Consciousness as a global workspace
In many respects, there is a strong contrast between the organization of the brain and that of consciousness.
Brain

• Billions of neurons, firing at an average rate of 40 nerve impulses/sec
• Dense interconnections: we can reach any single neuron from any other in less than seven steps!
• Processing is massively parallel and highly distributed
• Many specialized processors or modules that operate in a largely independent, fast, automatic, often mandatory, and inflexible fashion
• We could speak of a 'society of modules'
Brain: specialized modules

• Examples of specialized modules in reading:
  – letter and word identification
  – letter-to-phoneme mapping
  – eye-movement control
  – linguistic analyses such as
    • matching words to a mental lexicon
    • syntactic analysis
    • semantic analysis
Brain: specialized modules

• Important:
  These specialized modules operate unconsciously

→ call them USMs
  (unconscious specialized modules)
The Stroop effect:

Blue
Red
Green
Red
Blue
Green
Red
Blue
Green
Consciousness

- In contrast to the USMs, consciousness
  - is slow (calculate 15 x 15 x 15)
  - is serial (contents enter consciousness one-by-one)
  - has limited capacity (we can be conscious of only one content, e.g. one of two simultaneous spoken stories; one ball game on screen; only the currently rehearsed item in WM; we can execute only one action that demands consciousness)
  - is flexible (can adapt to novel situations)
  - is context-sensitive (responses can be adapted to context)
  - is relational, associative (can establish links between any two conscious contents → classical conditioning!)
What architecture could explain these largely opposite properties of the brain and consciousness?

Baars' answer: A Global Workspace
Global workspace (GW)

- The idea: Consciousness is a global workspace that serves to exchange and distribute information between different brain processors.
- Consciousness = central information exchange of the brain, the publicity organ of the brain.
- Consciousness makes information globally available for all the unconscious specialized modules and other brain processes.
- Consciousness creates access to many (all?) brain processors.
Consciousness creates access

- Simply by being conscious, information gains access to the vast collection of unconscious brain resources, such as USMs, memory stores etc.

- This is impressively demonstrated in (associative) learning: Simply by relating two (or more) items in consciousness, we learn them. Consciousness of something is all that is required to learn it. Completely unconscious learning, on the other hand, does not seem to be possible.

- Similarly, simply by consciously looking at pictures, we gain access to and can store them in the vast memory system of our brain
Consciousness creates access

- By simply being conscious of a problem, we access the problem-solving machinery of our brain, which will unconsciously deal with the problem, and, if we're lucky, come up with a solution and present it to consciousness.
- Another impressive demonstration of global access is the fact that conscious biofeedback enables access to virtually every brain system, from alpha waves to single neurons.
Global workspace

- On the input side, many contents, inputs, or stimuli compete for access to the global workspace= consciousness, but only one content at a time can become conscious

- limited capacity, serial, slow

- Attention is the mechanism that selects which content gets access to consciousness
Consciousness

- potentially conscious contents
- bottleneck (attention)
- global distribution or access
- input competition
- brain processors (USMs etc.)
GW as a theater

• This is the basic idea of the global workspace: input competition and global distribution of information in consciousness

• But the complete GW model has more features, which Baars has summarized into a neat and powerful metaphor: the theater metaphor of consciousness
### Context operators behind the scenes

<table>
<thead>
<tr>
<th>Director</th>
<th>Spotlight Controller</th>
<th>Local Contexts</th>
</tr>
</thead>
</table>

Competing for access to consciousness:

- **Outer Senses**
  - Seeing
  - Hearing
  - Feeling
  - Tasting
  - Smelling
  - Submodalities
  - Heat
  - Vibration

- **Inner Senses**
  - Visual Imagery
  - Inner Speech
  - Dreams
  - Imagined Feelings

- **Ideas**
  - Imaginal Ideas
  - Verbalized Ideas
  - Fringe Conscious Intuitions

---

...the spotlight of attention shining on the stage of working memory...

Working memory receives conscious input, controls inner speech, uses imagery for spatial tasks, all under voluntary control.

