Attention and spatial orientation

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May 13th , 2024

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2.2 Hemispatial neglect

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Attention

Theories and conceptual clarifications

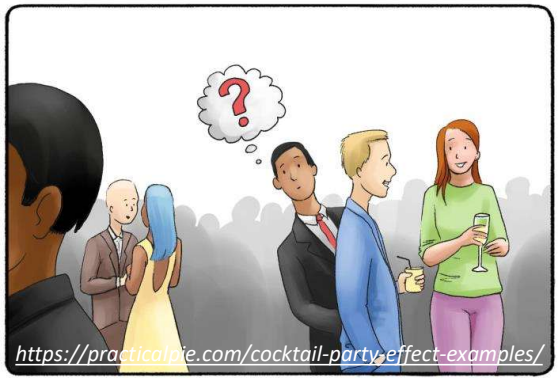
Attention is limited and selective

attention

the process by which certain information is **selected** for further processing and other information is **discarded**

selective attention

the process of directing our **awareness** to relevant stimuli while ignoring irrelevant stimuli in the environment



https://practicalpie.com/cocktail-party-effect-examples/

the cocktail party effect

the ability to selectively **attend to** a particular sound (e.g., voice) when it is **masked** by surrounding noise (e.g., other voices, such as during a party)

THE JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA VOLUME 25, NUMBER 5 SEPTEMBER, 1953

Some Experiments on the Recognition of Speech, with One and with Two Ears*

E. COLIN CHERRY
Imperial College, University of London, England, and Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Massachusetts

(Received May 5, 1953)

This paper describes a number of objective experiments on recognition, concerning particularly the relation between the messages received by the two ears. Rather than use steady tones or clicks (frequency or time-point signals) continuous speech is used, and the results interpreted in the main statistically.

Two types of test are reported: (a) the behavior of a listener when presented with two speech signals simultaneously (statistical filtering problem) and (b) behavior when different speech signals are presented to his two ears.

2. THE SEPARATION OF TWO SIMULTANEOUSLY SPOKEN MESSAGES

The first set of experiments relates to this general problem of speech recognition: how do we recognize what one person is saying when others are speaking at the same time (the "cocktail party problem")? On what logical basis could one design a machine ("filter") for carrying out such an operation? A few of the factors which give mental facility might be the following:

(a) The voices come from different directions.
(b) Lip-reading, gestures, and the like.
(c) Different speaking voices, mean pitches, mean speeds, male and female, and so forth.
(d) Accents differing.
(e) Transition-probabilities (subject matter, voice dynamics, syntax. . .).

https://pure.mpg.de/rest/items/item_2309493_5/component/file_2309492/content

The cocktail party effect in infants

Rochelle S. Newman ✉ & Peter W. Jusczyk

Perception & Psychophysics **58**, 1145–1156 (1996) | Cite this article

Abstract

Most speech research with infants occurs in quiet laboratory rooms with no outside distractions. However, in the real world, speech directed to infants often occurs in the presence of other competing acoustic signals. To learn language, infants need to attend to their caregiver's speech even under less than ideal listening conditions. We examined 7.5-month-old infants' abilities to selectively attend to a female talker's voice when a male voice was talking simultaneously. In three experiments, infants heard a target voice repeating isolated words while a distractor voice spoke fluently at one of three different intensities. Subsequently, infants heard passages produced by the target voice containing either the familiar words or novel words. Infants listened longer to the familiar words when the target voice was 10 dB or 5 dB more intense than the distractor, but not when the two voices were equally intense. In a fourth experiment, the assignment of words and passages to the familiarization and testing phases was reversed so that the passages and distractors were presented simultaneously during familiarization, and the infants were tested on the familiar and unfamiliar isolated words. During familiarization, the passages were 10 dB more intense than the distractors. The results suggest that this may be at the limits of what infants at this age can do in separating two different streams of speech. In conclusion, infants have some capacity to extract information from speech even in the face of a competing acoustic voice.

https://link.springer.com/article/10.3758/BF03207548

Cocktail–party effect in king penguin colonies

Thierry Aubin and Pierre Jouventin

Published: 07 September 1998 | https://doi.org/10.1098/rspb.1998.0486

Abstract

The king penguin, *Aptenodytes patagonicus*, breeds without a nest in colonies of several thousands of birds. To be fed, the chick must recognize the parents in a particularly noisy environment using only vocal cues. The call an adult makes when seeking the chick is emitted at a high amplitude level. Nevertheless, it is transmitted in a colonial context involving the noise generated by the colony and the screening effect of the bodies, both factors reducing the signal–to–noise ratio. In addition, the adult call is masked by a background noise with similar amplitude and spectral and temporal characteristics, enhancing the difficulty for the chick in finding its parents. We calculate that the maximum distance from the caller at which its signal can be differentiated from the background noise (signal–to–noise ratio equal to 1) should not exceed 8–9 m in a feeding area. But our tests show that, in fact, chicks can discriminate between the parental call and calls from other adults at a greater distance, even when call intensity is well below that of the noise of simultaneous calls produced by other adults. This capacity to perceive and extract the call of the parent from the ambient noise and particularly from the calls of other adults, termed the 'cocktail–party effect' in speech intelligibility tests, enhances the chick's ability to find its parents.

https://royalsocietypublishing.org/doi/abs/10.1098/rspb.1998.0486

Cocktail Party Effect

https://www.youtube.com/watch?v=mN--nV61gDo

King Penguins

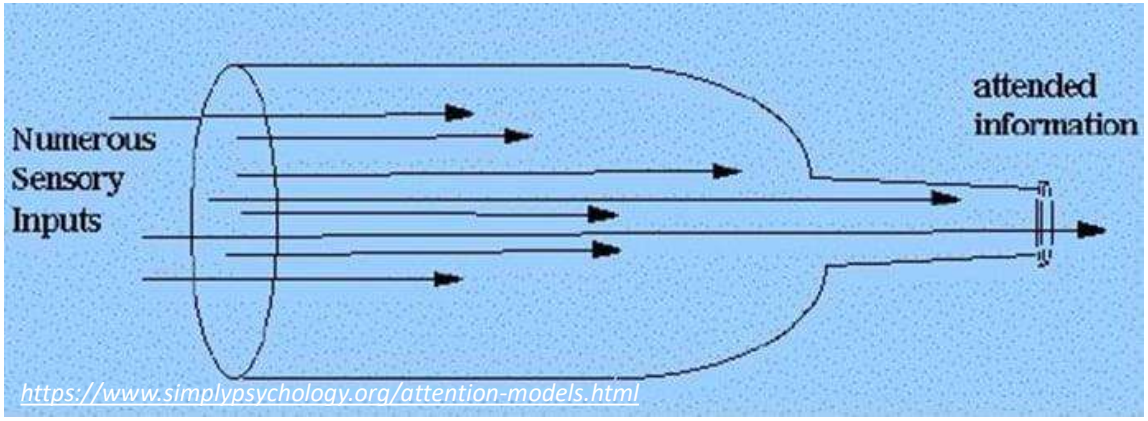
https://www.youtube.com/watch?v=CJC2nWNSWsc

Theories of selective attention

Early theories proposed a so-called **“bottleneck model”** of selective attention.

“When imagining a standard bottle placed horizontally, a large amount of fluid is allowed inside, but, as the opening becomes narrower, smaller amounts of fluid are allowed to pass through the neck, depending on the rate of flow. “

Bater & Jordan, (2019)
https://link.springer.com/referenceworkentry/10.1007/978-3-319-28099-8_1904-1



https://www.simplypsychology.org/attention-models.html

Bottleneck models => focus on *flow* and *filtering* of information

Broadbent's Filter Model (Broadbent, 1958)

Deutsch & Deutsch's Late Selection Theory (Deutsch & Deutsch, 1963)

Treisman's Attenuation Model (Treisman, 1964)

Load theories => address *perceptual* and *cognitive load*

Lavie's Perceptual Load Theory (Lavie and Tsal, 1994)

Tsal & Benoni's Dilution Theory (Tsal and Benoni, 2010)

Hybrid Theory (Murphy et al. 2016; Scalf et al. 2013)

perceptual load

physical properties of a stimulus

cognitive load

the **internal resources** or executive functioning abilities **required** to perform a task

Bottleneck Models

Filter Model (Broadbent, 1958)

=> physical characteristics of input stimuli enter the **sensory buffer** (the large part of the bottleneck), but only few stimuli enter the **selective filter**, where they will be further processed and committed to memory. **BUT** people pay attention when their name is mentioned in a noisy environment (cocktail party) => stimuli are analysed before they are filtered out (McLeod, 2018).

Late Selection Theory (Deutsch & Deutsch, 1963)

=> switched the order of the perceptual processes and the selective filter => **all stimuli are analysed for meaning**, **BUT not all stimuli are allowed to pass the filter**. It is both the physical characteristics and the relevance of the stimuli's meaning that explains why some stimuli are selected while others are discarded.

Attenuation Theory (Treisman, 1964)

=> the stimuli are **not filtered**, but **are attenuated** or enter into the sensory register at a lower intensity and are therefore given meaning early on.

