# **Synthetic Telepathy via Neural Implants: A Research Review**

## **Literature & Technical Developments**

**Neural Implants & High-Density Interfaces:** Recent years have seen rapid advances in brain-computer interfaces (BCIs) and neural implants that lay the groundwork for “synthetic telepathy” – direct brain-to-brain communication. Researchers have developed high-density neural interfaces capable of recording from large populations of neurons simultaneously. For example, the Neuropixels 2.0 probe contains over 5,000 electrode sites and can chronically record thousands of neurons at single-spike resolution ( [Neuropixels 2.0: A miniaturized high-density probe for stable, long-term brain recordings - PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC8244810/#:~:text=Measuring%20the%20dynamics%20of%20neural,from%20the%20same%20neurons%20for) ) dwidth implants, including novel flexible electrode “threads” and microwire arrays, dramatically increase the information that can be read from or written to the brain. These innova ([Neuralink vs. Competitors: Key Technological Differences](https://www.usaneuralink.com/neuralink-vs-competitors-key-technological-differences/#:~:text=The%20N1%20Chip%20and%20Surgical,Robot)) ([Neuralink vs. Competitors: Key Technological Differences](https://www.usaneuralink.com/neuralink-vs-competitors-key-technological-differences/#:~:text=Paradromics%20stands%20out%20for%20its,bandwidth%20approach)) h, spatial resolution, and stability, which are critical for encoding complex thoughts or sensory experiences.

**Neural Data Encoding & Decoding:** Decoding neural activity into communicable information has progressed markedly. In a 2021 breakthrough, the BrainGate consortium demonstrated an implanted sensor that let a paralyzed man *“type”* at 90 characters per minute by imagining handwriting. This doubled the previous record for BCI ([Brain-computer interface creates text on screen by decoding brain signals associated with handwriting | Brown University](https://www.brown.edu/news/2021-05-12/handwriting#:~:text=BrainGate%20research%20collaborative%20have%2C%20for,a%20computer%20in%20real%20time)) howcased high-fidelity decoding of intended letters from motor cortex signals. Other studies have decoded speech or words from brai ([Brain-computer interface creates text on screen by decoding brain signals associated with handwriting | Brown University](https://www.brown.edu/news/2021-05-12/handwriting#:~:text=In%20a%20study%20published%20in,involved%20in%20creating%20written%20letters)) inting at the potential for “mind-to-text” communication. For instance, a Facebook-funded University of California San Francisco (UCSF) project decoded a small vocabulary of spoken words in real time from cortical signals, achieving word error rates as low as 3% for 300-word sets. These technical developments illustrate the increasing accuracy ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=Facebook%20has%20described%20this%20new,first%20step%20towards%20telepathic%20communication)) which neural implants can translate thoughts into digital signals.

**Brain-to-Brain Communication Experiments:** Pioneering research has moved beyond brain-computer links to direct brain-to-brain interfaces (BBIs). Early animal studies provided proof-of-concept. In 2013, Miguel Nicolelis and colleagues linked the brains of two rats such that a “encoder” rat’s cortical activity (recorded via an implant) was delivered to a “decoder” rat via intracortical microstimulation, enabling the second rat to correctly perform tasks it **only** knew from the first rat’s brain signals. This real-time transfer of sensorimotor information suggested that networks of ([FIRST BRAIN-TO-BRAIN INTERFACE ALLOWS TRANSMISSION OF TACTILE AND MOTOR INFORMATION BETWEEN RATS | Laboratory of Dr. Miguel Nicolelis](https://www.nicolelislab.net/?p=369#:~:text=%5BImage%207%3A%20Vieira_ScientificRep_Figure,These%20results%20demonstrated%20that)) d exchange and share information directly. Around the same time, researchers successfully linked pairs of rats and even pairs of mon ([FIRST BRAIN-TO-BRAIN INTERFACE ALLOWS TRANSMISSION OF TACTILE AND MOTOR INFORMATION BETWEEN RATS | Laboratory of Dr. Miguel Nicolelis](https://www.nicolelislab.net/?p=369#:~:text=areas%20of%20a%20%E2%80%98%E2%80%98decoder%E2%80%99%E2%80%99%20rat,27%20Read%20the%20full)) ous tasks, effectively creating rudimentary “brain networks” in animals.

Translating this to humans, initial demonstrations have been achieved with non-invasive technology. ( [Conscious Brain-to-Brain Communication in Humans Using Non-Invasive Technologies - PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC4138179/#:~:text=way%20,%E2%80%93%20all%20of%20invasive%20nature) ) t-of-its-kind”\* human study in 2014, a team led by neuroscientist Alvaro Pascual-Leone transmitted simple words from one person’s brain to another’s without any spoken or written communication. They used an EEG-based BCI to read the sender’s brain signals for the words “hola” and “ciao”, then sent the da ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=In%20a%20first,located%205%2C000%20miles%20apart)) nternet, and delivered it to the receiver’s brain through transcranial magnetic stimulation (TMS). The receivers perceived the incoming message as flashes of light (phosphenes) that encoded the words in binary, which they ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=with%20Giulio%20Ruffini%20and%20Carles,TMS%29%20technologies)) interpret correctly. Remarkably, this brain-to-brain transmission was performed between individuals separated by 5,000 miles, using only neural signals and ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=Using%20EEG%2C%20the%20research%20team,did%20correctly%20receive%20the%20greetings)) . A few years later, in 2019, researchers at University of Washington extended the concept to a multi-person BBI called “BrainNet.” They networked t ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=In%20a%20first,located%205%2C000%20miles%20apart)) ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=with%20Giulio%20Ruffini%20and%20Carles,TMS%29%20technologies)) that two senders could transmit “Yes/No” thoughts via EEG signals to a third person’s brain (via TMS), allowing the trio to collaboratively play a Tetris-like game using only their minds. This was the first demonstration of a *multi*-person brain network and showed a person can simultaneously **receive** and **send** information with the brain.

**Influen (** [**How you and your friends can play a video game together using only your minds | UW News**](https://www.washington.edu/news/2019/07/01/play-a-video-game-using-only-your-mind/#:~:text=Telepathic%20communication%20might%20be%20one,problem%20using%20only%20their%20minds) **) (** [**How you and your friends can play a video game together using only your minds | UW News**](https://www.washington.edu/news/2019/07/01/play-a-video-game-using-only-your-mind/#:~:text=%E2%80%9CHumans%20are%20social%20beings%20who,%E2%80%9D) **) s:** The concept of synthetic telepathy has even earlier scientific roots. As far back as the 1960s, researchers showed that humans could voluntarily modulate ( [How you and your friends can play a video game together using only your minds | UW News](https://www.washington.edu/news/2019/07/01/play-a-video-game-using-only-your-mind/#:~:text=In%20BrainNet%2C%20three%20people%20play,to%20the%20preprint%20site%20arXiv) ) ves to convey information – for example, using alpha wave EEG signals to transmit Morse code. While crude, these early experiments hinted that **mental communication channels** were possible. Modern high-density implants and machine learning decoding have vastly improved the fidelity since then. Today ( [Conscious Brain-to-Brain Communication in Humans Using Non-Invasive Technologies - PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC4138179/#:~:text=Despite%20these%20and%20other%20significant,work%20has%20demonstrated%20fully%20non) ) work ranges from brain implant trials restoring communication to people with paralysis, to animal studies demonstrating “shared” sensory experiences between brains. Collectively, the literature shows a clear trajectory: increasing neural interface density, improved neural decoding algorithms, and early demon ([Brain-computer interface creates text on screen by decoding brain signals associated with handwriting | Brown University](https://www.brown.edu/news/2021-05-12/handwriting#:~:text=BrainGate%20research%20collaborative%20have%2C%20for,a%20computer%20in%20real%20time)) brain-to-brain data exchange are turning synthetic telepathy from science fi ([FIRST BRAIN-TO-BRAIN INTERFACE ALLOWS TRANSMISSION OF TACTILE AND MOTOR INFORMATION BETWEEN RATS | Laboratory of Dr. Miguel Nicolelis](https://www.nicolelislab.net/?p=369#:~:text=from%20two%20choices%20of%20tactile,27%20Read%20the%20full)) n experimental reality.