### Memory systems:

- **Lexicon**
- **Semantic networks**
- **Autobiographical & declarative memory**
  - Beliefs, knowledge of the world, of oneself and others.

- **Interpreting conscious contents:**
  - Recognizing objects, faces, speech, events.
  - Syntactic analysis.
  - Spatial relationships.
  - Social inferences.

### Automatisms:

- **Skill memory.**
- **Details of language, action control, reading, thinking, and thousands more...**
Elements of the theater: actors & the spotlight

• The actors correspond to the many contents that compete for consciousness.
• Only the actor in the spotlight, however, is conscious.
• The spotlight corresponds to attention ('spotlight of attention'). As we saw last time: attention creates consciousness. We become conscious of what we focus our attention on.
• The actor in the spotlight announces his message to the large audience in the darkness of the theater hall.
Elements of the theater: the audience

- The audience is unconscious. It corresponds to all the unconscious processors in the brain. Most notable are the unconscious specialized modules (USMs) we met before. The message proclaimed by the actor in the spotlight is globally broadcast to all these modules.

- It is important to note that not all the USMs respond to the global message. Only those that can "read" the global message will respond to it. So each module decides locally what to do with the global message.

- A USM will respond to the global message if it can read it, and if the message is novel and informative. In that case, the USM will adapt to the novel information. After that the information becomes redundant and the USM will habituate and no longer respond. If the information changes again, the USM will dishabituate.
Elements of the theater:

the audience

• Other elements of the audience are memory systems, as e.g. those related to vocabulary, syntax, meaning, autobiographical events, knowledge, beliefs etc, or motivational and emotional systems
Elements of the theater:
the fringe

• Around the center of the spotlight there is a fringe. It corresponds to those contents that are only vaguely conscious. These could be feelings of knowing something, of familiarity, beauty, goodness, or rightness. Fringe events are somehow conscious, but we can't tell exactly how we experience them.

• The qualia associated with fringe events are unclear, fuzzy, vague
Elements of the theater:
the fringe

focus your gaze and your attention here

these elements are fringe conscious
Elements of the theater: the stage

- The theater stage corresponds to working memory (WM)
- As we saw last time, items in WM can be made conscious immediately, they are held in an active temporary information store
- As we also saw, however, only the currently rehearsed item in WM is actually conscious. This item corresponds to the actor in the spotlight, whose message is conscious.
Elements of the theater: actors competing for access to the stage

- The actors competing for access to the stage are the many unconscious contents that could potentially become conscious.
- These include sensory stimuli, visual imagery, inner speech, emotional feelings, thoughts and ideas.
Elements of the theater: backstage

• Behind the scenes many unseen operators control or influence what is going on on stage
• These operators include a director, a spotlight controller and local contexts
• Less metaphorically speaking, these context operators correspond to processes that are themselves unconscious, but shape our conscious experience
Elements of the theater: backstage: director

- Note that the global workspace itself is not an executive, it does not itself decide which contents become conscious and are globally distributed
- The global workspace is controlled by executive systems in the brain that use it to achieve goals for which consciousness is required (e.g. learning)
Elements of the theater: 
backstage: spotlight controller

- Attention is what controls the spotlight (or maybe attention is the spotlight)
- Attention can be controlled either consciously or, very often, unconsciously
Elements of the theater: backstage: contexts

• Contexts are by far the most varied and numerous unconscious sources that constrain conscious experience.

• Every unconscious process or state that shapes the way in which we consciously experience something is called a context.

• Contexts are by definition unconscious. They can, however, be made conscious, but then they cease to be contexts.
Elements of the theater: backstage: contexts

• Examples for contexts are beliefs, expectations, conceptual and perceptual assumptions, knowledge, intentions, emotional dispositions, etc.
• Baars also sees the self as a context
• Consciousness can also create new contexts. A simple example are instructions subjects receive in a psychological task.
Unconscious contexts: examples and demos

- Priming effects (mentioned last week): it is well established that unconscious information can influence consciousness. E.g. the conscious interpretation of an ambiguous target word can be influenced by very briefly and unconsciously presenting a disambiguating word before the target word.