Load Theories

Perceptual Load Theory (Lavie and Tsal 1994)

=> disregarded the idea of a filter, focusing instead on the processing demands of the task at hand => the amount of perceptual and cognitive load regulates how effectively stimuli are selectively attended to (i.e., when perceptual load is high, irrelevant distractors are less likely to be processed). **BUT** **perceptual load** (i.e., the difficulty of a task arising from stimulus complexity and/or presentation brevity) was difficult to reliably define and hence experimentally test.

Dilution Theory (Tsal & Benoni, 2010)

=> support for the perceptual load theory within the literature is due to the **dilution** of the irrelevant stimuli's interference (i.e., the reduction in distractor processing in a high perceptual load task is caused by the dilution of distractor interference rather than by the unavailability of perceptual resources).

Hybrid Theory (Murphy et al. 2016; Scalf et al. 2013)

=> reinforces the original view that **low perceptual load** is associated with **a stronger impact** of task-**irrelevant** information. This might reflect different processing strategies in conditions with high and low perceptual load: while low perceptual load might allow for **bottom-up**-driven target selection, high perceptual load might call for **top-down** regulation. The latter leads to stronger filtering, which reduces the impact of task-irrelevant distractors.

The first thing that we may roughly conclude from these theories is that attentional processes are subject to both bottom-up and top-down properties. Namely, some **physical stimulus properties** may make a stimulus more **salient**, however **personally relevant** aspects of a stimulus (e.g., one's own name) may override the **attentional capture** potential of an otherwise more salient stimulus.

salience

the property of a stimulus to stand out (or **pop out**)

J Neurosci. 2020 Jul 8;40(28):5455-5464. doi: 10.1523/JNEUROSCI.1198-19.2020. Epub 2020 May 29.

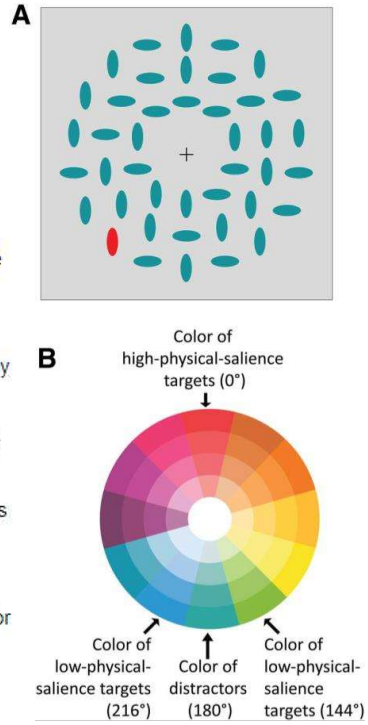
Physical Salience and Value-Driven Salience Operate through Different Neural Mechanisms to Enhance Attentional Selection

Matthew D Bachman [1], Lingling Wang [1], Marissa L Gamble [1], Marty G Woldorff [2]

Abstract

Previous studies have indicated that both increased physical salience and increased reward-value salience of a target improve behavioral measures of attentional selection. It is unclear, however, whether these two forms of salience interact with attentional networks through similar or different neural mechanisms, and what such differences might be. We examined this question by separately manipulating both the value-driven and physical salience of targets in a visual search task while recording response times (RTs) and event-related potentials, focusing on the attentional-orienting-sensitive N2pc event-related potential component. Human participants of both sexes searched arrays for targets of either a high-physical-salience color or one of two low-physical-salience colors across three experimental phases. The first phase ("baseline") offered no rewards. RT and N2pc latencies were shorter for high-physical-salience targets, indicating faster attentional orienting. In the second phase ("equal-reward"), a low monetary reward was given for fast correct responses for all target types. This reward context improved overall performance, similarly shortening RTs and enhancing N2pc amplitudes for all target types, but with no change in N2pc latencies. In the third phase ("selective-reward"), the reward rate was made selectively higher for one of the two low-physical-salience colors, resulting in their RTs becoming as fast as the high-physical-salience targets. Despite the equally fast RTs, the N2pc's for these low-physical-salience, high-value targets remained later than for high-physical-salience targets, instead eliciting significantly larger N2pc's. These results suggest that enhanced physical salience leads to faster attentional orienting, but value-driven salience to stronger attentional orienting, underscoring the utilization of different underlying mechanisms.

https://www.jneurosci.org/content/40/28/5455



bottom-up (exogenous) attention

- **passive**, **transient**, **automatic**, **stimulus-driven** process;
- driven by stimulus **properties** (e.g., colour, orientation);
- can capture attention **despite** observer's **intentions**;
- is deployed when **salient novel** stimuli are presented;
- is often **difficult to ignore**;
- works via signal **enhancement** of relevant signals;
- can trigger **attentional reorienting** in 100-120 ms.

top-down (endogenous) attention

- **voluntary**, **sustained**, **goal-driven** process;
- information that aligns with an observer's behavioural **goals** are **internally selected** for further processing;
- more **effortful**;
- operates via **enhancement** of relevant signals and **reduction** of irrelevant signals;
- can trigger **attentional reorienting** in 300 ms.

Depending on the task demands, attention can be **deployed** according to either **endogenous** or **exogenous** mechanisms. Despite certain stimuli being salient, our task goal may cause us to completely miss them, as in the case of inattentional blindness (Simons & Chabris, 1999, *https://psycnet.apa.org/record/1999-15804-001*), and the related phenomenon of change blindness (Rensink et al., 1997; Simons & Levin, 1998, *https://psycnet.apa.org/record/1999-00559-007*).

https://www.youtube.com/watch?v=vJG698U2Mvo

https://www.youtube.com/watch?v=FWSxSQsspiQ

slido

Did you notice the gorilla?

ⓘ Start presenting to display the poll results on this slide.

Feature Integration Theory (Treisman, 1988; Treisman & Gelade, 1980)

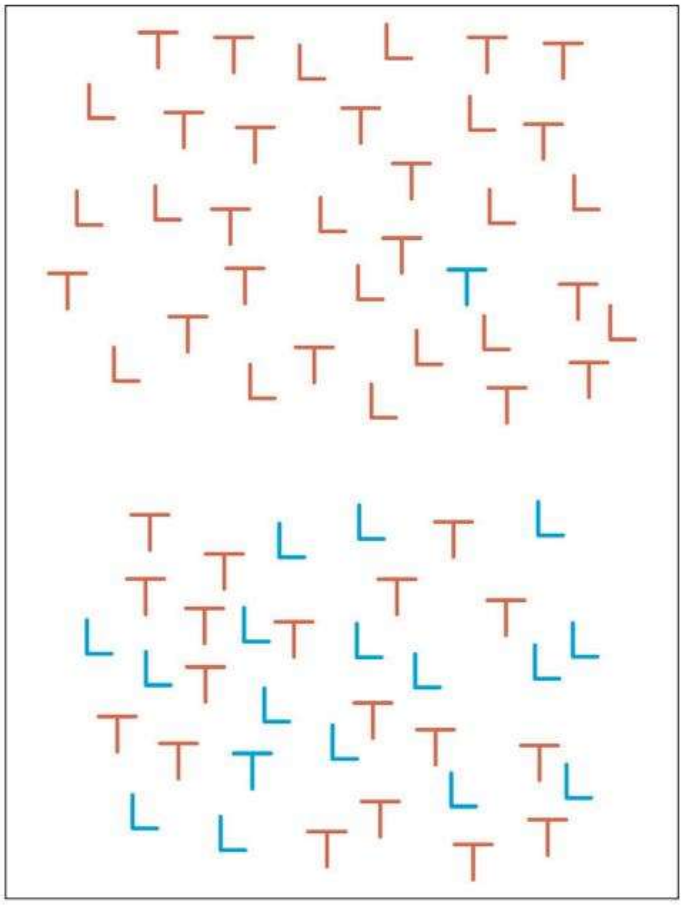


FIGURE 9.14: Try to find the blue "T" as quickly as possible. Why is one condition harder than the other? Feature integration theory assumes that basic features are coded in parallel but that focused attention requires serial search. When the letter differs from others by a single feature, such as color, it can be identified quickly by the initial stage of feature detection. When the letter differs from others by two or more features, attention is needed to serially search.

Feature Integration Theory

individual features (e.g., shape, colour) are processed **early**, and in **parallel**, but attention is required to **bind** these and identify a target object

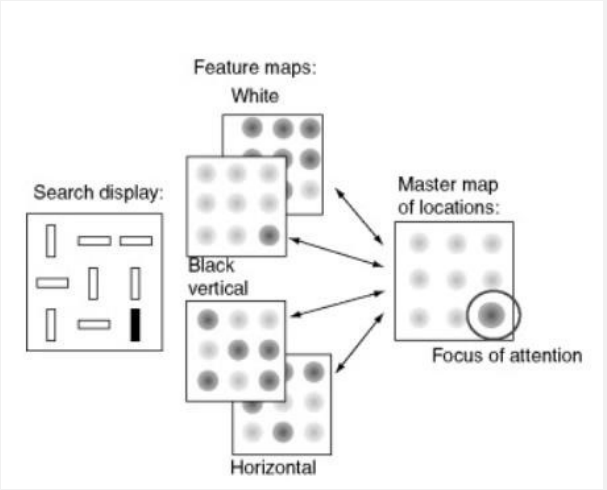
If an object does not share features with other objects in the array it appears to **pop out**. In the second array, the distractors are made up of the same features that define the object. Thus, the object cannot be detected by inspecting the color module alone (because some distractors are blue) or by inspecting the shape module alone (because some distractors are T-shaped). To detect the target one needs to bring together information about several features (i.e., a conjunction of color and shape). FIT assumes that this occurs by allocating spatial attention to the location of candidate objects. If the object turns out not to be the target, then the "spotlight" inspects the next candidate and so on in a serial fashion.

