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Brain research: Mining emerging trends and top research concepts

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Like the brain itself, brain research is complex and encompasses the study of Brain Anatomy, Neuroscience, Cognitive Science, and interrelated disciplines. Disciplinary silos are breaking down, with investigators from fields including Medicine, Biology, Engineering, Computer Science, and Psychology working within large collaborative research initiatives. The growing interest in new ways to treat or even prevent brain disorders, as well as the push towards cross-disciplinary research, provides context for a recently launched Brain Research Report (1) that offers an overview of the state of research in the area of Brain and Neuroscience. This report was discussed at Neuroscience 2014, the Society for Neuroscience's Annual Meeting, taking place in November in Washington, DC. Beyond understanding the publication output, growth and impact of key countries in Brain and Neuroscience research, new methodologies were experimented with to mine for emerging trends in this field, and to discern different research emphasis between funded grant awards and existing Brain and Neuroscience publications.

Brain research is Neuroscience and more

The document sets underlying our analyses were created using text mining and natural language processing techniques inherent in the semantic Elsevier Fingerprint Engine™. Our approach to define Brain and Neuroscience is multi-method and iterative, and relies on both automatic and manual input to select relevant articles for analysis. By combining three approaches – an initial journal-based classification system, semantic fingerprinting using the Fingerprint Engine, and internal and external expert review and selection of key concepts – we were able to identify a broad set of articles that best represent the entire field of Brain and Neuroscience research. For example, our document set comprised about 91% of all articles in the Neuroscience journal category in 2009-2013, and 64% of the articles in the Psychology journal category in Scopus (see Figure 1). Figure 2 shows the concepts where the selection rate was 100%, meaning that all documents that contained these concepts were included.

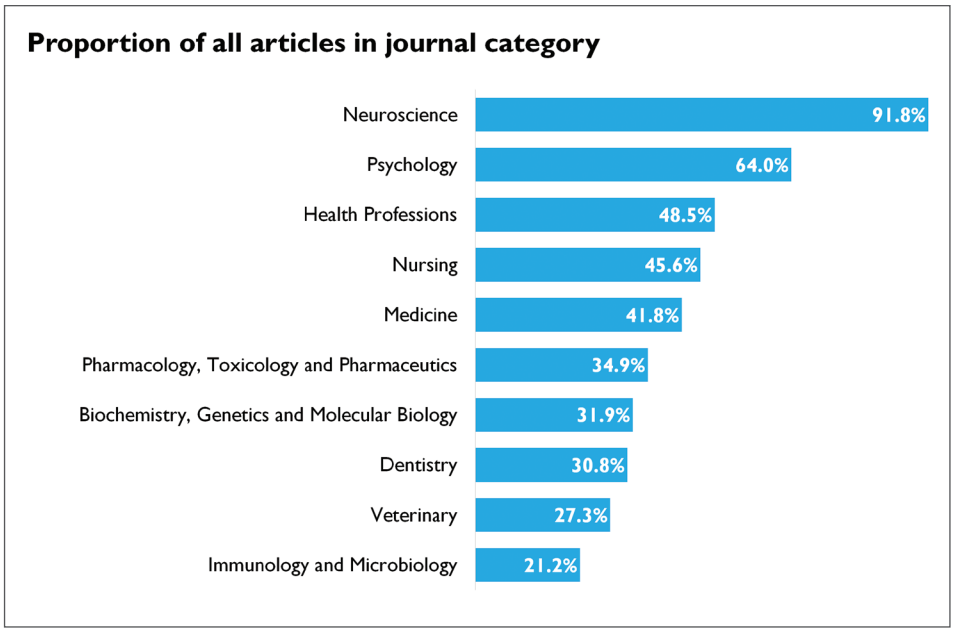

Figure 1: Selected articles were not only from the Neuroscience journal category in Scopus, but also other related journal categories. The top 10 journal categories are shown in this figure, along with the proportion of all documents in each journal category which were included in our selected document set. Source: Scopus

