# A Blur Connection in Cognition, Psychology and Artificial Intelligence-Machine Learning

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## ABSTRACT

This paper discusses psychology and contemporary studies in the backdrop of neuro-instruments, computational paradigms, and artificial intelligence & machine learning techniques. There has been a historical connection with psychology, primarily cognitive, albeit, where pioneers initially shared their interests in both fields. As the advent in both the subjects unfolded, neuro-instruments and the corresponding images provided a broader scope of understanding the mind while both kept growing side by side. Hence, it is projected that in the future, with concurrent and appropriate use of these, the trend will likely become more noticeable and distinct, allowing us to reveal the unrealized potential of the mind and its range, which has been a natural search among us since the birth of civilization.

As psychology developed thru centuries and branched out to many application domains, viz., education, clinical, cognitive, industrial, and many similar ones, recent scientific progress led to the use of computers for gradual further unfoldment. Conspicuously, the 1948 work of Claude Shannon's information theory nonetheless revolutionized information processing in many domains, contemporarily the backbone of today's era of modern communication. Nevertheless, psychology, primarily the cognitive studies domain, has never been an exception in grasping the advantage of this theory while the mind-information-processing nature became more obviously discoverable. Subsequently, the computer Turing era and concept gradually led to the advent of artificial intelligence and machine learning.

American Psychologist George Miller came out with on 11th Sep 1956 the concept of the 'Magical number seven plus or minus two', the same year earlier in the famous summer conference of Artificial Intelligence by John McCarthy. It is interesting to note that Mervin Minsky, a Cognitive Scientist, learned Psychology from George Miller. Notably, his invention of the confocal microscope, an instrument that removed the difficulty of out-of-focus light, became dependable for cell biology laboratory experiments often used in brain laboratory experiments of cellular mapping. In the research of computers since the 1950's IBM has long remained the pioneer. The phrase "machine learning" is credited to Arthur Samuel of IBM Engineer for his research on the game of checkers (Samuel, 1959).

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Interestingly, Arthur Samuel was also a proposer in the team of John McCarthy along with Claude Shannon, Marvin Minsky, and N Rochester (McCarthy et al., 1955) for subsequently organizing the first summer conference on artificial intelligence.

Frank Rosenblatt, an American psychologist often called the father of deep learning, a further subset of artificial intelligence, introduced perceptron and authored a book in 1962 titled 'Principles of Neurodynamics, Perceptrons, and the Theory of brain mechanisms'. Contemporarily, Donald Hebb, Canadian Psychologist, in more technical terms, he stated that "Any two cells or systems of cells that are regularly active at the same time will tend to become "connected," so that activity in one helps activity in the other." He is famous for the quote "Cells that fire together, wire together." This phrase is famous in the artificial intelligence/machine learning domain of artificial neural networks as a theoretical cornerstone. Inspired by Neurologist Wilder Penfield for introducing the Montreal procedure in epilepsy, Brenda Milner became one of the founders of Cognitive Neuroscience, often interwoven with cognitive psychology, i.e., an application of cognitive psychology that addresses how the brain works (M. K. Johnson, 2016). It has been credited to Gazzaniga, who first used the coined term cognitive neuroscience in the 1970s during a taxi ride in New York along with George Miller. (Posner & Rao, 1967), (Gazzaniga, 2000), (Gazzaniga, 2020).

Beginning in the nineteenth century, experimental psychology sparked a fascination with learning about higher mental functions increased gradually and after 1950's the cognitive revolution leads to cognitive psychology. As it is widely known that the rejection of behaviourism and computer modelling laten on in the beginning of twenty first century as the chronicle of it. The mental processes of information operating on human mind is the cornerstone of modern cognitive psychology (Smith, 2015). The cognitive psychology in and around sensation, perception, awareness, memory, classification, education, language, discernment, and reasoning that lead to problem solving thus inevitably offers tremendous scope of experimentations (Kihlstrom & Park, 2016). The views of brain development in human are of ontogenetic, phylogenetic views are all of cognitive developments arena. Dealing with memory as it comprises of long-term memory and short-term memory, cognitive load theory and the architecture encompasses cognitive principles and effects (Sweller, 2019). Experimentation in Twentieth-century Educational Psychology began as social reforming parallel results. The How to Experiment in Education guidebook was released in 1923 by American psychologist William McCall. (Dehue, 2015a), (Dehue, 2015b). The social factors that affects perceptions and actions are well-described in top-down modulations (Ramsey & Ward, 2020). Building cognitive robots , functional computational modelling for experimentations and the reciprocal interactions are studied (D'Mello & Franklin, 2011) Building customs database for veganism study and sampling thereof with data analytics paradigm has been showed (Gregson et al., 2022). Physical activity and behavioural psychology have been studied with use of statistical technique and visualization thereof (Biddle, 2021). Who will benefit from CBT? A thorough evaluation of the research and meta-analysis using machine learning (CBT) has been produced severe mental health disorders regime (Vieira et al., 2022). The research was based on electronic database like PubMed etc. Professional YouTuber's health (del Río Carral et al., 2021). Digitalisation in psychology has offered enormous scope and possibility in the field of research and application (Ostermann et al., 2021). Nonverbal behaviour and mimicry features are also identifiable from the application as discussed in this paper (Roegiers et al., 2022). Personality analysis and research in ML era has also been discussed well in this paper (Stachl et al., 2020).

