g., Wechsler paper; they did more poorly in the multitasking than single task condition for many driving behaviors).
- People can strategically allocate their attention (e.g., Seli paper; mind-wandering while doing an easy task).
    - Attention is selective (based on many different features), capacity-limited, driven internally (e.g., endogenously through top-down goals or top-down prior experience) or captured externally (e.g., exogenously through bottom-up stimulus salience), covert (without moving the eyes) or overt (moving eyes).

What are tasks that are used to measure attention? What are their behavioral patterns? Think about both our discussions and demos in class and the papers you've read (Kang and Wheatley—pupil synchronization; Middlebrooks—divided attention; Wechsler—driving simulator; Seli—mind-wandering). Some topics include: multi-tasking, mind-wandering, selective attention, working memory, visual search, and neural measures. For the papers, think about *why* that method was used.

- Multi-tasking:
    - Task-switching
        - "Switch costs": people are slower and less accurate to respond when the task switches from the previous trial than when it repeats
        - From NPR Hidden Brain's "Life, Interrupted": you can think of this as a sort of attentional residue –switching between your mental representations of the rules and features for each task is cognitively demanding
        - We did a brief demo on this in class
    - Dual-tasking:
        - How does performance on the secondary task become affected as a function of the difficulty of the primary task?
        - We did a brief demo of this in class, with the moving dot and target detection task
        - Wechsler is also a version of this – they have participants do no additional tasks (control), multiple tasks (like memory, reasoning, typing tasks) while driving (supposedly automatic behavior), and multiple tasks without driving (other control). They look at how driving is impacted as a function of the difficulty of the "load" tasks (e.g., how much people sped up or

slowed down, variability in speed, veering from the road, variability in veering) – decrement in multi-tasking relative to doing a single task. They look at both primary and secondary task performance.
        - Why method: The driving simulator was useful to have specifically for relating this work to real-world behavior and scenarios.
    - Self-report:
        - Asking about how much people multitask, how much do they use media
- Mind-wandering:
    - Seli paper: mind-wandering probes while doing different tasks
        - The variation is in how people treat mind-wandering: intentional, unintentional, on-task vs. other characterizations (meandering, etc.)
        - Why method: Is there another way to measure mind-wandering? The strategy component came from the task being *predictable*.
            - You could think of the Kang and Wheatley paper as an extension of mind-wandering: if they could find pupil dilation synchrony when people were sharing attention for an engaging story, perhaps the future will involve looking at synchrony of neural signals – if no longer in sync, are they mind-wandering? Many kinks still to work out, of course, so this bullet is all speculation.
- Selective attention:
    - The Stroop task:
        - One version is the color-word Stroop: you are instructed to name the printed ink color while ignoring the word.
            - You are slower and less accurate to respond when the ink color is incongruent with the meaning of the word than when ink color is congruent with word meaning.
        - It demonstrates selective attention, because you are trying to selectively focus on the ink color, i.e., your top-down goal, while ignoring other features in the environment, i.e., bottom-up processing of the word meaning, via the automatic, overlearned reading response.
    - In the Middlebrooks paper, they tested selective attention by making certain stimuli worth more points. If participants paid attention to that dimension more so than other things (e.g., filtering out the music they were listening to; not monitoring the digits so well), they showed more later memory for the items worth more points. In other words, they *prioritized* one dimension or stimulus feature over others.
        - Why method: assigning different points to different items allowed them to see whether participants prioritized one dimension over another.
    - Dichotic listening task:
        - Instructed to pay attention to one ear, while ignoring what you hear in the other ear. Various manipulations have been made to the unattended stream to see what is selected early vs. late (Broadbent/Treisman/late), and how that is affected by context.
    - Not covered in class:
        - Simon task: Manipulates how location and response button align. E.g., people are slower and less accurate when the spatial location of the

stimulus on-screen is incongruent with the response location (i.e., left side paired with right button) than when they are congruent.
        - Flanker task: a target detection task where the target is surrounded by distractors or similar stimuli, e.g., press z when you see t and T is shown HHHTHHH (incongruent – distractors don't match the target) and TTTTTTT (congruent – distractors match the target).
        - And more…
- Working memory (holding things in mind; can think of it as internal attention):
    - N-back paradigm: remembering an image or word or stimulus that was presented N times ago in a sequence. 2-back means matching the images from 2 trials ago. This forces you to keep a sequence of images in mind.
        - We did a brief demo of this in class
    - Working memory capacity, like the digit span task—
        - They tell you a sequence of items to remember, like digits, and each time you report it correctly, they increase the sequence by one item; if you get it incorrectly, the decrease the sequence by one item. Until they can figure out on average how many items you can hold in your mind.
- Visual Search:
    - Single feature search: searching for a single feature in a display of images/features (e.g., vertical lines or red lines)
        - You don't vary in how fast you respond based on how many items are on screen (set size), because the single feature will "pop-out" to you (bottom-up processing – i.e., attention based on stimulus properties) and be processed in parallel with the items are on screen.
    - Conjunction search: searching for the conjunction or combination of two features in a display of images/features (e.g., red AND vertical lines)
        - You are much slower to respond, and how many items are on screen (set size) matter, because this is considered "serial processing": you have to look for one feature (does it match red lines) and then look for the other feature (does it match vertical lines) instead of all at once.
    - How we actually form a continuous experience (i.e., how individual features are bound together) is predicted by Treisman's Feature Integration Theory, which was often tested in visual search displays
- Neural measures:
    - Eye-tracking:
        - Last fixation, first fixation, duration of fixation, pupil dilation like in Kang and Wheatley article as a function of shared attention
            - Could Kang and Wheatley have used another method of shared attention? What would their experiment have looked like in fMRI (how would the design change)? What about EEG?

What happens when we don't attend to things?

- Inattentional blindness (change detection demos): not attending to something that is clearly visible

    - This doesn't mean our perceptual system is terrible. In fact, it's not advantageous to pay attention to everything given our capacity limitations, and our perceptual system focuses on what's most important.
- Sometimes we can't: Neglect syndrome
    - 'Neglect syndrome', or 'hemi-spatial neglect' is reflected in the patient's marked inability to attend to the left side of personal and extra-personal space (and even to internal, memory representations!). Importantly, these patients' eyesight and visual cortex function just fine, indicating that their specific deficit is attentional in nature.

Draw out the relationship between attention and arousal.

- Inverted u-shape

What do typical results from endogenous (top-down) and exogenous (bottom-up) cueing?

- Attention can be guided endogenously ('top-down', i.e. by our internal goals) or exogenously ('bottom-up', i.e. by salient stimulus features of the environment).
    - In a typical endogenous cuing study ('Posner task'), target detection times are fastest following valid cues, and slowest following invalid cues.
    - In a typical exogenous cueing study, people are faster when cued than uncued at the beginning (because attention was captured), but then slower when cued than uncued ~300 ms after the stimulus was presented (because attention has started to drift away from where they were cued).

How do these various paradigms and papers apply to the real-world?

- Cocktail party effect
- Visual search & cancer detection, visual search & TSA training
- Multitasking & driving, multitasking & studying
- The Stroop effect & spies, selectively attending to certain material for studying and strategizing for when to let your mind wander
- Everyday when we hear stories and sit in classrooms (shared attention)

Pick one of the four attention papers that we have covered so far. Think about a limitation in the study (beyond sample size) and decide on a future experiment to run addressing that limitation. Go farther than what you have in your reading worksheets: what would your future experiment tell you? What would your hypothesis be? Why would this experiment be important? You can use a different methodology than is used in the paper as well, but should justify the method.