Ward, (2020), p. 217

Information outside of the **spotlight** is presumed not to receive processing that requires attention.

FIGURE 9.3: Attention has been likened to a spotlight that highlights certain information or a bottleneck in information processing. But how do we decide which information to select and which to ignore?

Ward, (2020), page 205



In FIT, stimuli are disassembled into their component features and represented in multiple 'feature maps,' which all feed into a 'master map of locations.' Visual attention must be directed to a position in the master map to extract all the features corresponding to this position and bind them together in a single object representation. In the original theory proposed by Anne Treisman and G. Gelade, location information was exclusively confined to the master map.
Later variants and extensions of the theory differ in the way they allow positional information to be encoded within the feature maps themselves, making them more plausible physiologically.

Schmidt, (2009)
https://www.sciencedirect.com/science/article/abs/pii/B9780123738738000591

covert orienting

moving attention **without** moving the eyes or head

overt orienting

moving the eyes or head **along with** the focus of attention

Attention

Neural substrates of attention

Published: 01 March 2002

Control of goal-directed and stimulus-driven attention in the brain

Maurizio Corbetta ✉ & Gordon L. Shulman

Nature Reviews Neuroscience **3**, 201–215 (2002) | Cite this article

Key Points

- This review proposes that two networks of brain areas are involved in controlling attention. One network is primarily responsible for applying cognitive, top-down selection for stimuli and responses, whereas the other detects behaviourally relevant stimuli and might act as a 'circuit breaker' for the first system.

- Humans use cognitive information to direct attention to relevant objects (targets) in a visual scene. Information such as the target's colour or location is represented as a 'perceptual set'. Similarly, advance information about the required response to a target is represented as a 'motor set'. These can be considered together as an 'attentional set', which aids the detection of and response to targets.

- Such top-down control of attentional processes activates dorsal posterior parietal and frontal regions of the brain bilaterally in both monkeys and humans. This dorsal frontoparietal system is responsible for the generation of attentional sets.

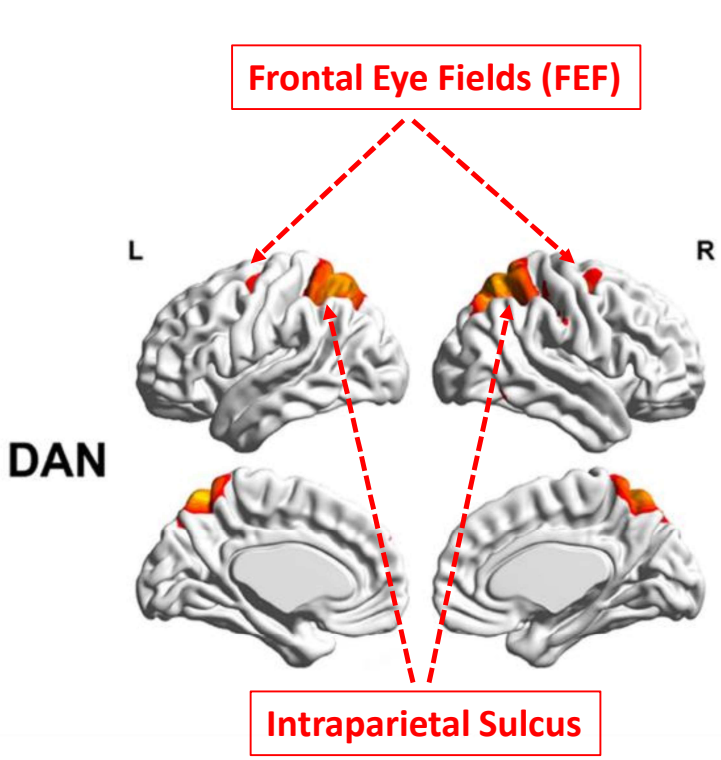
- Attention can also be driven by stimulus properties rather than cognitive processes. This 'bottom-up' control of attention explains why we find ourselves drawn to 'oddball' stimuli that are very different from the background, or to salient stimuli that share some sensory features, such as colour, with the target for which we are searching. The dorsal frontoparietal system seems to maintain a 'salience map' that combines bottom-up with top-down information during visual search.

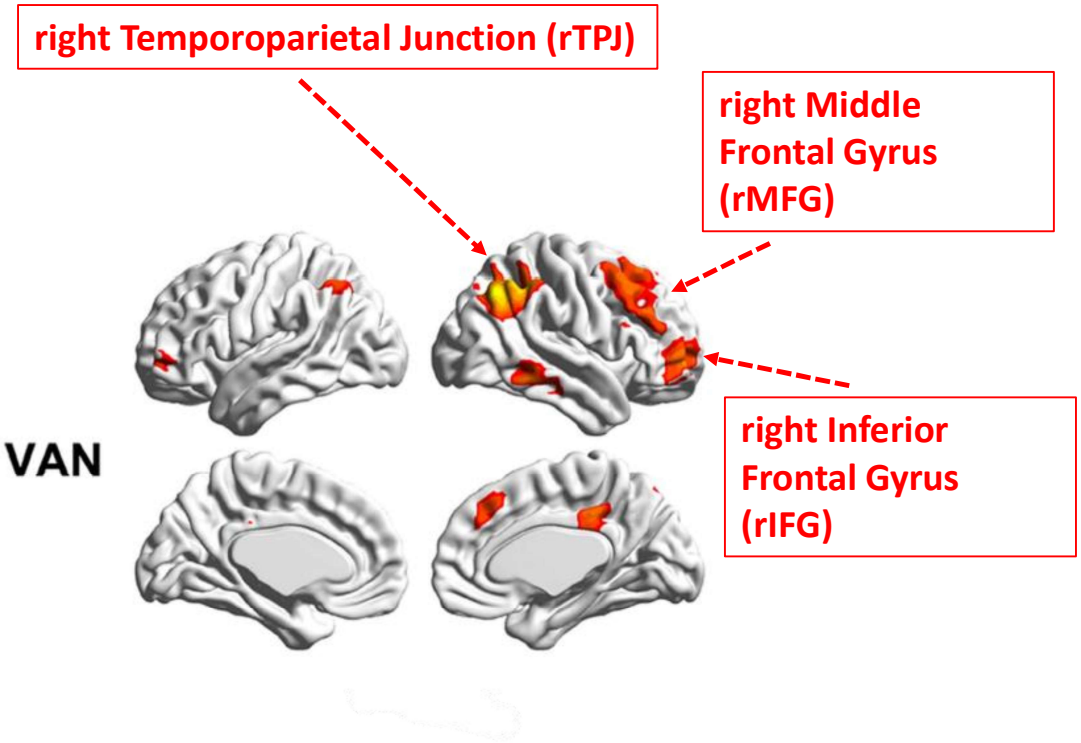
- Potentially important sensory stimuli, such as loud alarms or sudden movement, can attract our attention regardless of the ongoing task. This sensory orienting process seems to be mediated by the second attentional network, which is mainly lateralized to the right side of the brain and includes the temporoparietal junction and the ventral frontal cortex. This network seems to interrupt ongoing cognitive activity when a stimulus that might be behaviourally important is detected.

- These two networks could interact in humans to control attention. It is possible that damage to these networks is responsible for the syndrome of neglect, in which patients that have suffered damage to the right side of the brain tend to ignore stimuli on the left side of space. The authors suggest that neglect results from damage to the ventral network that also 'functionally inactivates' the dorsal network.

https://www.nature.com/articles/nrn755

The frontal-parietal attention network





Dorsal Attention Network (DAN)

- bilateral frontal eye fields (FEF)

- bilateral intraparietal sulcus

Images adapted from
Xia et al. (2015), https://pubmed.ncbi.nlm.nih.gov/26053355/

Ventral Attention Network

- right temporoparietal junction (rTPJ)

- right ventral frontal cortex (rVFC), comprising the right middle frontal gyrus (rMFG) and the right inferior frontal gyrus (rIFG)

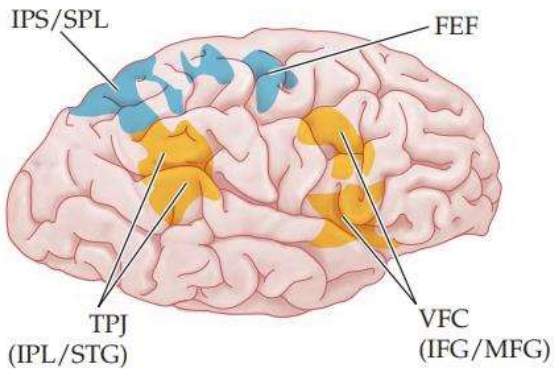


FIGURE 29.6 A postulated attentional control network, illustrated in the right hemisphere. The areas in blue indicate the dorsal frontal-parietal regions that tend to be activated by endogenous stimuli; the areas in yellow indicate the more ventral regions that tend to be activated during reorienting, and by exogenous stimuli. IPS/SPL = interparietal sulcus/superior parietal lobule; FEF = frontal eye fields; TPJ = temporal–parietal junction; IPL/STG = inferior parietal lobule/superior temporal gyrus; VFC = ventral frontal cortex; IFG/MFG = inferior frontal gyrus/middle frontal gyrus. (After Corbetta and Shulman, 2002.)