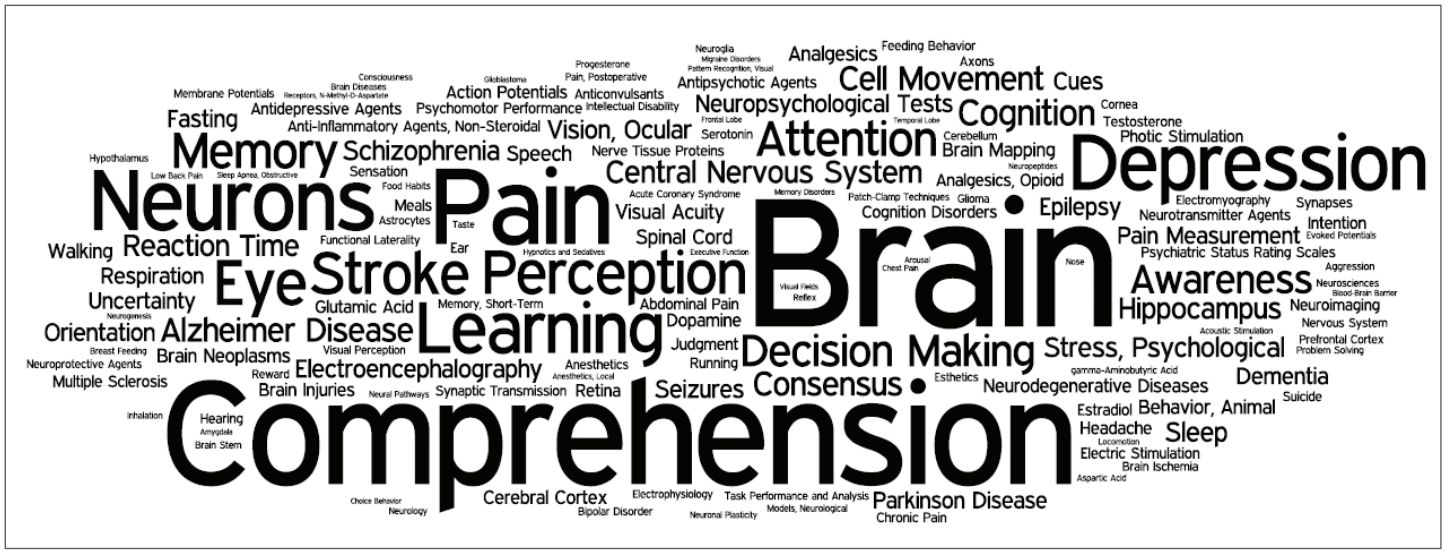

Figure 2: Concepts from selected document set where the selection rate was 100%, meaning that all relevant documents that contained these concepts were included in our analysis. The size of each concept is weighted by the number of occurrences in the selected document set. Source: Scopus

Emerging trends

Trends and correlations can provide insight into how topics of interest emerge from research outputs; however, the challenge remains to differentiate obvious trends from those that are emergent: one approach is to compute them using big data, and then have the results validated by experienced practitioners and scientists of the field. The burst detection algorithm proposed by Kleinberg (2) provides a model for the robust and efficient identification of word bursts, and allows the identification of rapid growth within categories or thesauri. By applying the burst detection algorithm, we were able to find concepts which displayed rapid growth over the years, signaling a "burst of activity". Compared to the period 2003-2008, both broad and specific Brain and Neuroscience concepts grew rapidly in 2009-2013. These include concepts such as "High-throughput Nucleotide Sequencing," "Molecular Targeted Therapy," "Molecular Docking Simulation," "Sirtuin 1," "Purinergic P2X Receptor Antagonists" and "Anti-N-Methyl-D-Aspartate Receptor Encephalitis."

Top concepts in published Brain and Neuroscience research were organized by overall theme (semantic group). Under the disorders group, concepts such as "Stroke," "Depression," "Neoplasms," and "Alzheimer Disease" were seen most often, while under anatomy, "Brain," "Eye," and "Neurons" were most common (see Table 1).