## **Ongoing Projects & Case Studies**

**Academic Research & Trials:** University and government-funded labs worldwide are pushing the frontiers of neural communication. The **BrainGate** trial (a collaboration between Brown, Stanford, and others ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=%E2%80%9CPeople%20could%20become%20telepathic%20to,with%20friends%2C%E2%80%9D%20the%20report%20states)) ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=%22By%20using%20advanced%20precision%20neuro,complementing%20or%20bypassing%20traditional%20language)) testing implanted electrode arrays in humans, yielding breakthroughs like the high-speed neural typing mentioned above. Researchers at Duke University (Nicolelis Lab) demonstrated brain-to-brain communication in animals, as noted, and later explored “BrainNet” concepts in primates. At the University of Washington, Rajesh Rao’s team not only created the BrainNet for three-person communic ([Brain-computer interface creates text on screen by decoding brain signals associated with handwriting | Brown University](https://www.brown.edu/news/2021-05-12/handwriting#:~:text=BrainGate%20research%20collaborative%20have%2C%20for,a%20computer%20in%20real%20time)) rlier in 2013 showed a simpler brain-to-brain link in which one person’s thoughts (recorded via EEG) could trigger movement in another person’s hand via magnetic stimulation. These academic case studies serve as **proof-of-concept** for synthetic telepathy. On the non-invasive front, a team in Spain and France (Starlab and Axilum Robotics) led by Carles Grau and Giulio Ruffini joined Pascual-Leone in the 2014 *PLOS ONE* study, highlighting how internat ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=In%20a%20first,located%205%2C000%20miles%20apart)) ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=with%20Giulio%20Ruffini%20and%20Carles,TMS%29%20technologies)) tackling BBI experiments.

Government agencies are also heavily involved. DARPA (the U.S. Defense Advanced Research Projects Agency) has sponsored programs explicitly aiming for thought-based communication. One example is **Silent Talk** (circa 2009), a project to decode “pre-speech” signals from a soldier’s brain and transmit t ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=with%20Giulio%20Ruffini%20and%20Carles,TMS%29%20technologies)) r soldier, enabling radio-free battlefield communication. That project funded research into identifying EEG patterns corresponding to specific words before they are spoken, then sending that data to a remote recipient. Although still in experimental stages, DARPA’s continued interest (e.g. the **N3 – Next-Generation Nonsurgical Neurotechnology** program) underscores the s ([Pentagon Preps Soldier Telepathy Push | WIRED](https://www.wired.com/2009/05/pentagon-preps-soldier-telepathy-push/#:~:text=Darpa,mediated%20telepathy)) ([Pentagon Preps Soldier Telepathy Push | WIRED](https://www.wired.com/2009/05/pentagon-preps-soldier-telepathy-push/#:~:text=The%20project%20has%20three%20major,transmit%20over%20a%20limited%20range)) N3 program (completed in 2021) sought to develop *“high-performance, bi-directional”* neural interfaces that **do not** require surgery, combining the precision of invasive devices with the accessibility of wearables. Such efforts have led to novel prototypes (like mixed acoustic/optical systems) that might one day allow soldiers or operators to silently send commands brain-to-brain on the battlefield.

**Industry & Startup Initiatives:** Private companies and startups are aggressively working on neural interface technology with eventual telepathic com ([Next-Generation Nonsurgical Neurotechnology](https://www.darpa.mil/research/programs/next-generation-nonsurgical-neurotechnology#:~:text=The%20Next,bodied%20service%20members)) ([Next-Generation Nonsurgical Neurotechnology](https://www.darpa.mil/research/programs/next-generation-nonsurgical-neurotechnology#:~:text=Whereas%20the%20most%20effective%2C%20state,world%20settings)) le players include:

* **Neuralink (USA):** Elon Musk’s Neuralink is developing an implant called the “Link,” a coin-sized chip with *1,024 ultra-thin electrode threads* surgically inserted into the cortex. The company’s long-term vision is to enable direct brain-to-computer control for patients, and ultimately *“human-to-human”* mind communication. Musk has openly stated that in the future, people *“won’t have to talk”* because Neuralink could facilitate telepathic conversation. In 2024, Neuralink launched its first human trials, implanting the device in a volunte ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=In%20a%202020%20webcast%2C%20Musk,connect%20with%20a%20smartphone%20app)) en able to move a cursor and even play computer games using thought alone. The device is wireless and designed for real-time brain signal streaming, and Musk has claimed it could be installed in under an hour via robotic surgery. Neuralink’s team includes top neuroscientists a ([Elon Musk Predicts Human-to-Human Mind Communication in 10 Years - Business Insider](https://www.businessinsider.com/elon-musk-prediction-human-to-human-mind-communication-10-years-2020-5#:~:text=,Insider%27s%20homepage%20for%20more%20stories)) ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=%E2%80%9CPeople%20could%20become%20telepathic%20to,with%20friends%2C%E2%80%9D%20the%20report%20states)) watched as a bellwether for invasive BCI technology.
* **Synchron (USA/Australia):** Synchron is taking a less invasive approach with its **Stentrode** device – an implant de ([Neuralink vs. Competitors: Key Technological Differences](https://www.usaneuralink.com/neuralink-vs-competitors-key-technological-differences/#:~:text=Recent%20Achievements)) ([Neuralink vs. Competitors: Key Technological Differences](https://www.usaneuralink.com/neuralink-vs-competitors-key-technological-differences/#:~:text=In%20early%202024%2C%20Neuralink%20reached,34%20cursor%20through%20thought%20alone)) d vessels (via a catheter) instead of open brain surgery. The stentrode is a mesh-like electrode that self-expands inside a cortical vein. In 2020–21, Syn ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=,Image%3A%20NeuraLink)) ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=In%20a%202020%20webcast%2C%20Musk,connect%20with%20a%20smartphone%20app)) s allowed patients with paralysis to control computer tasks (like texting or online shopping) *“through direct thought, and without the need for open brain surgery”*. By 2022, Synchron received FDA approval to begin U.S. trials (the COMMAND study) to assess its BCI for hands-free device control in severe paralysis. The company touts ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=Officials%20at%20Synchron%20%E2%80%94%20developer,capture%20signals%20from%20the%20brain)) safety and accessibility benefits – implanted via a **vein** in a minimally invasive procedure – as a key advantage. This approach could make BCI technology *“simpler, safer and more accessible”* than traditional implants while still providing useful bandwidth. (Notably, media reports sugg ([Patients with Severe Paralysis Use Stentrode Brain-Computer Interface to Text, Email, Shop, Bank Online, First-in-human Study Reports - BioSpace](https://www.biospace.com/patients-with-severe-paralysis-use-stentrode-brain-computer-interface-to-text-email-shop-bank-online-first-in-human-study-reports#:~:text=the%20study%20shows%20the%20Stentrode%E2%80%99s,JNIS)) ([Patients with Severe Paralysis Use Stentrode Brain-Computer Interface to Text, Email, Shop, Bank Online, First-in-human Study Reports - BioSpace](https://www.biospace.com/patients-with-severe-paralysis-use-stentrode-brain-computer-interface-to-text-email-shop-bank-online-first-in-human-study-reports#:~:text=The%20patients%20enrolled%20in%20the,system%20from%20day%2086%20and)) ed investing in Synchron, underscoring its status as a leading competitor in BCI.)
* **Blackrock Neurotech (USA):** Blackrock (formerly Blackrock Mi ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=Last%20month%2C%20the%20company%20completed,computer%20interface)) a pioneer that has supplied Utah Array implants for human BCI research for nearly two decades. Its implanted Utah Array (a tiny bed-of-needles electro ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=brain%20to%20a%20device%20in,brain%20surgery)) been used in human studies since 2004, with *zero* serious adverse events reported. Blackrock’s devices have enabled locked-in patients to contr ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=%5BImage%202%3A%20Synchron%20Stentrode%20brain,brain%20surgery)) , cursors, and even regain a sense of touch through prosthetics. In 2021, Blackrock’s clinical BCI platform “MoveAgain” earned an FDA Brea ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=Synchron%E2%80%99s%20rise%20to%20rival%20BCI,coming%20together%20of%20the%20compa345anies)) designation for helping paralyzed patients control devices by thought. Blackrock is now preparing the first commercial BCI offerings, even partnering with surgical device firm ClearPoint to automate implant procedures. Though primarily focused on medical applications, Blackrock’s long experience with *high-resolution* neural da ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=While%20some%20companies%20have%20made,serious%20adverse%20events%20since%20then)) ize their high channel-count and stability) makes them central to any future brain-to-brain communication breakthroughs.
* **Kernel (USA):** Kernel, founded by Bryan Johnson, initially explored memory prosthesis implants but pivoted to non-invasive tech. In 2021, Kernel unveiled *Kernel Flow*, a w ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=In%202021%2C%20Blackrock%20Neurotech%20received,communicating%20more%20effectively%20and%20quickly)) that uses time-domain near-infrared spectroscopy (TD-fNIRS) to measure brain activity with high temporal resolution. While not designed for direct ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=Blackrock%20Neurotech%20to%20develop%20an,ALS%2C%20blindness%20and%20hearing%20loss)) ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=Blackrock%20and%20the%20University%20of,commercial%20product%20early%20next%20year)) resents the push for high-performance *non-invasive* interfaces. Kernel’s longer-term vision still involves cognitive enhancement – Johnson spoke of *“boosting human in (*[*Neuralink vs. Competitors: Key Technological Differences*](https://www.usaneuralink.com/neuralink-vs-competitors-key-technological-differences/#:~:text=As%20a%20pioneer%20in%20BCI,Blackrock%20Neurotech%20brings%20significant%20experience)*) g neural chip implants”* – which could one day include thought sharing. For now, Kernel Flow is being used to gather brain data for wellness and research, but it’s an example of industry efforts toward practical, everyday neurotech.
* **Paradromics (USA):** This startup is developing an ultra high-bandwidth implant nicknamed the **Argo** system. It reportedly involves an array with ([7 Leading Brain-Computer Interface Companies and their Current and Prospective Products – Ross Dawson](https://rossdawson.com/futurist/companies-creating-future/leading-brain-computer-interface-companies-bci/#:~:text=Kernel%20is%20building%20the%20next,that%20maintains%20or%20improves%20on)) sands of electrodes (early prototypes target ~65,000 channels) connected to a high-speed data transmitter. Paradromics’ goal is *“massively parallel”* neural data collection and stimulation – essentially connecting to as many neurons as possible to allow rich data ([7 Leading Brain-Computer Interface Companies and their Current and Prospective Products – Ross Dawson](https://rossdawson.com/futurist/companies-creating-future/leading-brain-computer-interface-companies-bci/#:~:text=The%20original%20goal%20of%20Kernel,Like)) h bandwidth could, in theory, support transmission of complex thoughts or even sensory images between brains. While Paradromics is still in animal testing, its approach has been highlighted as perhaps *“the highest-bandwidth interface in development”*, aiming for unprecedented data rates from brain to computer.
* **Others:** Numerous other companies and labs deserve note. *Meta (Facebook)* ran a Reality Labs project on BCIs, developing a brain-to-text decoding headset and ([Neuralink vs. Competitors: Key Technological Differences](https://www.usaneuralink.com/neuralink-vs-competitors-key-technological-differences/#:~:text=Differences%20www,development%3B%20Advanced%20electrode%20array)) ng a system that could **transcribe thoughts** at at least 100 words per minute using neural signals. Although Meta has since refocused on wrist-based neural interfaces, its project demonstrated Big Tech’s interest in telepathic communication as *“the next great wave in human-oriented computing”*. *Emotiv* and *Neurable* are startups creating EEG headsets for consumers, aiming to make neurotechnology *“simple and accessible enough to use in everyday life”* – a stepping stone to ([Neuralink vs. Competitors: Key Technological Differences](https://www.usaneuralink.com/neuralink-vs-competitors-key-technological-differences/#:~:text=Paradromics%20stands%20out%20for%20its,bandwidth%20approach)) n communication. And cutting-edge research institutions like the *Howard Hughes Medical Institute (HHMI)* and *Allen Institute* are backing high-density implant development and open-source neural data projects that benefit the entire field.