Purves et al. (2018), p. 675

the DAN (blue in the figure on the left)
is modulated by **top-down** attentional processes
(e.g., when we look for a stimulus which is task relevant).
For example, the DAN is more active during trials where the **target is present** than absent, and its activity decreases once the target has been localized (even if visual stimuli are still present).

the VAN (yellow in the figure on the left)
is modulated by **unexpected (i.e., "oddball")** stimuli which are not task relevant, but may bear other type of **relevance** (e.g., the fire alarm).

Attention deficit hyperactivity disorder (ADHD)

DSM-5 Criteria for ADHD (*https://www.cdc.gov/ncbddd/adhd/diagnosis.html*)

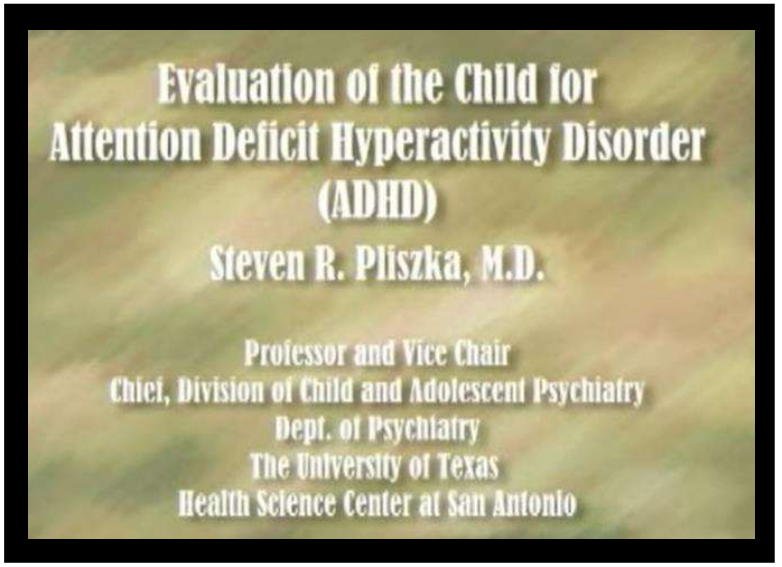
People with ADHD show a persistent pattern of inattention and/or hyperactivity–impulsivity that interferes with functioning or development

A. Inattention: Six or more symptoms of inattention for children up to age 16 years, or five or more for adolescents age 17 years and older and adults; symptoms of inattention have been present for at least 6 months, and they are inappropriate for developmental level:

1. Often **fails to give close attention to details** or makes careless mistakes in schoolwork, at work, or with other activities.
2. Often **has trouble holding attention** on tasks or play activities.
3. Often **does not seem to listen** when spoken to directly.
4. Often **does not follow through on instructions** and fails to finish schoolwork, chores, or duties in the workplace (e.g., loses focus, side-tracked).
5. Often **has trouble organizing tasks** and activities.
6. Often avoids, dislikes, or is reluctant to do tasks that require mental effort over a long period of time (such as schoolwork or homework).
7. Often loses things necessary for tasks and activities (e.g. school materials, pencils, books, tools, wallets, keys, paperwork, eyeglasses, mobile telephones).
8. Is often **easily distracted**.
9. Is often forgetful in daily activities.

B. Hyperactivity and Impulsivity: Six or more symptoms of hyperactivity-impulsivity for children up to age 16 years, or five or more for adolescents aged 17 years and older and adults; symptoms of hyperactivity-impulsivity have been present for at least 6 months to an extent that is disruptive and inappropriate for the person's developmental level

1. Often **fidgets** with or taps hands or feet, or squirms in seat.
2. Often **leaves seat** in situations when remaining seated is expected.
3. Often **runs about or climbs** in situations where it is not appropriate (adolescents or adults may be limited to **feeling restless**).
4. Often unable to play or take part in leisure activities quietly.
5. Is often "on the go" acting **as if "driven by a motor".**
6. Often **talks excessively**.
7. Often blurts out an answer before a question has been completed.
8. Often **has trouble waiting their turn.**
9. Often **interrupts** or intrudes on others (e.g., butts into conversations or games).



https://www.youtube.com/watch?v=F1WqpeRSY-E

Neuroimaging findings

Front Psychiatry. 2022; 13: 1070142.
Published online 2023 Jan 6. doi: 10.3389/fpsyt.2022.1070142
PMCID: PMC9853532
PMID: 36683981

Meta-analysis of structural and functional alterations of brain in patients with attention-deficit/hyperactivity disorder

Miaomiao Yu, [1,2,3,4,5,6,7] Xinyu Gao, [1,2,3,4,5,6,7] Xiaoyu Niu, [1,2,3,4,5,6,7] Mengzhe Zhang, [1,2,3,4,5,6,7] Zhengui Yang, [1,2,3,4,5,6,7] Shaoqiang Han,✉ [1,2,3,4,5,6,7,*] Jingliang Cheng,✉ [1,2,3,4,5,6,7,*] and Yong Zhang✉ [1,2,3,4,5,6,7,*]

Methods

We conducted an extensive literature search of whole-brain voxel-based morphometry (VBM) and functional magnetic resonance imaging (fMRI) studies associated with ADHD. Two separate meta-analyses with the seed-based d mapping software package for functional neural activation and gray matter volume (GMV) were carried out, followed by a joint analysis and a subgroup analysis.

Results

This analysis included 29 VBM studies and 36 fMRI studies. Structurally, VBM analysis showed that the largest GMV diminutions in patients with ADHD were in several frontal-parietal brain regions, the limbic system, and the corpus callosum. Functionally, fMRI analysis discovered significant hypoactivation in several frontal-temporal brain regions, the right postcentral gyrus, the left insula, and the corpus callosum.

Conclusion

This study showed that abnormal alterations in the structure and function of the left superior frontal gyrus and the corpus callosum may be the key brain regions involved in the pathogenesis of ADHD in patients and may be employed as an imaging metric for patients with ADHD pending future research. In addition, this meta-analysis discovered neuroanatomical or functional abnormalities in other brain regions in patients with ADHD as well as findings that can be utilized to guide future research.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9853532/

Neurosci Biobehav Rev. 2019 May; 100: 1–8.
Published online 2019 Feb 18. doi: 10.1016/j.neubiorev.2019.02.011

Brain alterations in children/adolescents with ADHD revisited: A neuroimaging meta-analysis of 96 structural and functional studies

Fateme Samea,[a] Solmaz Soluki,[a] Vahid Nejati,[a,b,1] Mojtaba Zarei,[c] Samuele Cortese,[d,e,f,g] Simon B. Eickhoff,[h,i] Masoud Tahmasian,[c,*,1] and Claudia R. Eickhoff[i,j,k]

Abstract

Go to:

The findings of neuroimaging studies in children/adolescents with ADHD, and even those of previous metaanalyses, are divergent. Here, Activation Likelihood Estimation meta-analysis, following the current best-practice guidelines, was conducted. We searched multiple databases and traced the references up to June 2018. Then, we extracted the reported coordinates reflecting group comparison between ADHD and healthy subjects from 96 eligible studies, containing 1914 unique participants. The analysis of pooled structural and functional, subanalyses restricted to modality, and in-/decreased contrast did not yield any significant findings. However, further sub-analyses in the task-fMRI experiments (neutral stimuli only) led to aberrant activity in the left pallidum/putamen and decreased activity (male subjects only) in the left inferior frontal gyrus. The overall findings indicate a lack of regional convergence in children/adolescents with ADHD, which might be due to heterogeneous clinical populations, various experimental design, preprocessing, statistical procedures in individual publications. Our results highlight the need for further high-powered investigations, but may also indicate ADHD pathophysiology might rest in network interactions rather than just regional abnormality.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7966818/

Review > Psychol Med. 2019 Nov;49(15):2475-2485. doi: 10.1017/S003329171900237X. Epub 2019 Sep 10.

