

Why the language-ready brain is so complex

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sov|rum ['so:vrem] (-uter: zimmer n; **~stad** (en; -stader) Schlafstadt f; **~säck** Schlafsnek vagn BAHN Schlafwagen m etw vorspielen; ~ för ngn bei j Klavierstunde nehmen: ~ 'bort spielen; ~ l'genom 'durchspiele st skel ['spakal' i. (-n; -ar) Sy tel m(f); 2. (-ct) Spachtelkit Sonin CD: bespielen, aufnehmen: drehen; ~ 'med mitspielen; ~ ' sich); spa 'kla ['spakla] spachtely MED a noch einmal spielen; - 'upp au spaa .paid] (-et, ung spg alität / len, vorspielen; ~ 'ut ausspielen trilla i spat ins W Sonöver übertreiben: spelare Spic gog Sonf) m spel|automat (-en; -er) Spiclaut m [ching (Kar-Spielecken m dervisning m; "bank Spielbank f; "bord i Spieltisch m; "dosa Spieldose . Kt werden utbildning Spielinsen m; Jona Spieloose "6"Vink umg (-en; -ar) Luftiku Windbeutel m (fig): Alim Spie m; Jhåla Spielhölle f: -kort n karte f: Jektion Musikstunde Jman Spielmann m, Musikant mark Spielmank f. span. .t; -) Spatensparka sir [spesifel] speziell, besonders incera [spesifi/serra] spezifizie-naher bezeichnen; einzeln auf-Fuß stof spak¹ [spa:k] ([†] ar) Hebel m; schiff Spake f LUG (Steuer-)Knüpstrampeh ngn i ände nifren; specifik spezifisch; specifi-kation Aufstellung f pel m spak² zahm, gefügig ten; ~ 'av abin sig (täcket) sic ka'tion Aufstellung f spedition [spedi'fun] (-en; -er) Ver-sand m, Spedition **5**; **spedi'tionsfir-**ma Speditionsfirma f, Speditionsge-schäft n; **spedi'tior** Spediteur(in f) m **spegel** ['speigal] (-n; -ar) Spiegal m; _blid Spiegelbild n; _blank spiegel-blank; "vänd spiegelbildlich **spegla** ['speiglal] spiegelbildlich **spegla** ['speiglal] spiegeln (slg sich); **spegling** Spiegelung f om kull mit dem Fuß umstoßen. 'till ngn jdm einen Fußtritt geben -mark Spielmarke f spaljé [spal*je1] (-n; -er) Spalier n
spalt [spalt] (-en; -er) Spalte f; spalta "mark Spielmarks f speling (en; -ar) Spielreg f; n fig Spielraum m; lämna ogg jäm freise Spiel lassen; -lid Sj dauer f; .år n must Spielzeit spenat (spelhauf) (-en) Spinat n spendrar (spelhauf) (-en) Spinat n 'till ngn jdm einer Fußtritt geben, undan wegstoßen: "ut ngn jda nauswerfen, umg hinausschneiden sparkapital [*spurkapi'toil] («d Sparkapital n sparkkytwor [*sparkbyksur] Pl Strampelhöschen n(P), solet 'spalta] spalten spana ['spaina] spähen (efter nach); MIL beobachten, aufklären, erkunden; Polizei: fahnden (efter nach); ~ 'upp erspähen: spanare Späher m. spendera [spen'detra] spendier (på Dat) Strampelhöschen n(Pl); "Cykel (m -ar) (Tret-)Roller m Kundschafter m; MIL Beobachter m, Aufklärer m spegling Spiegelung f spegla ['speja] spähen; kundschaften; "på ngn jdn belauern; spejare Späspene [*speina] (-n; -ar) Zitze
spenslig [*spensli(g)] schmlich