Across industry and academia, these o ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=Facebook%20has%20described%20this%20new,first%20step%20towards%20telepathic%20communication)) illustrate a vibrant ecosystem tackling the technical challenges of synthetic telepathy from different angles. Whether through invasive implants, minimally invasive stentrodes, or non-invasive we ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=Facebook%20has%20described%20this%20new,first%20step%20towards%20telepathic%20communication)) ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=In%20July%2C%20the%20technology%20giant,work%20seamlessly%20to%20transcribe%20thoughts)) tes pieces – higher bandwidth, safer delivery, better decoding – toward the ultimate goal of seamless brain-to-brain communication.

## **Future Implications & Ethi (**[**7 Leading Brain-Computer Interface Companies and their Current and Prospective Products – Ross Dawson**](https://rossdawson.com/futurist/companies-creating-future/leading-brain-computer-interface-companies-bci/#:~:text=Neurable%20describes%20itself%20as%20a,the%20brain%E2%80%99s%20emotional%20state%2C%20specifically)**) ations**

**Transforming Communication:** If synthetic telepathy via neural implants becomes viable, it could radically transform how humans interact. Communication could move from the audible and visual realm directly into the neural realm – in essence, sharing thoughts, concepts, or even emotions brain-to-brain. A 2019 Royal Society report on neural interfaces predicted that people *“could become telepathic to some degree, able to converse not only without speaking but without words – through access to each other’s thoughts at a conceptual level.”* This means conversations might convey ideas and nuances more directly than language allows today, potentially enabling unprecedented collaboration and understanding between people. Entirely new forms of social connection could emerge; friends or colleagues might **share mental states** or images (“neural postcards”) with one another. Such technology could especially empower those who cannot speak or write due to disability, restoring their ability to communicate at the speed of thought.

**Cognitive Enhancement and Collective Intelligence:** Beyond person-to-person communication, advanced neural interfaces might enable cognitive augmentation. Users could potentially access external databases or AI systems instantly via ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=%E2%80%9CPeople%20could%20become%20telepathic%20to,with%20friends%2C%E2%80%9D%20the%20report%20states)) rch engine,” or even exchange knowledge with other minds. Elon Musk has described Neuralink’s goal as achieving *“symbiosis with artificial intelligence,”* essentially merging hum ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=%E2%80%9CPeople%20could%20become%20telepathic%20to,with%20friends%2C%E2%80%9D%20the%20report%20states)) e intelligence. In a world of functional telepathy, human collaboration could take on new dimensions – teams might share information brain-to-brain, enabl ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=%E2%80%9CPeople%20could%20become%20telepathic%20to,with%20friends%2C%E2%80%9D%20the%20report%20states)) group intelligence or problem-solving that is much faster than verbal discussion. Some foresee a *“hive mind”* potential, where networked brains collectively work on tasks, though this raises as many questions as it answers.

**Disruption of Social Norms:** Widespread telepathic communication would challenge the norms of interpersonal interaction that have evolved over millennia. The privacy of one’s inner thoughts, currently taken for granted, would become a new kind of commodity or risk. People may need to develop mental disciplines to *“filter”* which thoughts they broadcast. Emotional and psychologica ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=Earlier%20this%20year%2C%20Neuralink%20made,bran%20directly%20to%20a%20computer)) ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=Key%20to%20achieving%20this%20parity,of%20the%20technology%20next%20year)) interpreted thoughts or inability to *“turn off”* others’ voices could create new social stresses. On the positive side, some speculate it could foster deeper empathy and reduce misunderstandings if used consensually, since communicating at a conceptual or emotional level might convey tone and intent more clearly than text or speech. Education and entertainment could also be transformed – imagine experiencing someone else’s memory or point of view directly, or “thinking” a story to someone else.

**Societal Impact & Inequality:** As with any disruptive technology, there is a risk that synthetic telepathy could widen social inequalities. If only a subset of people have access to cognitive augmentations or telepathic networks (for cost or ethical reasons), a new class divide might emerge between the *“neuro-enhanced”* and *“non-enhanced.”* This could impact employability, education, and social power dynamics. The Royal Society cautioned that if development is *“dictated by a handful of companies then less commercial applications could be sidelined,”* and called for public input to ensure broad benefits. Ideally, ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=%E2%80%9CPeople%20could%20become%20telepathic%20to,with%20friends%2C%E2%80%9D%20the%20report%20states)) d strive for equitable access, perhaps initially focusing on medical needs (e.g. helping paralyzed or locked-in patients) before extending to elective use.