Neuro-instruments such as functional near-infrared spectroscopy, magnetic resonance imaging (MRI) from nuclear magnetic resonance, and positron emission tomography (PET) (fNIRS), Electroencephalogram (EEG), Magnetoencephalogram (MEG) are being used for brain imaging are these essentially part of studies cum research in cognitive psychology and thus corresponding neuroscience for understanding the brain working underpinnings.

### *In time of synergy with Cognitive Psychology and AI-ML Advent*
Cognitive neuroscience is a subspecialty of cognitive psychology that deals with concerns about how the brain functions (M. K. Johnson, 2016). Yet, the development of neuro-instruments like fMRI, PET, EEG, etc. has made this easier to study (Detre & Floyd, 2001). A systematic review of the literature and meta-analysis study of ML who will benefit from cognitive behaviour therapy (CBT) has been produced severe mental health disorders regime (Vieira et al., 2022). The Professional YouTuber's health research was based on electronic database like PubMed etc. (del Río Carral et al., 2021). Digitalisation in psychology has offered enormous scope and possibility in the field of research and application (Ostermann et al., 2021). Nonverbal behaviour and mimicry features are also identifiable from the application as discussed in a paper by Roegiers et al (Roegiers et al., 2022). Personality analysis and study in the ML period has also been discussed well in a paper by Stachl et al (Stachl et al., 2020).

The last decades of internet booming use have led to an abundance of data from almost all walks of life. Correspondingly, data science emerged as a critical area for understanding and extracting the required information. Data science is the subset of domain knowledge, with the relevant knowledge of mathematics, statistics, and computer science, as shown in Figure 1A. Though often artificial intelligence cum machine learning, has been used in Data Science applications. Moreover, as evident from Figure 1B, Machine learning is a subset of artificial intelligence, while deep learning is a subset of machine learning.
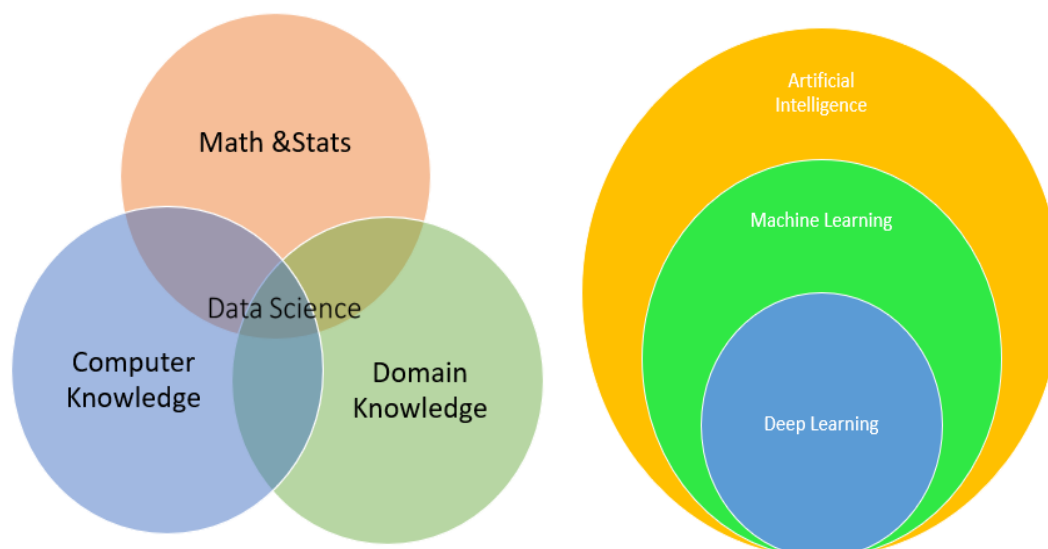