Impairments of large-scale functional networks in attention-deficit/hyperactivity disorder: a meta-analysis of resting-state functional connectivity

Yingxue Gao [1], Dandan Shuai [1], Xuan Bu [1], Xinyu Hu [1], Shi Tang [1], Lianqing Zhang [1], Hailong Li [1], Xiaoxiao Hu [1], Lu Lu [1], Qiyong Gong [1 2], Xiaoqi Huang [1 2]

Affiliations + expand

PMID: 31500674 DOI: 10.1017/S003329171900237X

Abstract

Altered resting-state functional connectivity (rsFC) has been noted in large-scale functional networks in attention-deficit/hyperactivity disorder (ADHD). However, identifying consistent abnormalities of functional networks is difficult due to varied methods and results across studies. To integrate rsFC alterations and search for coherent patterns of intrinsic functional network impairments in ADHD, this research conducts a coordinate-based meta-analysis of voxel-wise seed-based rsFC studies comparing rsFC between ADHD patients and healthy controls. A total of 25 datasets from 21 studies including 700 ADHD patients and 580 controls were analyzed. We extracted the coordinates of seeds and between-group effects. Each seed was then categorized into a seed-network by its location within priori 7-network parcellations. Then, pooled meta-analyses were conducted for the default mode network (DMN), frontoparietal network (FPN) and affective network (AN) separately, but not for the ventral attention network (VAN), dorsal attention network (DAN), somatosensory network (SSN) and visual network due to a lack of primary studies. The results showed that ADHD was characterized by hyperconnectivity between the FPN and regions of the DMN and AN as well as hypoconnectivity between the FPN and regions of the VAN and SSN. These findings not only support the triple-network model of pathophysiology associated with ADHD but also extend this model by highlighting the involvement of the SSN and AN in the mechanisms of network interactions that may account for motor hyperactivity and impulsive symptoms.

https://pubmed.ncbi.nlm.nih.gov/31500674/

Meta-Analysis > World J Biol Psychiatry. 2020 Nov;21(9):662-672. doi: 10.1080/15622975.2020.1775889. Epub 2020 Jun 30.

Resting-state network dysconnectivity in ADHD: A system-neuroscience-based meta-analysis

Bernis Sutcubasi [1], Baris Metin [1], Mustafa Kerem Kurban [2 3], Zeynep Elcin Metin [4], Birsu Beser [5], Edmund Sonuga-Barke [6]

Abstract

Objectives: Neuroimaging studies report altered resting-state functional connectivity in attention deficit/hyperactivity disorder (ADHD) across multiple brain systems. However, there is inconsistency among individual studies.

Methods: We meta-analyzed seed-based resting state studies of ADHD connectivity within and between four established resting state brain networks (default mode, cognitive control, salience, affective/motivational) using Multilevel Kernel Density Analysis method.

Results: Twenty studies with 944 ADHD patients and 1121 controls were included in the analysis. Compared to controls, ADHD was associated with disrupted within-default mode network (DMN) connectivity - reduced in the core (i.e. posterior cingulate cortex seed) but elevated in the dorsal medial prefrontal cortex sub-system (i.e. temporal pole-inferior frontal gyrus). Connectivity was elevated between nodes in the cognitive control system. When the analysis was restricted to children and adolescents, additional reduced connectivity was detected between DMN and cognitive control and affective/motivational and salience networks.

Conclusions: Our data are consistent with the hypothesis that paediatric ADHD is a DMN-dysconnectivity disorder with reduced connectivity both within the core DMN sub-system and between that system and a broad set of nodes in systems involved in cognition and motivation.

https://pubmed.ncbi.nlm.nih.gov/32468880/

Spatial Orientation

The spatial/Posner cueing paradigm

Attention operates spatially

The spatial/Posner cueing paradigm (Posner, 1980; Posner & Cohen, 1984)

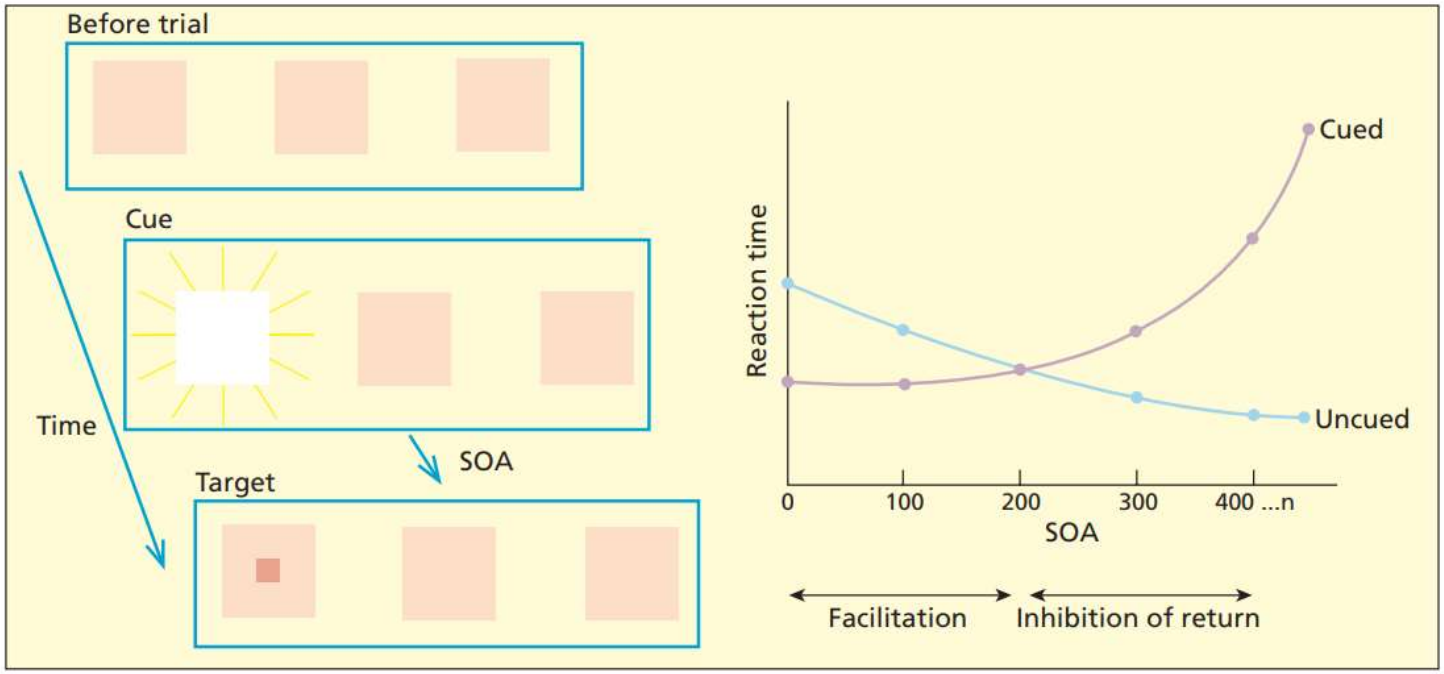


FIGURE 9.4: Participants initially fixate at the central box. A brief cue then appears as a brightening of one of the peripheral boxes. After a delay (called the "stimulus onset asynchrony," or SOA), the target then appears in the cued or uncued box. Participants are faster at detecting the target in the cued location if the target appears soon after the cue (facilitation) but are slower if the target appears much later (inhibition).

Ward, (2020), p. 206

SOA / stimulus onset asynchrony

time elapsed between **the onset** of the cue and **the onset** of the target

spatial cue

a stimulus appearing at a **designated location** for the purpose of directing the spotlight of attention

IOR / inhibition of return

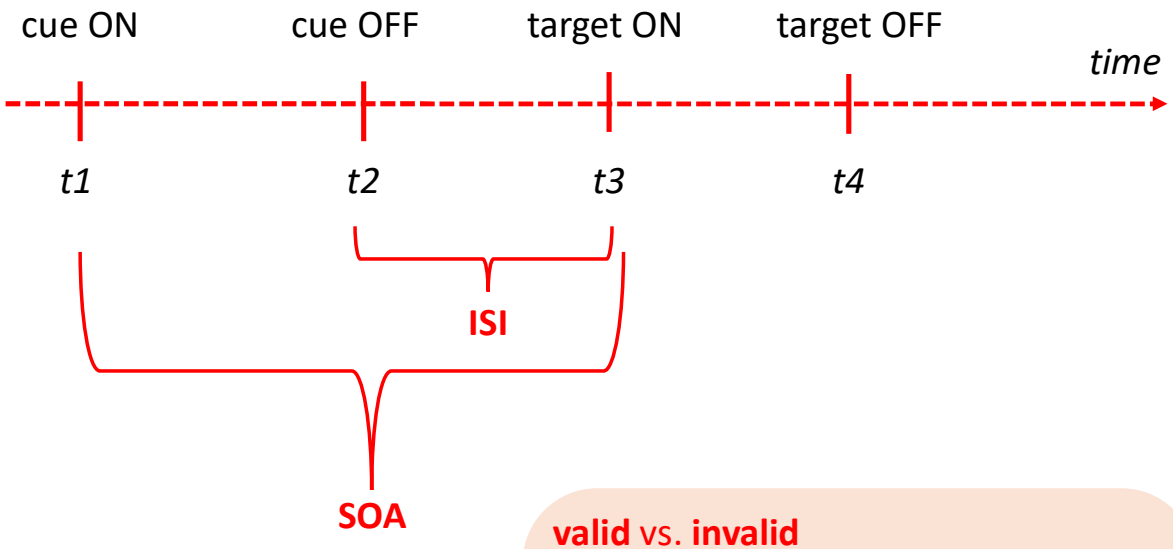
slower target detection (i.e., longer reaction times/RTs) at **validly cued** locations when SOA > 300 ms

Michael Posner described a classic study to illustrate that **attention operates on a spatial basis** (Posner, 1980; Posner & Cohen, 1984). The participants were presented with three boxes on the screen in different positions: left, central and right (see Figure 9.4 *[on the previous slide]*). The task of the participant was simply to **press a button when they detected a target in one of the boxes**. On **"catch trials"** no target appeared. At a brief interval before the onset of the target, a **cue** would also appear in one of the locations such as an increase in luminance (a flash). **The purpose of the cue was to summon attention to that location**. On some trials the cue would be in the same box as the target and on others it would not. As such, the cue is completely uninformative with regards to the later position of the target. When the cue precedes the target by up to 150 ms, participants are significantly faster at detecting the target at that location. **The cue captures the attentional spotlight,** and this **facilitates** subsequent perceptual processing at that location. At longer delays (above 300 ms) the reverse pattern is found: participants are slower at detecting a target in the same location as the cue. This can be explained by **assuming that the spotlight initially shifts to the cued location, but if the target does not appear, attention shifts to another location** (called **"disengagement"**). There is a **processing cost** in terms of reaction time associated with going back to the previously attended location. This is called **inhibition of return**.