**Ethical Risks – Privacy & Security:** The most immediate ethical concern is mental privacy. If thoughts can be read or transmitted, who controls that data? Could someone intercept or “hack” your thoughts? Unauthorized access to neural data is a frightening prospect – often termed **“mind hacking.”** Unlike a stolen password, stolen neural information could include the most intimate details of one’s personality, memories, or desires. As neurotech proliferates, protecting the **sanctity of the mind** becomes paramount. Leading scientists warn that neural interfaces could pose \*“severe risks if [brain data] falls into ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=smartphone%20was%20a%20few%20decades,engineering%20at%20Imperial%20College%20London)) ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=Facebook%20has%20described%20this%20new,first%20step%20towards%20telepathic%20communication)) ple, a malicious actor could attempt to surreptitiously read thoughts (violating privacy), or even inject false sensory inputs or commands (violating autonomy). The concept of mental **integrity** – freedom from unwanted manipulation – is emerging as a fundamental right in this context.

**Consent and Autonomy:** Ethical use of brain-to-brain tech demands robust consent frameworks. Unlike sending a text or speaking, a person may not easily delineate which thoughts are shared – raising the danger of *unintended leakage* of private thoughts. Users will need clear ways to control the interface (perhaps a deliberate mental “send” command) and to **opt-in** to what data is shared. Another scenario is employer or government misuse: if a job required a brain implant for efficiency or if authoritarian regimes demanded a ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=leading%20scientists%2C%20The%20Independent%20reported)) zens’ neural data, individuals’ right to cognitive liberty would be challenged. Ensuring that use of such implants is always voluntary and within the user’s control will be an ethical cornerstone.

**Psychological Impacts:** Constant telepathic connectivity may have less obvious effects on the ([Chile: Pioneering the protection of neurorights | The UNESCO Courier](https://courier.unesco.org/en/articles/chile-pioneering-protection-neurorights#:~:text=Once%20the%20process%20is%20completed%2C,or%20sold%2C%20trafficked%20or%20manipulated)) routinely experience others’ thoughts or feelings, where do they draw the boundary of their own identity? Philosophers and neuroethicists worry about erosion of the sense of self or free will. For instance, if a device can suggest or influence your thoughts (even benignly, like a cognitive assistant finishing your sentences), over time this could affect personal agency. The Royal Society report raised questions: *“If implantable chips take control of certain decision processes, is that person still themselves or are they now part-machine?”*. These issues force us to confront what it means to be human when technology enters the most private sanctuary of the mind.

**Positive Implications:** On the other hand, the potential benefits are profound. Synthetic telepathy could **bridge communication gaps** for those with language barriers or disabilities, foster global understanding by enabling direct sharing of ideas across cultures, and even help mitigate loneliness (imagine truly sharing how you feel with a loved one, with no words lost in translation). In therapeutic realms, being able to share the experience of someone with PTSD or depression (with consent) could revolutionize empathy in caregiving and psychology. The key will be maximizing these benefits while instituting safeguards to minimize abuse.

In summary, synthetic telepathy stands to *redefine* human communication and cogni ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=The%20report%20calls%20on%20the,as%20a%20tool%20for%20surveillance)) brings formidable ethical challenges. Striking a balance between innovation and protection – ensuring this technology **augments** humanity rather than undermines it – will be crucial as we move forward.

## **Regulatory Frameworks**

**Current Policies and Gaps:** Regulation of neural interfaces is still in its infancy. At present, invasive BCIs (like brain implants) are generally treated as medical devices, which means bodies like the FDA or EMA evaluate them for safety and efficacy in medical contexts. For example, the U.S. FDA issued a 2021 “leapfrog” guidance on testing implanted BCI devices, signaling regulators’ interest in guiding this emerging tech. However, there are not yet comprehensive laws specifically addressing **neural data privacy or brain-to-brain communication**. Most countries rely on existing data protection, medical privacy (e.g. HIPAA in the US), and human subject research laws to cover neurotech in the interim. This is problematic because neural data – arguably **uniquely sensitive** personal data – may not be fully protected under generic laws.

Recognizing this gap, some pioneering efforts have begun. **Chile** became the first country to move toward explicit neuro-specific rights: In 2021, Chile’s Senate approved a constitutional amendment to protect “neurorights” – aiming to safeguard mental privacy, free will, and prevent discrimination based on neural data. This law, expected to be enacted, would give brain data the same status as an inviolable part of the self (like an organ), me ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=The%20FDA%20last%20year%20issued,of%20importance%20to%20public%20health)) nnot be bought or sold, trafficked or manipulated.”\*. This Chilean initiative is being watched globally as a model for protecting citizens in the neurotechnology era.

In the absence of broad federal laws elsewhere, some regional and professional bodies are taking action. In the United States, the state of **Colorado** passed a privacy law in 2023 that **explicitly includes neural data** as protected personal data. This was a first at the state level. Other states like California and Minnesota have also considered similar provisions for neurodata. In Europe, regulators have started issuing opinions on neurotech: in 2023 the Spanish Data Protection Authority and the European Data Protection Supervisor released a joint report on “neuro ([Chile: Pioneering the protection of neurorights | The UNESCO Courier](https://courier.unesco.org/en/articles/chile-pioneering-protection-neurorights#:~:text=Once%20the%20process%20is%20completed%2C,or%20sold%2C%20trafficked%20or%20manipulated)) hallenges under EU law. They concluded that brain data from consumer neurotech (like EEG headsets) should be treated as highly sensitive personal data – often qualifying as biometric or healt ([Chile: Pioneering the protection of neurorights | The UNESCO Courier](https://courier.unesco.org/en/articles/chile-pioneering-protection-neurorights#:~:text=Once%20the%20process%20is%20completed%2C,or%20sold%2C%20trafficked%20or%20manipulated)) us deserves strong protection under GDPR. The UK’s Information Commissioner’s Office (ICO) similarly published a 2022 report calling for guardrails around neurotechnology to uphold privacy and prevent misuse.

Another aspect of regulation is device safety and efficacy. Regulatory agencies are beginning to adapt frameworks used for brain implants (such as deep br ([It’s All in Your Head? Not Anymore: EU Data Protection Authorities Report on Applying Data Protection Law to Consumer Neurotechnologies that Process Brain Data](https://www.mofo.com/resources/insights/240722-it-s-all-in-your-head-not-anymore-eu-data-protection#:~:text=Europe%2C%20and%20the%20United%20States,MoFo%20Minute%20about%20neural%20privacy)) rs) to cover BCIs for communication. For instance, the FDA’s Breakthrough Device designation awarded to Blackrock’s MoveAgain BCI and ([It’s All in Your Head? Not Anymore: EU Data Protection Authorities Report on Applying Data Protection Law to Consumer Neurotechnologies that Process Brain Data](https://www.mofo.com/resources/insights/240722-it-s-all-in-your-head-not-anymore-eu-data-protection#:~:text=UK%20Information%20Commissioner%E2%80%99s%20Office%20,MoFo%20Minute%20about%20neural%20privacy)) entrode facilitates a faster review process, acknowledging the potential benefit to patients who cannot otherwise communicate. As more BCI devices enter trials, regulators are grappling with new questions: How to standardize te ([It’s All in Your Head? Not Anymore: EU Data Protection Authorities Report on Applying Data Protection Law to Consumer Neurotechnologies that Process Brain Data](https://www.mofo.com/resources/insights/240722-it-s-all-in-your-head-not-anymore-eu-data-protection#:~:text=many%20others)) d-reading” accuracy? What constitutes an adverse event – just medical issues, or also psychological harms? These questions underscore the need for updated guidelines.

**Neurorights and Future Guidelines:** Thought leaders ([It’s All in Your Head? Not Anymore: EU Data Protection Authorities Report on Applying Data Protection Law to Consumer Neurotechnologies that Process Brain Data](https://www.mofo.com/resources/insights/240722-it-s-all-in-your-head-not-anymore-eu-data-protection#:~:text=,concerning%20health%2C%20both%20of%20which)) s have proposed establishing **“Neurorights”** – a set of fundamental rights to protect individuals in the neurotech age. The Morningside Group (a consortium of neuro ([It’s All in Your Head? Not Anymore: EU Data Protection Authorities Report on Applying Data Protection Law to Consumer Neurotechnologies that Process Brain Data](https://www.mofo.com/resources/insights/240722-it-s-all-in-your-head-not-anymore-eu-data-protection#:~:text=Europe%2C%20and%20the%20United%20States,MoFo%20Minute%20about%20neural%20privacy)) d ethicists led by Rafael Yuste) has advocated for rights such as mental privacy, personal identity, free will, equal access to augmentation, and protection from algorithmic bias in neurotech. Embedding these principles into law would mean, for example, that your neural data could not be collected or shared without explicit consent (mental privacy), and that you have a right to refuse brain intervention (cognitive liberty).