*Fig 1A & 1B: Data Science and AI/ML/DL subset form of pictorial representations*

The degree of similarity in various field that led to advent of cognitive science, as provided in the fig 2.
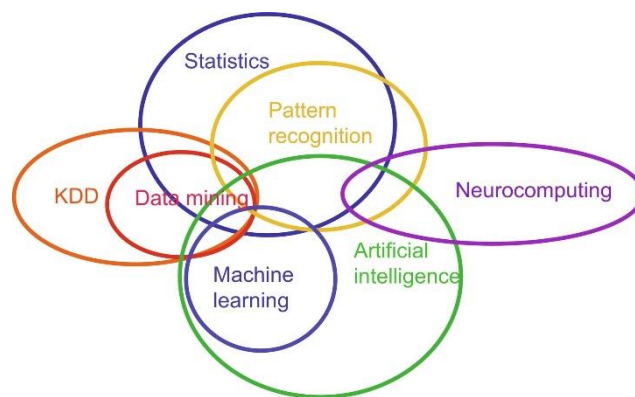
*Fig 2: Cognitive Science interconnectedness showing the degree of similarity between different fields (Shobha & Rangaswamy, 2018)*



*Fig 3: The Similarity concept is used in the Sun Microsystems company logo to create word from similar letters.*

Source of Fig: Wikipedia Sun Microsystems logo

The Gestalt similarity principle, illustrated in Fig. 3, is used by Sun Microsystems in the design of their logo when the word U is used appearing for S.

### *Functional neuroimaging, a key contributor in cognitive research*
The role of statistics in understanding trends in psychology has been known since the beginning. A time of abundance of data on a voluminous scale has led to the flourishing of the advent and application of AI and ML in many academic and industrial service domains. Keeping at par with this trend, in a different branch of psychology, AI and ML have found their scope of application in clinical, cognitive, educational, and behavioral fields—the outcome images of neuro-instruments in corresponding neuroscience domains. In cognitive psychology, how the brain works in different stimulus applications is a crucial research area in cognitive neuroscience. Machine learning is of three types, normally i,e., supervised, unsupervised and reinforcement learning. Regression and classification are of supervised learning while clustering is of unsupervised learning type as shown in Fig 6.

More than 20 years ago, it was found that fMRI, which is cheap and does not hurt, can measure the various brain regions that are active during rest and also when doing a task. The technology is potentially helpful for clinical applications because it is readily accessible. We plan to talk about a few fMRI techniques, a few neuroscience applications, and how electroencephalography (EEG) can be used with fMRI to find the source of a signal. Franciscus Donders made the cognitive subtraction approach and at Washington University cognitive psychologists Michael Posner, Steve Petersen, and Gordon Shulman was first supported by. It led to new ways to test PET scanning on volunteers. FMRI was later employed for the functional mapping of human brains (Gazzaniga et al., 2009).

*fMRI methods*

There are two types of fMRI applications i.e., either task-based or resting state. Resting-state fMRI is a technique used to look at the intrinsic networks in the brain while no task is being performed, in contrast to task-based fMRI applications where patients are given stimulants (rest). It helps map brain region connections in resting state fMRI. Following an intensive four weeks of RAP (rapid reading instruction, also called the "Reading Acceleration Program"), Fig. 4 shows how the brains of dyslexic children who have cognitive problems compared to normal children, connect differently than those of typical readers. Following training, there was an increase in the functional connectivity of visual and cognitive control brain networks at rest. There are many techniques used for supervised classification of rs-fMRI brain images as in Fig 5. Use of AI and ML has led resting state functional mapping of brain areas highly advantageous.
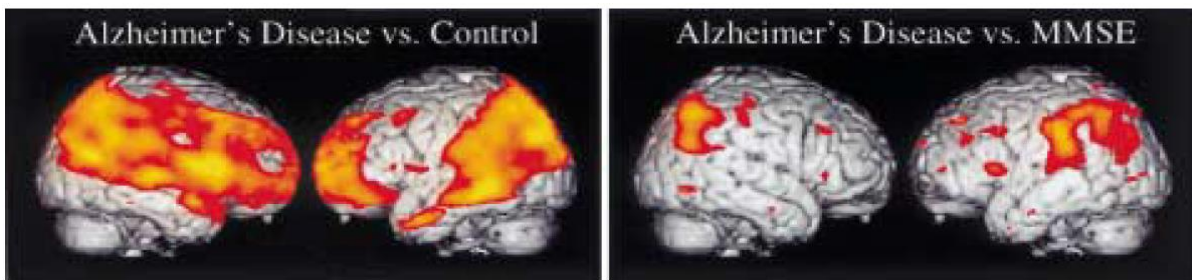