feinglied(e)rig sparkonto ["sparkonto] (-t; -n) Spa Spanien ['spanjon] Spanien spaning ['spaninj] (-en; -ar) Nachfor-schung f; MIL Aufklärung f; Beo-bachtung f; Erkundung f; Polizei: sparlåga ['sparlo:ga] (-n; -or) Spar her m; Kundschafter m sperma [*spærma] (-n od -i) Sj n; spermie (-n; -r) Spermium spets [spets] (-en; -ar) Spitze) flamme f (a. fig) sparris ['sparis] (-en) Bot Spargel m spektakel [spek'ta:kal] (-et; -) Spek-Fahndung f; vara på ~ fig auf der takel m, Lärm m, umg Radau m; umg Popanz m; ställa till ~ Spektasparsam ["sparsam] sparsam: sparsam: sparsam ["sparsam] sparsam: sparsam. lich; sparsamhet Sparsamkeit fi Suche sein; spaningsarbete n Fahnfig); zool. Spitz m; I ...en för i Spitze (Gen); driva ngt till sir kel machen; bil till ett ~ fig zum Ge-spött der Leute werden dung / spanjor [span'juir] (-en; -er) Spanier Spärlichkeit f auf die Spitze treiben; spetse spartan [spa'to:n] (-en; -er) Sparta-ner m: spartansk spartanisch m; spanjorska Spanierin J spektakulär [spektake'læir] spekta-['spetsa] (an)spitzen: (auf)spi spankulera [spanku'le:ra] dahinöronen die Ohren spitzen: sparv [sparv] (-en; -ar) Spatz m, Sperling m; stekta ar fig gebraten Tauben f/Pl; .hök Sperber m spekulant [speku'lant] (-en; -er) Spe-kulant(in f) m; Reflektant(in f) m. schlendern, umherschlendern sich zuspitzen; spetsfundighe findigkeit f; spetsig spitz (a. spann¹ [span] (-en; -ar od spänner) Interessent(in f) m; Bewerber(in f) a. anzüglich; spetskrage Spit Eimer m m; Kauflustige(r); spekula'tion Spespasm [spasm] (-en; -er) Spasmus m spann² (-et; -) ARCHI Bogen m, Öffgen m kulation f; **spekul'era** spekulieren (på auf Akk; på börsen an der Börspett [spet] (-er; -) Spieß m; I nung f; Gespann n spannmål ['spanmoll] (-en) Getreide Krampf m stange f: "(e)kaka etwa Baum spastisk ['spastisk] spasmisch se): erwägen 111 n. Korn n spatel ["sportal] (-n: -ar) Spa(child spel [spe:1] (-et; -) Spiel n; (Vogel-) spetälsk ['spettelsk] MED aus spansk [spansk] spanisch; "a sjukan m(f Aussätzige(r); spetäiska (-n) satz m, Lepra f spex umg [speks] (-et; -) eine Balz f; SCHIFF Spill n, Winde f; hålla best die (spanische) Grippe; spanspatios [spatsi'ers] weitläufig, genin god min i elakt ~ gute Miene zum bösen Spiel machen: dra sig ur ~et ska ['spanska] Spanierin f; Spanisch mig Studententheater n; spexa Ju spatser a [spat'serra] spazieren; gt n sich zurückziehen; sich aus dem spara ['spaira] (Präs Sg a. spar) spaoch ~ spazieren gehen; "tur Spazie Staub machen; sätta på ~ aufs Spiel chen spigg [spig] (-en; -ar) zoor Si ren; aufsparen, aufheben; schonen gang m setzen (sig sich); rr abspeichern, sichern; ~ speaker ['spirker] (-n; - od -s) Anse spela [*spe:la] spielen; Vogel: balzen; spik [spitk] (-en; -ar) Nagel m (od träffa) huvudet på ~en f ger m sjuk sich krank stellen; ~ teater (till) IT speichern; inte ~ någon Komödie spielen; ~ ngt för ngn jdm speceriaffär [spesə'ritafætt] (at af möda keine Mühe scheuen; ~ på

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In a review article published in *Science*, Peter Hagoort, professor of Cognitive Neuroscience at Radboud University and director of the Max Planck Institute for Psycholinguistics, argues for a new model of language, involving the interaction of multiple brain networks. This model is much more complex than the classical neurobiological model of language, which was largely based on single-word processing.