Internationa ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=In%202021%2C%20Blackrock%20Neurotech%20received,communicating%20more%20effectively%20and%20quickly)) ([Patients with Severe Paralysis Use Stentrode Brain-Computer Interface to Text, Email, Shop, Bank Online, First-in-human Study Reports - BioSpace](https://www.biospace.com/patients-with-severe-paralysis-use-stentrode-brain-computer-interface-to-text-email-shop-bank-online-first-in-human-study-reports#:~:text=the%20study%20shows%20the%20Stentrode%E2%80%99s,JNIS)) to call for governance. UNESCO has discussed neurorights as part of its bioethics initiatives, and the OECD has issued recommendations on responsible innovation in neurotechnology. The European Parliament has also debated “mental privacy” amendments. All these indicate a growing consensus that **brain data requires special handling** distinct from general personal data.

Moving forward, regulators will likely focus on several key areas:

* **Data Privacy and Security:** Enact laws that classify neural data as sensitive personal data, requiring encryption, strict consent, and usage limitations. This could include penalties for companies that misuse brain recordings or attempt to monetize neural signals without c ([Privacy and the Rise of “Neurorights” in Latin America](https://fpf.org/blog/privacy-and-the-rise-of-neurorights-in-latin-america/#:~:text=Privacy%20and%20the%20Rise%20of,integrity%E2%80%9D%20and%20neurodata%20in)) ([General 1 — The Neurorights Foundation](https://neurorightsfoundation.org/chile-2#:~:text=General%201%20%E2%80%94%20The%20Neurorights,and%20mental%20privacy%2C%20becoming)) urisdictions are already moving this way.
* **Consent and User Rights:** Develop standards for informed consent specific to neural interfaces. Users should have the right to know what information is being read or written to their brain, and to easily disconnect or opt-out. “Right to mental privacy” could be encoded legally such that any form of brain telemetry or stimulation without consent is clearly illegal.
* **Safety and Efficacy Standards:** Extend medical device regulations to cover the unique risks of BCIs. This includes not just physical safety (biocompatibility, infection control) but also *neuropsychological* safety – ensuring devices don’t cause unintended mood changes, cognitive deficits, or vulnerabilities to hacking. Regulators may require BCI makers to prove not only that a device works for its intended function (e.g. communication) but also that it has fail-safes (for example, a secure off-switch).
* **Certification and Oversight:** Create certification for practitioners and firms deploying neural interfaces. Just as doctors an ([It’s All in Your Head? Not Anymore: EU Data Protection Authorities Report on Applying Data Protection Law to Consumer Neurotechnologies that Process Brain Data](https://www.mofo.com/resources/insights/240722-it-s-all-in-your-head-not-anymore-eu-data-protection#:~:text=,concerning%20health%2C%20both%20of%20which)) re certified, there may be a need for “neurotechnology operators” or clinics with approved protocols. Research ethics boards will play a role in overseeing trials, but down the line we may need something akin to a *Neurotechnology Regulatory Agency* if consumer use becomes common.
* **Equitable Access:** Policymakers should consider programs to avoid neurotech becoming accessible only to the wealthy. If communication BCIs become invaluable (for instance, as an assistive device or even a productivity tool), insurance and healthcare systems should adapt to cover those in need. Some have suggested treating certain neural enhancements as a public good (much like the internet), to prevent a gulf between those with neural access to information networks and those without.
* **International Cooperation:** Because brain signals and potentially telepathic communications could cross borders (as the 2014 India-to-France experiment showed), international agreements might be required. Much like cybercrime treaties today, we may see **“neurorights”** treaties tomorrow, ensuring that countries commit to banning neural eavesdropping or coercive brain-hacking, and to extradite offenders who violate those norms.

In conclusion, regulatory frameworks are just beginning to catch up with technology. The consensus emerging is that *brain data is special* and warrants proactive protections. As one legal analysis put it, *“Neural data can reveal intimate personal details, and the power of AI to infer information from it is only growing”*. Therefore, governments are urged to establish rules now, before BCIs and synthetic telepathy become widespread. Forward-looking guidelines – drawing on privacy law, human rights, and medical ethics – will be essential to ensure this technology is developed and deployed in a **safe, ethical, and equitable** manner.

## **Comparative Analysis of Neural Interface Technologies**

Not all neural interfaces are created equal. There is a spe ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=In%20a%20first,located%205%2C000%20miles%20apart)) ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=with%20Giulio%20Ruffini%20and%20Carles,TMS%29%20technologies)) systems (that read/write brain activity without surgery) to fully invasive implants. Each approach has trade-offs in bandwidth, latency, resolution, biocompatibility, and practicality:

* **Non-Invasive Interfaces:** These include EEG caps, MEG devices, functional near-infrared spectroscopy (fNIRS) headbands, and transcranial magnetic or electrical stimulators. The clear advantage is safety and ease – no brain surgery is needed, so risk is minimal and they can be used by almost anyone. They are also typically *wearable* or at least external. However, non-invasive methods suffer from lower si ([It’s All in Your Head? Not Anymore: EU Data Protection Authorities Report on Applying Data Protection Law to Consumer Neurotechnologies that Process Brain Data](https://www.mofo.com/resources/insights/240722-it-s-all-in-your-head-not-anymore-eu-data-protection#:~:text=The%20Report%20highlights%20the%20approach,key%20takeaways%20from%20the%20Report)) ([It’s All in Your Head? Not Anymore: EU Data Protection Authorities Report on Applying Data Protection Law to Consumer Neurotechnologies that Process Brain Data](https://www.mofo.com/resources/insights/240722-it-s-all-in-your-head-not-anymore-eu-data-protection#:~:text=challenges%20stem%20from%20the%20sensitive,key%20takeaways%20from%20the%20Report)) stance, records brain waves through the skull, which blurs and attenuates signals. This limits spatial resolution (centimeter-level at best) and bandwidth – only coarse information can be extracted. As DARPA noted, existing noninvasive tech *“do[es] not offer the precision, signal resolution, and portability required for advanced applications”* on par with invasive approaches. Non-invasive BCIs also often have higher latency for certain signals (e.g. an fMRI-based BCI might have a 2-second lag due to hemodynamic response). The **throughput** (bits of information per minute) of non-invasive BCIs is generally much lower than invasive ones. For example, a proficient user of a consumer EEG speller might achieve a few tens of characters per minute, whereas an implanted interface hit 90 char/min in the case of the BrainGate handwriting study. On the output side, non-invasive brain stimulation like TMS can only crudely activate brain regions (e.g., causing a muscle twitch or a flash of light in vision), which is far from the nuanced writing of information that invasive electrodes can achieve. Despite these limits, non-invasive methods are improving – higher-density EEG caps, advanced signal processing, and novel approaches like functional ultrasound or time-domain NIRS promise better resolution without sacrificing safety. They are likely to remain the **preferred option for healthy users** in the near term, due to the non-zero risks of surger ([Next-Generation Nonsurgical Neurotechnology](https://www.darpa.mil/research/programs/next-generation-nonsurgical-neurotechnology#:~:text=Whereas%20the%20most%20effective%2C%20state,world%20settings)) ally Invasive Interfaces:\*\* Sitting between the two extremes are approaches like ECoG (electrocorticography) grids placed on the brain surface or endovascular devices like Synchron’s Stentrode. These avoid penetrating the brain tissue deeply. ECoG, for example, requires a surgery to open the skull, but the electrodes rest on the cortical surface rather than stabbing into it. Signals are cleaner than EEG (no skull in between) with higher spatial resolution, and ECo ([Brain-computer interface creates text on screen by decoding brain signals associated with handwriting | Brown University](https://www.brown.edu/news/2021-05-12/handwriting#:~:text=In%20a%20study%20published%20in,involved%20in%20creating%20written%20letters)) decoding of spoken words and other signals with decent accuracy. The trade-off is that it’s still a surgical implant (with infection/complication risks), and resolution, while better than EEG, is poorer than truly intracortical electrodes that get closer to individual neurons. The Stentrode approach avoids opening the skull at all – it’s delivered via blood vessels – offering a compelling compromise. Its bandwidth is less than a Utah array (fewer electrodes and slightly further from neurons), but patients in trials still achieved useful communication (e.g. 14–20 characters per minute typing with Stentrode) with far less risk. Minimally invasive devices thus try to capture many benefits of invasive tech (improved signal quality, permanence) while mitigating risks.
* **Invasive Interfaces:** These involve surgical implantation of electrodes into the brain tissue. Examples include the Utah array (100-channel silicon spike array), Neuralink’s flexible threads (~1024 channels), and upcoming high-density meshes like Paradromics’. The clear benefit is **signal fidelity** – these electrodes can pick up action potentials of individual neurons or small clusters, providing very high spatial and temporal resolution. This translates to high bandwidth and low latency control. Invasive BCIs have enabled fine-grained control of robotic limbs, high-speed typing, and rich sensory feedback when coupled with stimulation. Because they connect *directly* to neurons, they can read subtle complex patterns that non-invasive tech cannot detect. For synthetic telepathy, this could mean the difference between transmitting a vague feeling versus a detailed sentence or image. However, invasiveness brings significant downsides: risk of i ([Patients with Severe Paralysis Use Stentrode Brain-Computer Interface to Text, Email, Shop, Bank Online, First-in-human Study Reports - BioSpace](https://www.biospace.com/patients-with-severe-paralysis-use-stentrode-brain-computer-interface-to-text-email-shop-bank-online-first-in-human-study-reports#:~:text=tracker%20for%20cursor%20navigation%2C%20without,system%20from%20day%2086%20and)) tial tissue damage or scarring (the foreign body response) that can cause signal quality to degrade over months or years, and the cost and logistics of neurosurgery. There’s also a limit to coverage – implants record from specific regions, so achieving full “mind reading” might require multiple implants in different brain areas (motor cortex, speech areas, visual cortex, etc.), compounding the risk. Biocompatibility is a challenge; implants must be made of materials that don’t irritate the brain, and even then, microglial scarring often occurs over time. Companies like Neuralink and Blackrock are experimenting with ultra-flexible polymers to reduce damage, and coatings to improve longevity. Power and data are another issue: invasive devices ideally need wireless power or battery and wireless data transmission to avoid infection-prone percutaneous connectors. Neuralink’s implant, for instance, uses an inductive charger and Bluetooth-like wireless data. These features make the system more user-friendly, but also must be failsafe (a dead battery in one’s skull could be problematic). In summary, invasive BCIs currently offer the **highest performance** – highest bandwidth, lowest latency, and greatest precision – at the cost of surgical risk and scalability issues.
* **Bandwidth:** In the context of telepathy, bandwidth refers to how much information can be sent/received per unit time. Invasive interfaces have demonstrated the highest bandwidth (e.g., hundreds of bits per minute in clinical trials). Non-invasive BCIs often have bandwidth limitations (a typical EEG speller might be ~5–20 bits per minute). For true fluid thought transmission, high bandwidth will be necessary – likely only achievable with many channels and low noise (favoring invasive tech or yet-to-be-invented high-throughput non-invasive methods). Projects like Paradromics explicitly target bandwidth as a key metric, with tens of thousands of channels to massively increase data rates.
* **Latency:** How quickly can a thought be encoded, sent, and decoded? Invasive recordings tap dire ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=In%20a%202020%20webcast%2C%20Musk,connect%20with%20a%20smartphone%20app)) ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=the%20brain%20for%20continuously%20recording,connect%20with%20a%20smartphone%20app)) hich are instantaneous on the order of milliseconds, and can be decoded in real-time, yielding very low latency (the bottleneck is computation or transmission, not the brain). Non-invasive methods sometimes rely on slower signals (like blood flow in fNIRS or fMRI, lagging by seconds) – clearly too slow for natural conversation. EEG and MEG have good time resolution (milliseconds) but may need time averaging to improve signal, adding some lag. For a natural telepathic dialogue, total system latency would need to be low (say, <100 ms to feel interact ([Brain-computer interface creates text on screen by decoding brain signals associated with handwriting | Brown University](https://www.brown.edu/news/2021-05-12/handwriting#:~:text=In%20a%20study%20published%20in,involved%20in%20creating%20written%20letters)) e systems are closer to this, while current non-invasive ones are typically higher latency.
* **Spatial Resolution:** Invasive electrodes can record from a very localized region (on the order of tens of microns) – enough to pick up single neuron activity. Non-invasive electrodes (EEG) or sensors capture broad swathes of cortex (centimeters), mixing signals from millions of neurons. Thus, invasive tech can discriminate much finer details of brain activity. ([Neuralink vs. Competitors: Key Technological Differences](https://www.usaneuralink.com/neuralink-vs-competitors-key-technological-differences/#:~:text=Differences%20www,development%3B%20Advanced%20electrode%20array)) nes transmitting a mental image or a specific concept, it likely involves patterns across many small neural populations – something invasive arrays could capture better. Non-invasive tech may only capture the “gist” (for example, general excitement vs calm, or rough categories of thoughts). New techniques like high-field magnetoencephalography or advanced decoding algorithms are trying to push non-invasive resolution, but the physics impose hard limits due to skull filtering.
* **Biocompatibility & Longevity:** Non-invasive devices win here – nothing resides in the body, so no chronic health risk (though prolonged use of tight EEG caps can cause skin irritation at most). Invasive implants face long-term biocompatibility issues: scar tissue can form around electrodes (impeding recordings), electrodes can corrode or migrate, and there’s a risk of seizures or other complications from brain implantation. Researchers are exploring coatings (like hydrogels or carbon) to make electrodes more “invisible” to the immune system, and soft electrodes that move with the brain to reduce irritation. The goal is for invasive implants that last decades. Today, many implanted BCIs have lasted a few years before needing replacements or showing degradation. For telepathy to be practical, either implants must become much more stable long-term, or the field must achieve telepathy with minimally/non-invasive methods that can be used repeatedly without health risk.
* **Practicality and User Experience:** Non-invasive devices can be as simple as a wearable headset (e.g. EEG headphones or VR headsets with EEG sensors). They can be taken on and off as needed. The downside is they often require gel, calibration, and can be uncomfortable or conspicuous. There is active work on dry EEG electrodes and making systems more user-friendly – for instance, NextMind (recently acquired by Snap) had a slim EEG that could clip on a cap for basic brain control of interfaces. Invasive devices, once implanted, might actually be *more convenient* in daily use (since nothing to don or doff, it’s just in you), but that assumes a seamless fully internal solution. Current implanted BCIs used by clinical trial participants involve a plug or wireless transmitter worn on the head a ( [Neuropixels 2.0: A miniaturized high-density probe for stable, long-term brain recordings - PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC8244810/#:~:text=days%20and%20weeks%2C%20but%20this,traditional%20silicon%20probes) ) ( [Neuropixels 2.0: A miniaturized high-density probe for stable, long-term brain recordings - PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC8244810/#:~:text=damage%2C%20considerable%20effort%20has%20been,70%2C%2036) ) nvisible. Companies like Neuralink aspire to make the implant *“cosmetically invisible”* (sitting flush with the skull), which would be a game-changer in practicality. Even so, the up-front barrier (brain surgery) is a huge consideration. For healthy individuals, the threshold for elective brain surgery is high. A likely scenario is that non-invasive BCIs will be the first used for any kind of mind-to-mind communication trial among healthy users, until invasive ones become low-risk and perhaps reversible.