Different research emphasis in the EU and the US

Next, we compared the top concepts within the Brain and Neuroscience research publications from Scopus against publications produced by the recipients of funded grant awards related to Brain and Neuroscience research from the National Institutes of Health (NIH) (3), and project abstracts that were available from the list of brain research projects supported by the European Commission (EC) (4). Concepts were extracted from about 2 million Brain and Neuroscience articles from Scopus, 59,637 articles produced by recipients of funded grant awards relating to Brain and Neuroscience research from NIH, and 136 project abstracts available from the Brain research projects supported by the EC.
As expected, concepts such as "Brain," "Neurons," "Seizures," and "Brain Neoplasms" were seen with similar frequency in the published articles and the NIH-funded grant abstracts. However, concepts such as "Eye," "Pain," and "Stress, Psychological" were more highly represented in published articles than in NIH-funded abstracts, suggesting a divergence from funding to publication.

Not surprisingly, NIH-funded abstracts more often contained disease-related concepts, consistent with the NIH's focus on areas of research with perceived high societal impact. Compared to the research funded by the EC, US research focused on the concepts "Glioma," "Child Development Disorders, Pervasive," and "Bipolar Disorder." Conversely, concepts such as "Memory Disorders," "Vision Disorders," "Myasthenia Gravis," "Hearing Loss," and "Alkalosis" were more frequent in the EC-funded research compared to the US, suggesting a different emphasis in research relating to disorders in Brain and Neuroscience (see Table 2). In the US, drugs related to substance abuse were highly researched, with the appearance of concepts such as "Methamphetamine," "Nicotine," and "Cannabis." In contrast, antipsychotic drugs such as "Risperidone" and "Clozapine" that are mainly used to treat schizophrenia were areas of focus in the EC-funded research (see Table 3).

Activities & Behaviors	Anatomy	Chemicals & Drugs	Disorders	Genes & Molecular Sequences
Exercise (12,473)	Eye (14,836)	Proteins (12,255)	Stroke (21,404)	Single Nucleotide Polymorphism (4,007)
Suicide (6,106)	Neurons (14,388)	Glucose (7,423)	Depression (21,668)	Alleles (3,248)
Motor Activity (6,454)	Cells (15,167)	Food (8,477)	Neoplasms (25,047)	Genome (2,742)
Speech (8,055)	Muscles (10,758)	Alcohols (6,396)	Alzheimer Disease (14,522)	Quantitative Trait Loci (590)
Behavior (11,274)	Stem Cells (7,034)	Insulin (6,021)	Pain (16,719)	Major Histocompatibility Complex (450)
Smoking (4,667)	Brain (15,980)	MicroRNAs (4,180)	Schizophrenia (13,752)	Homeobox Genes (449)
Costs and Cost Analysis (6,437)	T-Lymphocytes (6,261)	Pharmaceutical Preparations (10,822)	Parkinson Disease (11,366)	Catalytic Domain (811)
Residence Characteristics (7,277)	Bone and Bones (7,257)	Peptides (6,718)	Wounds and Injuries (13,414)	Transcriptome (777)
Walking (5,517)	Spermatozoa (3,944)	Acids (5,225)	Syndrome (13,258)	Transgenes (513)
Work (7,139)	Face (5,974)	Cocaine (3,153)	Multiple Sclerosis (9,275)	Oncogenes (394)

Table 1: Top 10 concepts that occurred in Brain and Neuroscience research articles from Scopus between 2008 and 2013, based on the semantic groups to which they belong, sorted by the sum of term frequency-inverse document frequency (tf-idf) of the concept in the document set, where the tf-idf value reflects the relevance and importance of the concept in the document. Figures in parentheses are the frequency with which the concept occurred in the set of Brain and Neuroscience research articles from Scopus between 2008 and 2013 (i.e. the tf value). Source: Scopus