Ward, (2020), p. 205

ISI / Interstimulus interval

time elapsed between **the offset** of a stimulus/cue and **the onset** of the next stimulus/target



catch trials

in a target detection paradigm, trials where the **target is absent**; responses are nonetheless **recorded**; useful to prevent participants from trying to anticipate e.g., the location of the target prior to the cue onset

valid vs. **invalid**

when referring to experimental cues, whether the cue matches the defining property (or the location) of the target on a given trial (**valid**), or not (**invalid**)

Spatial Orientation

Hemispatial neglect

Brain. 2003 Sep;126(Pt 9):1986-97. doi: 10.1093/brain/awg200. Epub 2003 Jun 23.

The anatomy of visual neglect

Dominic J Mort [1], Paresh Malhotra, Sabira K Mannan, Chris Rorden, Alidz Pambakian, Chris Kennard, Masud Husain

Affiliations + expand

PMID: 12821519 DOI: 10.1093/brain/awg200

Abstract

The brain regions that are critically associated with visual neglect have become intensely disputed. In particular, one study of middle cerebral artery (MCA) stroke patients has claimed that the key brain region associated with neglect is the mid portion of the superior temporal gyrus (STG), on the lateral surface of the right hemisphere, rather than the posterior parietal lobe. Such a result has wide-ranging implications for both our understanding of the normal function these cortical areas and the potential mechanisms underlying neglect. Here, we use novel high resolution MRI protocols to map the lesions of 35 right-hemisphere patients who had suffered either MCA or posterior cerebral artery (PCA) territory stroke. For patients with MCA territory strokes, the critical area involved in all neglect patients was the angular gyrus of the inferior parietal lobe (IPL). Although the STG was damaged in half of our MCA neglect patients, it was spared in the rest. For PCA territory strokes, all patients with neglect had lesions involving the parahippocampal region, on the medial surface of the temporal lobe. PCA patients without neglect did not have damage to this area. We conclude that damage to two posterior regions, one in the IPL and the other in the medial temporal lobe, is associated with neglect. Although some neglect patients do have damage to the STG, our findings challenge the recent influential proposal that lesions of this area are critically associated with neglect. Instead, our results implicate the angular gyrus and parahippocampal region in this role.

https://pubmed.ncbi.nlm.nih.gov/12821519/

Patients who have suffered a stroke in **their right inferior parietal lobe** will **neglect** (ignore) information **presented** to them (or **remembered**) from the **left visual field**. This occurs despite otherwise **unimpaired vision**.

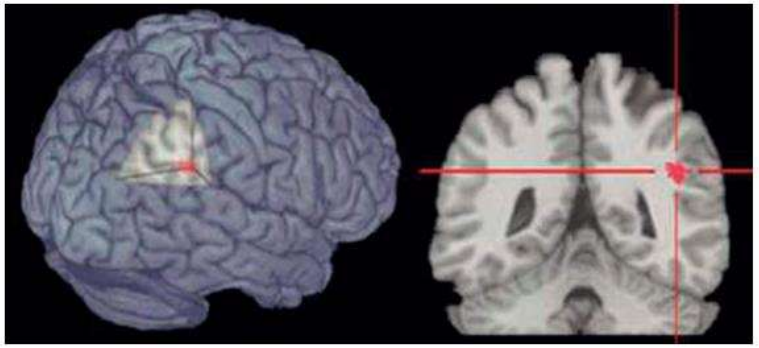
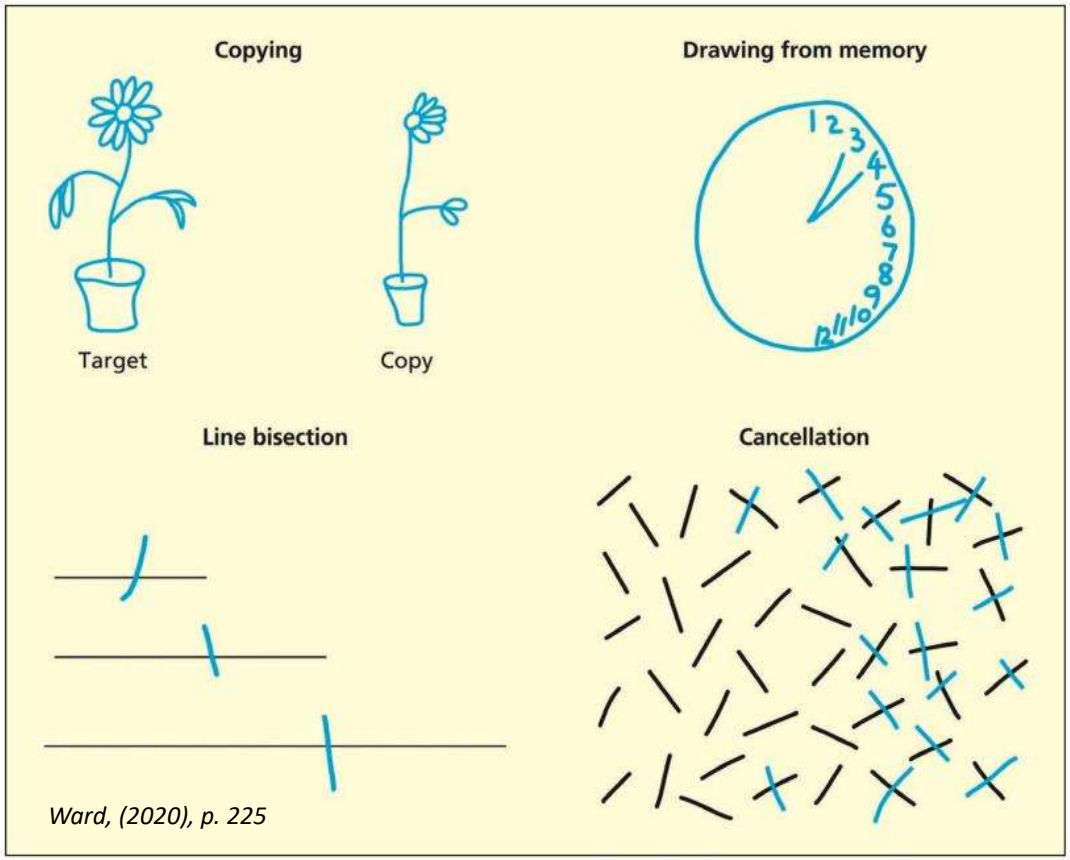


FIGURE 9.22: Neglect is associated with lesions to the right inferior parietal lobe. This photo shows the region of highest overlap of the lesions of 14 patients.

Ward, (2020), p. 225

Assessing hemispatial neglect



Ward, (2020), p. 225

FIGURE 9.21: Different ways of assessing neglect include copying, drawing from memory, finding the center of a line (line bisection) and crossing out targets in an array (cancellation).

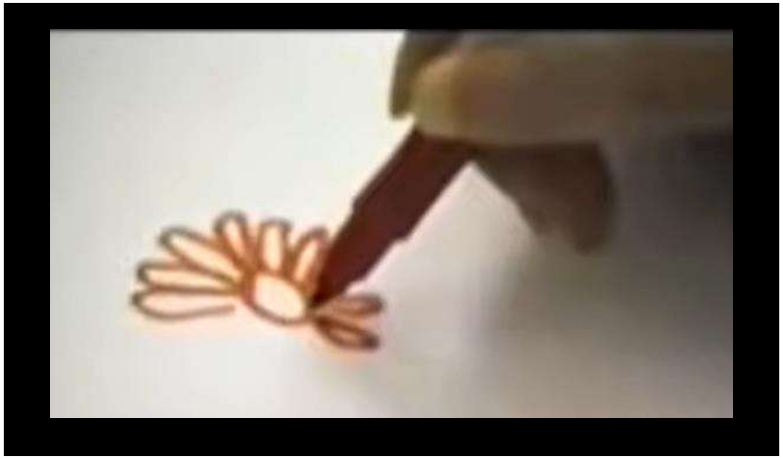
KEY TERMS

Line bisection
A task involving judging the central point of a line.