The capacity for <u>language</u> is distinctly human. It allows us to communicate, learn things, create culture, and think better. Because of its complexity, scientists have long struggled to understand the neurobiology of language.

In the classical view, there are two major language areas in the left half of our brain. Broca's area (in the <u>frontal lobe</u>) is responsible for the production of language (speaking and writing), while Wernicke's area (in the temporal lobe) supports the comprehension of language (listening and reading). A large fibre tract (the arcuate fasciculus) connects these two 'perisylvian' areas (around the Sylvian fissure, the split which divides the two lobes).

"The classical view is largely wrong," says Hagoort. Language is infinitely more complex than speaking or understanding single words, which is what the classical model was based on. While words are among the elementary 'building blocks' of language, we also need 'operations' to combine words into structured sentences, such as 'the editor of the newspaper loved the article.' To understand and interpret such an utterance, knowing the speech sounds (or letters) and meaning of the individual words is not enough. For instance, we also need information about the context (who is the speaker?), the intonation (is the tone cynical?), and knowledge of the world (what does an editor do?).

Multiple language areas



In recent years neuroanatomists have discovered that Broca's and Wernicke's regions actually contain multiple neuroanatomical areas. Also, newly discovered language areas extend beyond the classical areas, even into the parietal lobe, with more connections between these areas than previously thought. Moreover, the traditional areas are involved in language comprehension as well as production. Scientists also learned that other regions of the brain are more important for language than once thought, including the right hemisphere and the cerebellum. Interestingly, language areas also turn out to be somewhat variable. For instance, in people who are born blind, language can spread to the occipital lobe (or visual brain).

Our brains process language with astonishing speed and 'immediacy,' in a dynamic network of interacting brain areas. All the <u>relevant information</u> becomes available immediately, as we start combining the meanings of individual words, unifying the different sources of information. To speed up this process, our brain actively predicts what is coming next (for instance, we might expect 'newspaper' to follow 'the editor of the...').

As most utterances are part of a conversation, some information is usually already shared between the speaker and the listener. Speakers make sure that they mark 'new information,' using the order of the words or pitch to focus the listener's attention (after hearing that readers of the newspaper did not like the article, one could say 'the EDITOR of the newspaper loved the article'). Only when relevant 'new' information is unexpected or ungrammatical, people's brains are shown to react. Listeners likely process 'old' information in a 'good-enough' manner, ignoring some of the details, explains Hagoort, which is why they do not seem to notice unexpected 'old' information.

To make matters even more complex, language is often indirect. To know what a speaker really means, listeners need to infer a speaker's



intention. For instance, 'It is hot here' could well be intended as a request to open the window, rather than a statement about the temperature. Neuroimaging studies show that such 'pragmatic' inferences depend on brain areas that are involved in "Theory of Mind," or thinking about other people's beliefs, emotions and desires.

Language is a "complex biocultural hybrid," concludes Hagoort. But what is the essence of human language? Is it syntax, to be found in Broca's area? Hagoort challenges this old notion: "Accounting for the full picture of human language skills is not helped by a distinction between essential and nonessential aspects of speech and language." Instead, the neuroscientist argues for a multiple brain-network view of language, in which some operations might well be shared with other cognitive domains, such as music and arithmetic.

Language being the multi-layered system that it is, no wonder that the language-ready <u>brain</u> is so enormously complex," says Hagoort.

More information: P. Hagoort at Max Planck Institute for Psycholinguistics in Nijmegen, Netherlands el al., "The neurobiology of language beyond single-word processing," *Science* (2019). <u>science.sciencemag.org/cgi/doi ... 1126/science.aax0289</u>

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