*Figure 4. MRI of the perfusion in Alzheimer's patients. The sites of significant hypoperfusion in 11 age-matched control subjects and 17 Alzheimer's patients are shown on the left in a statistical parametric map. Significant hypoperfusion is present in the frontal, temporal, and parietal lobes. Right, in the same sample of Alzheimer's patients, a correlation between resting hypoperfusion and performance on the Short Mental Status Exam (MMSE) demonstrates that poor performance on this test is associated with hypoperfusion, which is most visible in the temporal and parietal regions. (Detre & Floyd, 2002)*
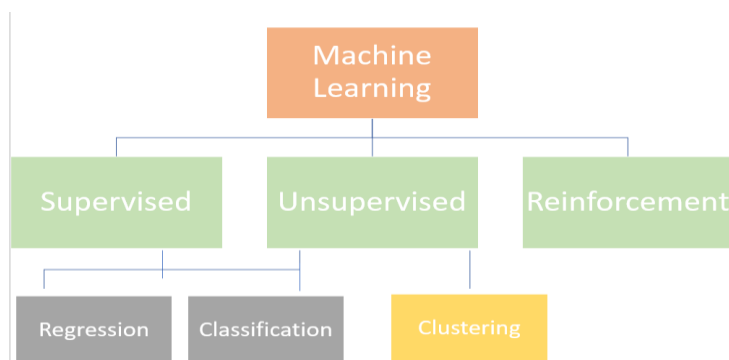

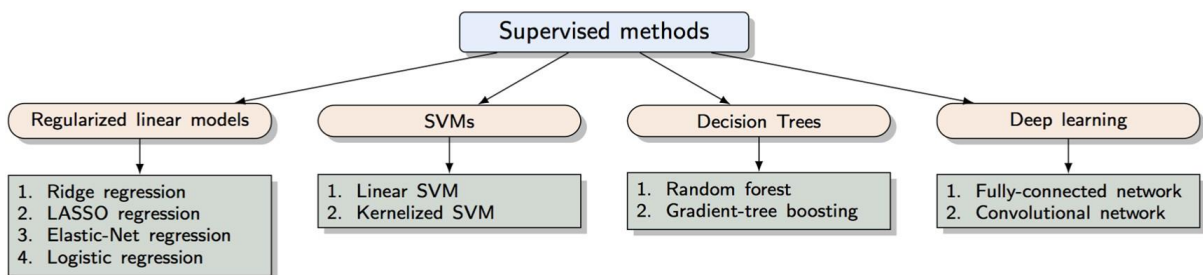
*Fig 5: Type of machine learning*



*Fig 6: Some supervised machine learning techniques for rs-fMRI images (Khosla et al., 2019)*

### *fMRI applications:*

fMRI has got many applications per se in different areas of neuroscience apart from cognitive neuroscience, i.e., clinical neuroscience, behavioural neuroscience. Fig 7 shows the brain functional mapping based on the neuro images of resting state fMRI studies.
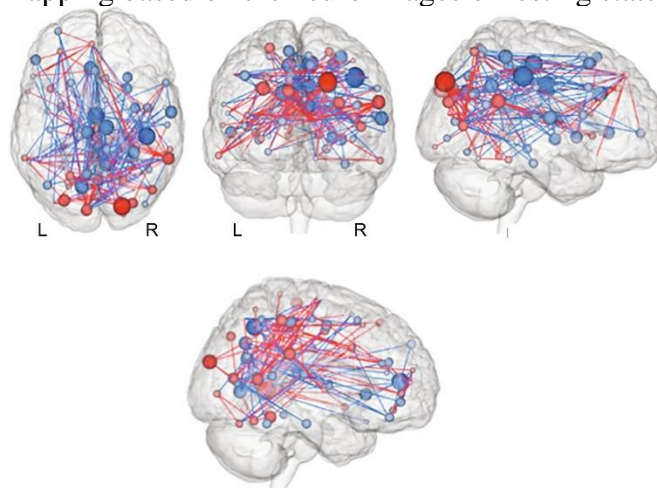