In summary, **invasive vs. non-invasive** presents a classic trade-off: **performance** versus **safety/ease**. Invasive neural implants currently offer the only viable route to high-bandwidth, low-latency, precise “telepathic” links – as evidenced by their success in advanced BCI demos. Non-invasive methods, while improving, still lag in fidelity; yet they are far more practical for widespread use and avoid medical risks. It’s conceivable the future will see a convergence of approaches – for instance, novel *molecular or nano-BCIs* that blur the line (minimally invasive particles that can record neurons and transmit signals externally). DARPA’s vision with N3 was along these lines: a non-surgical device that achieves *“precision to read from and write to 16 independent channels within a 16 mm^3 (*[*Neuralink — Pioneering Brain Computer Interfaces*](https://neuralink.com/#:~:text=Neuralink%20%E2%80%94%20Pioneering%20Brain%20Computer,mobile%20device%20anywhere%20you%20go)*) rain tissue within 50 ms, with sub-millimeter specificity”*, essentially rivaling invasive tech without surgery. Achieving that will require breakthroughs in physics and engineering (to get signals through the skull efficiently). Until then, the choice of interface will depend on the application. For medical patients who need communication restoration, the invasiveness may be justified by the life-changing functionality (as seen with implanted patients regaining the ability to *“talk”* through a computer). For consumer or wide use, developers might first leverage non-invasive BCIs for simpler forms of telepathy (perhaps exchange of basic thoughts or emotions) and gradual ([Brain-computer interface creates text on screen by decoding brain signals associated with handwriting | Brown University](https://www.brown.edu/news/2021-05-12/handwriting#:~:text=In%20a%20study%20published%20in,involved%20in%20creating%20written%20letters)) apability as technology allows.

## **Leading Companies, Institutions, and Researchers**

The quest for advanced neural interfaces and synthetic telepathy is truly interdisciplinary, spanning academia, industry, and government. Below we highlight some of the key players and influencers driving the field:

* **Neuralink (Company):** Founded in 2016 by Elon Musk, Neuralink has become almost synonymous with futuristic BCIs. Neuralink’s core team of engineers and neuroscientists (such as DJ Seo and Philip Sabes) developed the *“N1”* implant – a high-density electrode device inserted by a robotic surgeon. The company’s show-and-tell events hav ([Next-Generation Nonsurgical Neurotechnology](https://www.darpa.mil/research/programs/next-generation-nonsurgical-neurotechnology#:~:text=The%20envisioned%20N,in%20the%20brain%20at%20once)) d monkeys controlling cursors and typing with their implant, and in 2023 they began human trials. Musk often credits scientists like **Ian Burkhart** (an early BCI test pilot) and academic work from **UC Davis** (which partnered with Neuralink on animal studies) for laying the groundwork. Neuralink has recruited top neural interface researchers from academia, exemplifying the close ties between ([Patients with Severe Paralysis Use Stentrode Brain-Computer Interface to Text, Email, Shop, Bank Online, First-in-human Study Reports - BioSpace](https://www.biospace.com/patients-with-severe-paralysis-use-stentrode-brain-computer-interface-to-text-email-shop-bank-online-first-in-human-study-reports#:~:text=the%20study%20shows%20the%20Stentrode%E2%80%99s,JNIS)) s and industry. Its vision of brain-to-brain communication and “conceptual telepathy” is a major inspiration in the tech world.
* **Kernel (Company):** Led by CEO **Bryan Johnson**, Kernel initially hired renowned neuroscientists such as **Ted Berger** (known for memory prosthesis research) to pursue implantable memory chips. While that direction shifted, Kernel’s team (including neuroscientist **Osman (Oz) al Shehhi** and others) delivered the Kernel Flow headset in 2021. They collaborate with academic partners to validate this technology. Johnson’s bold statements about *“uploading memories”* and boosting intelligence gave Kernel a high profile. Now, Kernel is influential in the *non-invasive* neurotech space, working with institutions to use Flow for cognitive research ([Neuralink vs. Competitors: Key Technological Differences](https://www.usaneuralink.com/neuralink-vs-competitors-key-technological-differences/#:~:text=The%20N1%20Chip%20and%20Surgical,Robot)) (Company):\*\* **Dr. Thomas Oxley**, a vascular neurologist, is Synchron’s co-founder and CEO. His work at University of Melbourne on the stentrode concept propelled Synchron’s formation. Under Oxley’s leadership, Synchron’s team (including CTO **Nick Opie**) achieved the first endovascular BCI implants in humans. They collaborate with academic hospitals in Australia and the US (e.g., University of Melbourne, Mount Sinai in New York) for clinical trials. Synchron’s success h ([7 Leading Brain-Computer Interface Companies and their Current and Prospective Products – Ross Dawson](https://rossdawson.com/futurist/companies-creating-future/leading-brain-computer-interface-companies-bci/#:~:text=electrodes%20techcrunch,and%20manipulated%20using%20artificial%20intelligence)) ompetitor to watch; even Elon Musk reportedly took interest. By proving a **no-craniotomy** implant can enable ([Elon Musk Predicts Human-to-Human Mind Communication in 10 Years - Business Insider](https://www.businessinsider.com/elon-musk-prediction-human-to-human-mind-communication-10-years-2020-5#:~:text=,Insider%27s%20homepage%20for%20more%20stories)) Synchron’s group has positioned themselves at the forefront of practical BCI deployment.
* **Blackrock Neurotech (Company):** Co-founded by neuroengineer **Florian Solzbacher**, Blackrock is a stalwart in neural interfaces. They work closely with top research universities: for instance, they supply Utah arrays to the **BrainGate consortium** and l ([7 Leading Brain-Computer Interface Companies and their Current and Prospective Products – Ross Dawson](https://rossdawson.com/futurist/companies-creating-future/leading-brain-computer-interface-companies-bci/#:~:text=Kernel%20is%20building%20the%20next,that%20maintains%20or%20improves%20on)) rsity of Pittsburgh, Caltech, etc. **Marcus Gerhardt**, Blackrock’s CEO, and **Cindy Chestek**, a prominent researcher (at University of Michigan) who collaborates with them, ar ([7 Leading Brain-Computer Interface Companies and their Current and Prospective Products – Ross Dawson](https://rossdawson.com/futurist/companies-creating-future/leading-brain-computer-interface-companies-bci/#:~:text=The%20original%20goal%20of%20Kernel,Like)) ures. Blackrock’s technology has been used in many “firsts” – first person to control a robotic arm with thought, first sensation of touch via a BCI arm, etc. Their nearly 20-year dataset of human implant experience is unmatched. They also partner with institutions like Carnegie Mellon University’s BCI group to miniaturize and move BCIs toward home use.
* **Paradromics (Company):** Founded by **Matt Angle**, Paradromics employs a team of silicon and ([Patients with Severe Paralysis Use Stentrode Brain-Computer Interface to Text, Email, Shop, Bank Online, First-in-human Study Reports - BioSpace](https://www.biospace.com/patients-with-severe-paralysis-use-stentrode-brain-computer-interface-to-text-email-shop-bank-online-first-in-human-study-reports#:~:text=the%20study%20shows%20the%20Stentrode%E2%80%99s,JNIS)) ineers to realize its high-channel count vision. They aren’t as public-facing as Neuralink, but their work is published in engineering forums and they often reference collaborations with researchers from places like **Stanford** and \*\*Br ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=Synchron%E2%80%99s%20rise%20to%20rival%20BCI,coming%20together%20of%20the%20compa345anies)) heir tech in animal models. If Paradromics achieves its 65k-electrode device, it will likely do so in partnership with academic neuroscience labs needing massive neural recordings.
* **Major Academic Institutions & Labs:**
  + **University of Washington (Center for Neurotechnology):** Led by **Rajesh Rao** and **Andrea Stocco**, UW has pioneered human brain-to-brain experiments. Rao’s lab carried out the first human BBI in 2013 and the multi-person BrainNet in 2019. They are known for combining disciplines (computer science, psychology, neuroscience) and have NSF funding for neurotechnology.
  + **Stanford University (Neural Prosthetics Translational Lab):** Co-directed by **Prof. Krishna Shenoy** (an electrical engineer/neuroscientist) and neurosurgeon **Dr. Jaimie Henderson**, this lab has produced a string of BCI innovations – ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=While%20some%20companies%20have%20made,serious%20adverse%20events%20since%20then)) typing BCIs to brain-controlled prosthetic limbs. They are key members of BrainGate and often publish in *Nature* and \*Scien ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=Blackrock%20and%20the%20University%20of,commercial%20product%20early%20next%20year)) s also home to **Dr. E.J. Chichilnisky** who works on high-density retinal implants (related interface tech) and **Prof. Howard Wu** exploring neuromodulation for communication.
  + **Brown University & Partners (BrainGate Consortium):** Brown’s **Carney Institute for Brain Science** (with Prof. **Leigh Hochberg**, Prof. **John Donoghue** – the original BrainGate inventor, and others) coordinates the multi-institution BrainGate trials. T ([Neuralink vs. Competitors: Key Technological Differences](https://www.usaneuralink.com/neuralink-vs-competitors-key-technological-differences/#:~:text=Differences%20www,development%3B%20Advanced%20electrode%20array)) nstrumental in translating academic BCI research into clinical application.
  + **MIT (McGovern Institute & Media Lab):** At MIT, figures like **Ed Boyden** (co-inventor of optogenetics) are creating advanced neural tools – e.g., optogenetic and magnetogenetic interfaces that might one day allow wireless control of neural circuits. The MIT Media Lab’s *Fluid Interfaces* group previously de ( [How you and your friends can play a video game together using only your minds | UW News](https://www.washington.edu/news/2019/07/01/play-a-video-game-using-only-your-mind/#:~:text=In%20BrainNet%2C%20three%20people%20play,to%20the%20preprint%20site%20arXiv) ) em called “AlterEgo” (by **Arnav Kapur**) that enabled subvocal communication by reading neuromuscular signals from the jaw – not exactly brain-to-brain, but a novel “silent speech” interface that hints at new communication modalities. MIT’s strong neuroengineering programs make it a hotbed for next-gen interface research, including high-density electrode development and brain network mapping.  
     ([Brain-computer interface creates text on screen by decoding brain signals associated with handwriting | Brown University](https://www.brown.edu/news/2021-05-12/handwriting#:~:text=The%20new%20study%20is%20part,professor%20of%20neurosurgery%20at%20Stanford)) University (Neurotechnology Center):\*\* **Prof. Rafael Yuste** at Columbia is known both for cutting-edge neurotech (like all-optical brain manipulation tools) and neuroethics leadership (he’s a driving force behind neurorights). Columbia’s teams work on brain decoding, memory editing, and other tech that inform what future telepathy devices might do. Yuste’s advocacy on neurorights has influenced Chile’s legislation and beyond.
  + **EPFL (École Polytechnique Fédérale de Lausanne, Switzerland):** EPFL has a world-renowned neuroprosthetics program. **Prof. José del R. Millán**, a pioneer in BCIs for the disabled, was at EPFL for many years, produci ([Brain-computer interface creates text on screen by decoding brain signals associated with handwriting | Brown University](https://www.brown.edu/news/2021-05-12/handwriting#:~:text=The%20new%20study%20is%20part,professor%20of%20neurosurgery%20at%20Stanford)) l work on non-invasive brain-controlled wheelchairs and spelling systems. (He is now at UT Austin, but his legacy continues at EPFL’s labs.) **Prof. Stéphanie Lacour** leads EPFL’s Laboratory for Soft Bioelectronic Interfaces, developing flexible implantable electrodes that can conform to the brain – crucial for next-gen implants with better biocompatibility. EPFL’s Blue Brain Project (while focused on simulation) and its neuroscience center also contribute knowledge about brain structure that can guide interface placement. In short, EPFL marries engineering and neuroscience as few places do.
  + **University of Pittsburgh & Carnegie Mellon (Pitt/CMU):** The Pittsburgh region hosts a consortium on neural engineering. **Dr. Jennifer Collinger** and **Dr. Robert Gaunt** at Pitt have led trials where paralyzed individuals controlled robotic arms and even experienced tactile feedback through brain implants. CMU’s **Neurotech Center** (with folks like \*\*Doug Webe ([Brain-Computer Interfaces to Enable People to Communicate with Their Thoughts - Science news - Tasnim News Agency](https://www.tasnimnews.com/en/news/2019/09/10/2093756/brain-computer-interfaces-to-enable-people-to-communicate-with-their-thoughts#:~:text=%E2%80%9CPeople%20could%20become%20telepathic%20to,with%20friends%2C%E2%80%9D%20the%20report%20states)) MU, formerly DARPA) works on bidirectional BCIs. These groups often collaborate with Blackrock Neurotech.
  + **Harvard & MIT (Boston area):** In addition to MIT, Harvard Medical School’s Beth Israel Deaconess Medical Center (where Pascual-Leone is based) is notable for the 2014 brain-to-brain study. Harvard’s **Brain Science Initiative** and Massachusetts General Hospital (MGH) are doing BCI research for restoring speech (e.g., **Sydney Cash** and colleagues decode internal speech in paralyzed patients). Boston University’s **Stephen Grossberg** and **Frank Guenther** have done foundational work modeling how the brain could communicate thoughts (Guenther’s team was behind an early speech BCI that let a locked-in patient attempt to speak via a synthesizer). This cluster of Boston institutions has a rich history in both the tech and the neuroscience of communication BCIs.
* **Individual Researchers and Innovators:**
  + **Miguel Nicolelis (Neuroscientist, Duke University):** A trailblazer who demonstrated that brains can be networked. His famous quote upon linking rat brains – *“We have established a direct communication linkage between brains”* – captured the imagination of many. Nicolelis also showed monkeys controlling virtual avatars and exoskeletons via brain signals, foreseeing a future where brains interchange information in real time.
  + **Alvaro Pascual-Leone (Neurologist, Harvard/BIDMC):** A leader in non-invasive brain stimulation, he co-led the first human brain-to-brain communication paper. ([7 brain-computer interface companies you need to know](https://www.massdevice.com/brain-computer-interface-bci-companies/#:~:text=Blackrock%20and%20the%20University%20of,commercial%20product%20early%20next%20year)) work in TMS and plasticity provides insight into how to write information into the brain safely, a key aspect of synthetic telepathy.
  + **Giulio Ruffini (Physicist, Starlab, Spain):** Co-author ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=,brain%20communication)) human BBI study, Ruffini specializes in EEG/TMS interfaces. He and other European researchers (like **Andrea Stocco** and **Carles Grau**) form a network of scientists pushing the envelope on non-invasive BBIs.
  + **Philip Low and Mary Lou Jepsen:** Low (of NeuroVigil) and Jepsen (founder of OpenWater) are entrepreneurs taking novel approaches. Low worked on single-channel EEG algorithms that purportedly detected a patient’s imagined communication (controversially with Stephen Hawking). Jepsen is developing a wearable cap that uses infrared lasers and holography to image brain activity at high resolution, aiming for fMRI-like insights in a beanie – which could provide a path to high-bandwidth, non-invasive “mind reading.”
  + **Edward Chang (Neurosurgeon, UCSF):** Dr. Chang has led studies decoding speech from the cortical surface. In 2021, he demons ([Brain-to-brain interface lets rats share information via internet](https://www.theguardian.com/science/2013/feb/28/brains-rats-connected-share-information#:~:text=Brain,Nicolelis%20said%20in%20a%20statement)) peech neuroprosthesis” that enabled a man who was unable to speak to generate sentences on a screen by decoding signals from his speech motor cortex. His advances in decoding internal speech and language intentions are directly relevant to brain-to-text and thus brain-to-brain communication of language.
  + **Nita Farahany and Ienca & Andorno (Ethicists):** In t ([Direct brain-to-brain communication demonstrated in human subjects | ScienceDaily](https://www.sciencedaily.com/releases/2014/09/140903105646.htm#:~:text=,brain%20communication)) main, legal scholar **Nita Farahany** has been actively writing about cognitive liberty and the need for new rights in the neurotech era. Ethicists **Marcello Ienca** and **Roberto Andorno** authored influential papers calling for “neuroprivacy” and “personal identity” rights, helping shape policy discussions.
  + **DARPA Program Managers:** People like **Al Emondi** (who oversaw the N3 program) and **Justin Sanchez** (ran earlier BCI programs at DARPA) quietly shape the direction of the field by funding high-risk, high-reward research. They often have one foot in academia and one in defense, bridging those worlds.

This is by no means an exhaustive list – the field of neural interfaces is large and growing – but these entities and individuals are among those most prominently driving the science and development of synthetic telepathy. Their combined efforts, from building the hardware and algorithms to addressing the human and ethical implications, are bringing closer a future where “thought communication” may be as normal as texting. As the Royal Society report noted, the possibilities are vast, but it’s crucial that a diverse set of stakeholders (universities, companies, public agencies) continue to shape this technology so t ([Paralyzed Man's Brain Signals Decoded to Words by AI and BCI](https://www.psychologytoday.com/ca/blog/the-future-brain/202107/paralyzed-mans-brain-signals-decoded-words-ai-and-bci#:~:text=Paralyzed%20Man%27s%20Brain%20Signals%20Decoded,deep%20learning%20and%20a)) its are realized safely and broadly.