Cancellation task
A variant of the visual search paradigm in which the patient must search for targets in an array, normally striking them through as they are found.

https://www.youtube.com/watch?v=FlI7GsBHok8

https://www.youtube.com/watch?v=XQqgbjrUQtI



https://www.youtube.com/watch?v=ymKvS0XsM4w

Hemispatial neglect is **NOT** a disorder of low-level visual perception, but one of **spatial awareness**

Case Reports › Brain. 2000 Aug;123 (Pt 8):1624-33. doi: 10.1093/brain/123.8.1624.

Unconscious activation of visual cortex in the damaged right hemisphere of a parietal patient with extinction

G Rees [1], E Wojciulik, K Clarke, M Husain, C Frith, J Driver

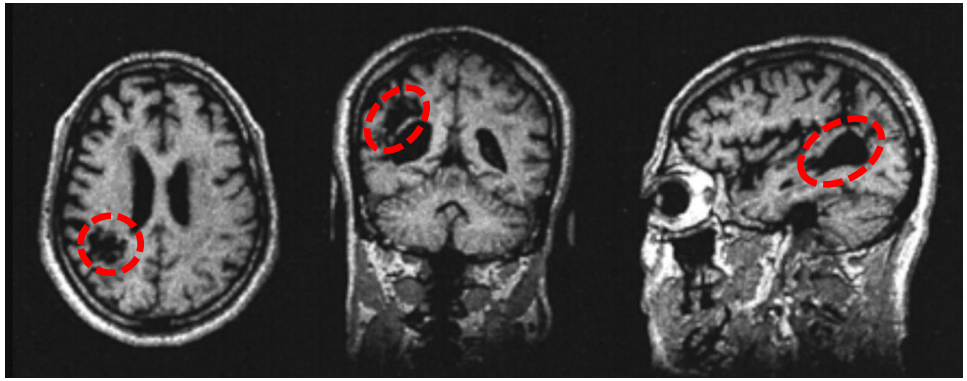
Affiliations + expand

PMID: 10908192 DOI: 10.1093/brain/123.8.1624

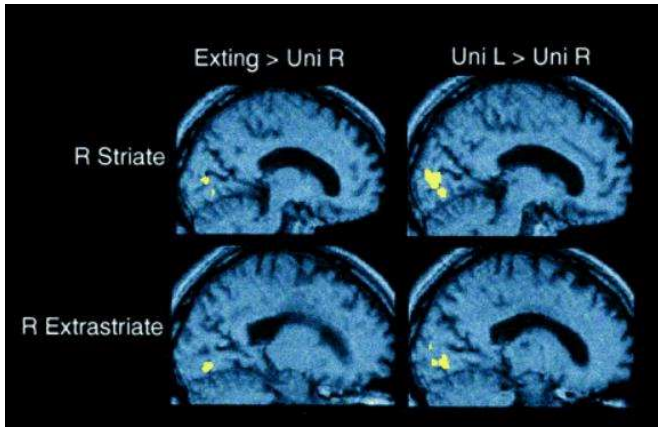
Abstract

Visual extinction is a sign classically associated with right parietal damage. The patient can see a single stimulus presented in the ipsilesional or contralesional visual field, but is characteristically unaware of the same contralesional stimulus during simultaneous stimulation of both fields. The ipsilesional stimulus is said to 'extinguish' the contralesional stimulus from awareness during bilateral stimulation, perhaps due to a pathological bias in attention towards the ipsilesional side. Recent psychophysical evidence suggests that, although extinguished stimuli are not consciously seen, they may undergo residual processing and exert implicit effects on performance. However, the neural structures mediating such residual processing for extinguished stimuli remain unknown. Here we studied the neural activity evoked by an extinguished visual stimulus, using event-related functional MRI (fMRI), in a patient with circumscribed right inferior parietal damage and profound left-sided extinction. Monochrome objects (faces or houses) were presented in the left or right field, either unilaterally or bilaterally on each trial, with the patient indicating by button press whether he saw an object on the left, the right or on both sides. He usually saw only the right object on bilateral trials, yet the fMRI data showed activation of visual cortex contralateral to the extinguished left stimulus on these trials (compared with right-only stimulation), in both striate and early extrastriate areas of the right hemisphere. This activity had a similar location and time-course to that resulting from a single stimulus in the left versus right visual field. Cortical pathways involved in the normal processing of a single seen stimulus can thus still be activated by an unseen, extinguished stimulus after right parietal damage. Comparison of fMRI responses for faces versus houses revealed some category-specific activation for extinguished stimuli in right fusiform regions, but only at low statistical threshold. These results are discussed in terms of theoretical accounts for parietal extinction and, more generally, for the neural substrates of visual awareness.

https://pubmed.ncbi.nlm.nih.gov/10908192/



Anatomical location of lesion. Three sections (axial, coronal and sagittal) are shown through G.K.'s T_1-weighted MRI. A low attenuation area within the right inferior parietal lobule, consistent with an old cerebral infarction, is shown. Note the highly circumscribed nature of the lesion, sparing visual cortex structurally.



Areas activated by consciously seen unilateral stimuli in the left visual field and by extinguished left visual field stimuli on bilateral trials. These panels show the location of the largest and most reliable activations, revealed either by the comparison of bilateral trials (showing extinction) minus unilateral right trials (*left panels*), or by the comparison of unilateral left trials minus unilateral right trials (*right panels*).

Spatial Orientation

Hippocampal place and grid cells

Place navigation impaired in rats with hippocampal lesions

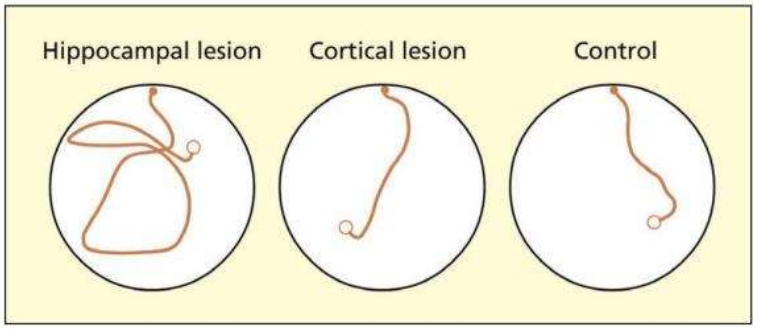
R. G. M. Morris, P. Garrud, J. N. P. Rawlins & J. O'Keefe

Nature **297**, 681–683 (1982) | Cite this article

Abstract

Electrophysiological studies have shown that single cells in the hippocampus respond during spatial learning and exploration[1–4], some firing only when animals enter specific and restricted areas of a familiar environment. Deficits in spatial learning and memory are found after lesions of the hippocampus and its extrinsic fibre connections[5,6] following damage to the medial septal nucleus which successfully disrupts the hippocampal theta rhythm[7], and in senescent rats which also show a correlated reduction in synaptic enhancement on the perforant path input to the hippocampus[8]. We now report, using a novel behavioural procedure requiring search for a hidden goal, that, in addition to a spatial discrimination impairment, total hippocampal lesions also cause a profound and lasting placenavigational impairment that can be dissociated from correlated motor, motivational and reinforcement aspects of the procedure.

https://www.nature.com/articles/297681a0



The route taken by a typical rat in the **Morris water maze**. The control rat and ones with cortical lesions can remember the location of the submerged platform and go directly there, whereas the hippocampal-lesioned rats find the platform by trial and error.

Ward, (2020), p. 284

Morris Water Maze

https://www.youtube.com/watch?v=leHLL4vcbCc

Joseph Nunez

Michigan State University
Department of Psychology, Neuroscience Program

ELSEVIER

Experimental Neurology

Volume 51, Issue 1, 1976, Pages 78-109

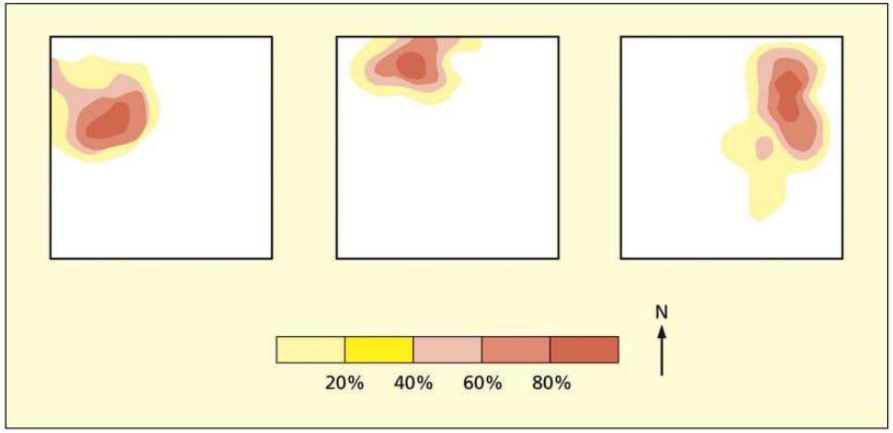
Place units in the hippocampus of the freely moving rat