Top 10 concepts relating to disorders in:		
Set A - Brain and Neuroscience articles from Scopus	**Set B - Brain and Neuroscience funded grant awards from the NIH**	**Set C - Brain research project synopses supported by the European Commission**
Stroke (21,404)	Alzheimer Disease (842)	Stroke (6)
Depression (21,668)	Stroke (328,070)	Parkinson Disease (7)
Neoplasms (25,047)	Schizophrenia (19,489)	Schizophrenia (5)
Alzheimer Disease (14,522)	Pain (15,742)	Memory Disorders (3)
Pain (16,719)	Parkinson Disease (15,963)	Vision Disorders (2)
Schizophrenia (13,752)	Depression (6,028)	Alzheimer Disease (4)
Parkinson Disease (11,366)	Neoplasms (14,585)	Myasthenia Gravis (1)
Wounds and Injuries (13,414)	Glioma (9,271)	Hearing Loss (3)
Syndrome (13,258)	Child Development Disorders, Pervasive (4,062)	Alkalosis (1)
Multiple Sclerosis (9,275)	Bipolar Disorder (2,571)	Pain (1)

Table 2: Top 10 concepts that occurred in Brain and Neuroscience research articles relating to disorders from document sets A, B and C, based on the sum of term frequency-inverse document frequency (tf-idf) of the concept in the document set that it belonged to. Figures in parentheses are the frequency with which the concept occurred in the document set. Highlighted in grey are concepts that appeared in the top 10 disorder-related concepts in all three document sets, reflecting common areas of focus. Highlighted in orange are concepts that only appeared in Set A and Set B. Concepts that are not highlighted were those unique to each document set, indicating different areas of focus in disorder-related concepts in Brain and Neuroscience research.

Top 10 concepts relating to chemicals & drugs in:		
Set A - Brain and Neuroscience articles from Scopus	**Set B – Brain and Neuroscience output from funded grant awards from the NIH**	**Set C – Brain research project synopses supported by the European Commission**
Proteins (12,255)	Alcohols (663)	Enzymes (2)
Glucose (7,423)	Cocaine (4,670)	NADPH Oxidase (1)
Food (8,477)	Ethanol (653)	Inflammation Mediators (1)
Alcohols (6,396)	Methamphetamine (13,551)	Anticonvulsants (2)
Insulin (6,021)	Analgesics, Opioid (1,068)	Quantum Dots (1)
MicroRNAs (4,180)	Nicotine (14,836)	Iron (1)
Pharmaceutical Preparations (10,822)	MicroRNAs (407,989)	Peptides (1)
Peptides (6,718)	Dopamine (6,756)	Risperidone (1)
Acids (5,225)	Cannabis (3,270)	Clozapine (1)
Cocaine (3,153)	Prions (17,586)	Phosphotransferases (2)

Table 3: Top 10 concepts that occurred in Brain and Neuroscience research articles relating to chemicals & drugs from document sets A, B and C, based on the sum of term frequency-inverse document frequency (tf-idf) of the concept in the document set that it belonged to. Figures in parentheses are the frequency at which the concept occurred in the document set. Highlighted in orange are concepts that only appeared in Set A and Set B. Highlighted in grey are concepts that only appeared in Set A and Set C. Concepts that are not highlighted were those unique to each document set, indicating different areas of focus in chemicals & drugs-related concepts in Brain and Neuroscience research.

Conclusion

The hidden complexities of the brain are being explored by scientists working across boundaries and across disciplines to overcome technological challenges and to develop new techniques, methods, and better equipment to study the brain. In our study of the top concepts in funded grant awards, research is driven towards a better understanding of diseases and disorders related to Brain and Neuroscience, such as autism and Alzheimer Disease. This is coupled with an emphasis on drug development, for instance in the area of schizophrenia treatment. Strong research is also evident in the area of genes and molecular sequences where concepts such as connectome and transcriptome have either been detected as having rapid growth or are already considered important concepts in Brain and Neuroscience research publications.

By providing the first attempt to understand the overall state of research in Brain and Neuroscience, the report reveals patterns of activities globally, which we hope will be useful to policy makers and decision makers in steering future strategy in Brain research. There is also potential to conduct a deeper analysis of research in specific semantic groups of Brain and Neuroscience research, for example, focusing only on disorders, or chemical and drugs related publications and concepts.

Exploring the brain is akin to exploring the mind and exploring the self. Thus it is with great interest and anticipation that we watch for further developments in this important field of science, which will certainly affect us in one way or another as we learn more about our own brains.

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