***Fig 7: Normalization of functional connections at rest in dyslexic kids,*** **Neuroimage Clin *8, 619–630.***

Since nearly all studies use temporal data, which enables the whole brain volume to be collected in 1-3 seconds, fMRI is used for epilepsy localization, also known as seizure foci, as well as cognitive localization and lateralization, such as memory lateralization and language lateralization (Detre & Floyd, 2001). Significant tissue contrast due to blood flow is revealed by blood oxygen level dependence (BOLD) and arterial spin labelling (ASL) derived perfusion contrast identifies blood flow as the primary source of contrast (Detre, 2004). A recent qualitative analysis of RT-fMRI-NF experiments that sought to reduce clinical signs in a population of psychiatrists; mental illness 2) a quantitative evaluation of the effectiveness of NFs using RT-fMRI for treating different psychiatric diseases; and 3) methodological advice for future research (Pindi et al., 2022). In studies on social anxiety disorder (SAD), naturalistic fMRI was more accurate at classifying people (69.17%) than other methods, and the movie's content affected how well it worked. The categorization models also found areas of the brain that played a role, and some of those areas were linked to SAD symptom scores. However, combining the three modalities' individual brain properties could have improved categorization accuracy. These results show that careful, realistic imaging is an excellent way to find children and teens in danger (Zhang, 2022). The Vision loss following retinal or cerebral visual injury (CVI) study employed the fMRI scan for individuals with ON who experience cortical and subcortical neuroplasticity reversal residual vision activation theory as proposed by Sabel for restoration of vision due to retinal lesion (Sabel et al., 2011), which reflects the scope, importance, and usability of fMRI technique for a particular case. Nevertheless, AI and ML provides a distinctly advantageous techniques in study and research of neuro-images which manual interpretation are time consuming as well as includes possibility of human omission.

Further, Electroencephalogram (EEG)-fMRI has been around for a while, and now that it is widely used in MRI facilities, safety and signal quality, concerns can be effectively handled. This combination is appealing since fMRI and EEG both exhibit the same sensitivity to synaptic function. As a result, simultaneous EEG-fMRI with high temporal and spatial

resolution can be used to assess brain function (Mulert, 2013). One of the most promising ways to use EEG-fMRI is to figure out the structure and movement of brain networks.

MRI delivers structural and functional morphological pictures with exceptional spatial resolution. EEG, in contrast, uses dry or wet electrodes placed across the skull to capture electrical activity in milliseconds and provides the optimal temporal resolution. Using simultaneous EEG and fMRI acquisitions, the researchers investigate the relationship between hemodynamic mutation and electrical brain activity. In contrast to EEG, the delayed BOLD response in fMRI makes it impossible to get an accurate temporal sampling, which is good (in milliseconds) but not good enough (in the order of seconds) for finding the source of a signal. It is feasible to get over both methods' fundamental restrictions by creating a hybrid simultaneous acquisition with these two techniques, which also expands the types of analyses and information that may be gathered. The simultaneous acquisition also ensures that the subject's mental state, task performance, and inferences about the recording environment are all recorded similarly. This is not the case if the two approaches are recorded independently, primarily if they are used with cognitively unstable patients and in distinct contexts (Mele et al., 2019). Since any neuroimage produces a massive amount of data, invariably applying techniques of AI and ML is likely a compulsive choice. The basic AI-ML concept is to find a pattern in the data that drives its use, which is potentially interwoven in study and research domains apart from scientific applications. Similar to EEG techniques, functional near infra-red (fNIR) is also used in educational and social area of psychological application setting especially in cerebral cortex regions which also has the advantage of using AI&ML techniques.

## CONCLUSION

Psychology and artificial intelligence-machine learning have since origin witnessed a historical blur connection that transpired into later exciting research avenues. In contemporary times, understanding of the mind becomes more scholarly and contemplated areas so as the corresponding use of application of AI and ML in times of various neuro-instruments and corresponding images, which are not limited to clinical diagnosis of brains only. It has also been stated that some experimental proof of consciousness, which depends on the brain processing information, research that used machine learning methods following integrated information theory (IIT), a prominent theory in consciousness studies (Afrasiabi et al., 2021). So, it is anticipated that in the future, with concurrent and corresponding use of these, the trend will likely become more visible and distinct, allowing us to unfold the undiscovered aspects of the mind and its reach that has been, since the dawn of civilization, a natural quest surfaced among us.

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