John O'Keefe [1]

Abstract

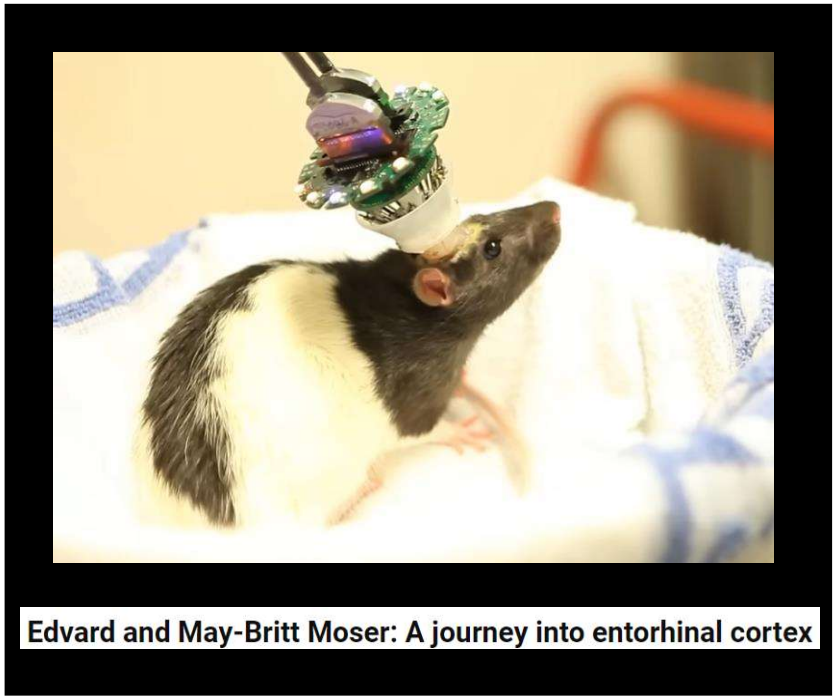
Single units were recorded from the CA1 field of the hippocampus in the freely-moving rat. They were classified as *place* units, *displace* units or others. Place units were defined as those for which the rat's position on the maze was a necessary condition for maximal unit firing. Some of these place units (*misplace units*) fired maximally when the animal sniffed in a place, either because it found something new there or failed to find something which was usually there. Displace units increased their rates during behaviors associated with theta activity in the hippocampal slow waves. In general these were behaviors which changed the rat's position relative to the environment. The influence of various environmental manipulations (e.g., turning off the room lights) on the firing pattern of the place units was tested and the results suggest that they were not responding to a simple sensory stimulus nor to a specific motor behavior. Nor could the unit firing be due purely to motivational or incentive factors. The results are interpreted as strong support for the cognitive map theory of hippocampal function.

https://www.sciencedirect.com/science/article/abs/pii/0014488676900558?via%3Dihub

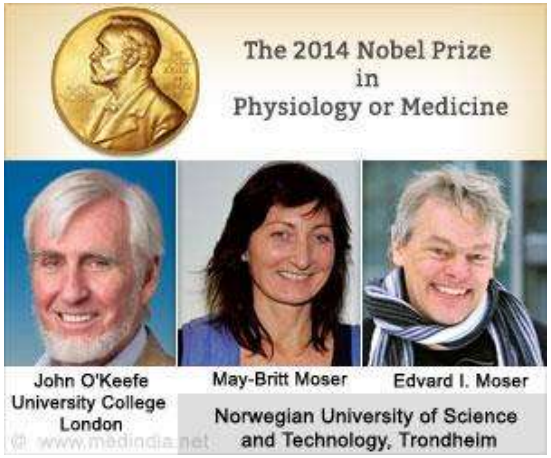


The **firing rate** of three different **place cells** (*the darker the shade, the more likely it is to respond*). The data are obtained using **single-cell recordings** from the **rat hippocampus**.

Ward, (2020), p. 284



https://www.youtube.com/watch?v=jYCR0pQLd_U



Neuron. 2014 Dec 17; 84(6): 1120–1125.
doi: 10.1016/j.neuron.2014.12.009

The 2014 Nobel Prize in Physiology or Medicine: A Spatial Model for Cognitive Neuroscience

Neil Burgess[1,*]

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Abstract

Understanding how the cognitive functions of the brain arise from its basic physiological components has been an enticing final frontier in science for thousands of years. The Nobel Prize in Physiology or Medicine 2014 was awarded one half to John O'Keefe, the other half jointly to May-Britt Moser and Edvard I. Moser "for their discoveries of cells that constitute a positioning system in the brain." This prize recognizes both a paradigm shift in the study of cognitive neuroscience, and some of the amazing insights that have followed from it concerning how the world is represented within the brain.

https://pubmed.ncbi.nlm.nih.gov/25521374/

Microstructure of a spatial map in the entorhinal cortex

Torkel Hafting, Marianne Fyhn, Sturla Molden, May-Britt Moser & Edvard I. Moser

Nature **436**, 801–806 (2005) | Cite this article

Abstract

The ability to find one's way depends on neural algorithms that integrate information about place, distance and direction, but the implementation of these operations in cortical microcircuits is poorly understood. Here we show that the dorsocaudal medial entorhinal cortex (dMEC) contains a directionally oriented, topographically organized neural map of the spatial environment. Its key unit is the 'grid cell', which is activated whenever the animal's position coincides with any vertex of a regular grid of equilateral triangles spanning the surface of the environment. Grids of neighbouring cells share a common orientation and spacing, but their vertex locations (their phases) differ. The spacing and size of individual fields increase from dorsal to ventral dMEC. The map is anchored to external landmarks, but persists in their absence, suggesting that grid cells may be part of a generalized, path-integration-based map of the spatial environment.

https://www.nature.com/articles/nature03721

place cells

hippocampal cells responding strongly when the rat is at a particular **location**

grid cells

cells in the entorhinal cortex responding to **multiple locations** within a repeating, triangular grid-like structure

Review > Cold Spring Harb Perspect Biol. 2015 Feb 2;7(2):a021808.
doi: 10.1101/cshperspect.a021808.

Place cells, grid cells, and memory

May-Britt Moser [1], David C Rowland [1], Edvard I Moser [1]

Affiliations + expand

PMID: 25646382 PMCID: PMC4315928 DOI: 10.1101/cshperspect.a021808

Abstract

The hippocampal system is critical for storage and retrieval of declarative memories, including memories for locations and events that take place at those locations. Spatial memories place high demands on capacity. Memories must be distinct to be recalled without interference and encoding must be fast. Recent studies have indicated that hippocampal networks allow for fast storage of large quantities of uncorrelated spatial information. The aim of the this article is to review and discuss some of this work, taking as a starting point the discovery of multiple functionally specialized cell types of the hippocampal-entorhinal circuit, such as place, grid, and border cells. We will show that grid cells provide the hippocampus with a metric, as well as a putative mechanism for decorrelation of representations, that the formation of environment-specific place maps depends on mechanisms for long-term plasticity in the hippocampus, and that long-term spatiotemporal memory storage may depend on offline consolidation processes related to sharp-wave ripple activity in the hippocampus. The multitude of representations generated through interactions between a variety of functionally specialized cell types in the entorhinal-hippocampal circuit may be at the heart of the mechanism for declarative memory formation.

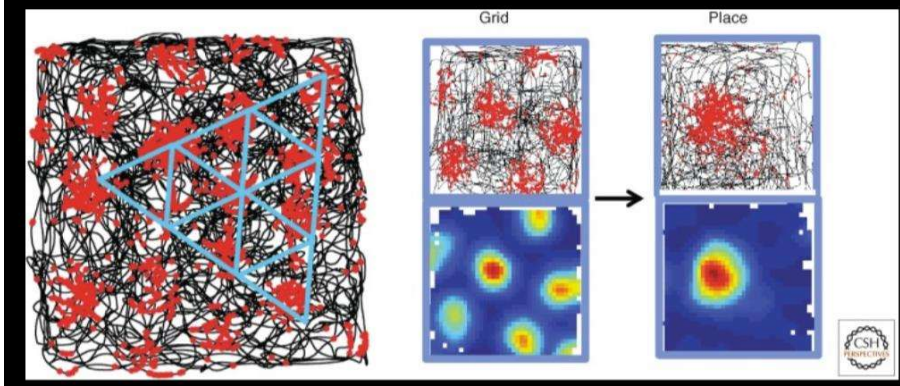

Figure 1. Grid cells and place cells. (*Left*) A grid cell from the entorhinal cortex of the rat brain. The black trace shows the trajectory of a foraging rat in part of a 1.5-m-diameter-wide square enclosure. Spike locations of the grid cell are superimposed in red on the trajectory. Each red dot corresponds to one spike. Blue equilateral triangles have been drawn on top of the spike distribution to illustrate the regular hexagonal structure of the grid pattern. (*Right*) Grid cell and place cell. (*Top*) Trajectory with spike locations, as in the *left* part. (*Bottom*) Color-coded rate map with red showing high activity and blue showing low activity. Grid cells are thought to provide much, but not all, of the entorhinal spatial input to place cells.

https://pubmed.ncbi.nlm.nih.gov/25646382/