DERLEME REVIEW

DOI: 10.5336/healthsci.2017-57584

How Different Cognitive Neuroscientific Approaches Have Contributed to Our Understanding of Perspective Taking and Theory of Mind

Farklı Nörobilişsel Yöntemler Bizim Perspektif Alma Anlayışımıza ve Zihin Kuramına Nasıl Katkı Yaparlar?

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Received: 08.08.2017
Received in revised form: 08.01.2018
Accepted: 15.01.2018
Available online: 28.08.2018

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ABSTRACT For a suitable social functioning, the capacity of understanding and thinking of other people's perspective which is known as perspective taking has a critical importance. Perspective-taking is an essential ability in order to understand and communicate with other people and is the ability to take someone else's viewpoint into account when thinking. Perspective taking refers to our ability to think about how our self feels and think and how other people feel and think without confusing on our feelings and thoughts with other's feelings and thoughts. Perspective taking is also considered to the capacity of empathize with other people and view the word from their perspective. Theory of mind is the part of perspective taking and is the capacity of both realising that other people may have diversified feelings, psychological states, understanding, motivation and ideas different from us and realising that how these differences have influence on their behaviours again different from our behaviours. Different field of sciences such as psychology and educational sciences examined both perspective taking and theory of mind from their perspective. In this article, the contribution of the different cognitive neuroscientific approaches, especially PET and fMRI, to our understanding of perspective taking and theory of mind will be analysed in order to constitute a clear understanding of cognitive basis of reasoning about mental states as well as contributing to look at ToM with a wide view. For this purpose, databases (Google Scholar, JSTOR, PsycINFO, ScienceDirect, PubMed) were searched with the selected key words (theory of mind', "fMRI", "MEG", "PET" and "EEG") to choose the articles.

Keywords: Theory of mind; magnetic resonance imaging; cognitive science; child development

ÖZET Uygun bir sosyal işlevsellik için, perspektif alma olarak bilinen diğer insanların bakış açısını anlama ve düşünme kapasitesi kritik öneme sahiptir. Perspektif alma, başkalarını anlamak ve iletişim kurmak için önemli bir yetenektir ve düşünürken başkasının bakış açısını dikkate almayı da içermektedir. Perspektif alma, başkalarının nasıl hissettiği ve düşündüğü hakkında düşünme ve aynı zamanda kendimizin nasıl hissetiğinin ve düşündüğünün farkında olma yeteneğidir. Bununla birlikte, kendimize ait olan düşünce ve duygular ile başkalarına ait olanları birbirine karıştırmamamızı da sağlar. Perspektif alma, diğer insanlarla empati kurma ve dünyayı başka insanların bakış açısından görme, düşünürken onların bakış açısını da hesaba katma kapasitesi olarak da değerlendirilir. Zihin teorisi, perspektif almanın bir parçasıdır ve başkalarının bizden farklı olarak değişik hislere, psikolojik durumlara, anlayışa, motivasyona ve düşüncelere sahip olabileceğini ve bu farklılıkların bizim davranışlarımızdan nasıl farklı olarak onların davranışları üzerinde nasıl etkili olabileceğini fark edebilme becerisi olarak görülmektedir. Psikoloji ve eğitim bilimleri gibi farklı bilim dalları hem perspektif almayı hem de zihin teorisini kendi bakış açılarıyla incelemişlerdir. Bu makalede zihin durumlarımız hakkında düşünmenin kognitif bileşenlerini daha iyi anlamak ve zihin kuramına daha geniş perspektiften bakmak maksadı ile farklı bilişsel sinirbilimi yaklaşımlarının, özellikle PET ve fMRI'nin, perspektif alma ve zihin kuramı hakkındaki anlayışımıza katkısı incelenecektir. Bu amaçla, veritabanları (Google Scholar, JSTOR, PsycINFO, ScienceDirect, PubMed) seçilen anahtar kelimeler (theory of mind', "fMRI", "MEG", "PET" and "EEG") kullanılarak taranmış ve ilgili makaleler seçilmiştir.

Anahtar Kelimeler: Zihin kuramı; manyetik rezonans görüntüleme; bilişsel bilim; çocuk gelişimi

It is obviously described that thinking about mental states such as knowledge, beliefs, feelings and desires has an essential role for a series of cognitive activities including our ability to communicate, to understand other person's point of view, to determine actions, to explain and predict behaviour.[1-3] The human brain is uniquely able to represent and think on the mental states of both the others and the self as well as the relation between these mental states in order to make the connection of ideas possible.[2] Perspective-taking, one of the complex cognitive processes has known as an important part of a correct social functioning.[4] Perspective taking includes being able to correctly imagine or to adopt another person's viewpoint. Adopting another person's viewpoint does not just contain simply giving our full attention to the other, at the same time, it also contains thinking of how this human is influenced by their own condition without having any suspicion about the feelings which felt by the self and the ones which felt by the other people.[5]

Perspective taking is generally worked through perspective taking of third person, however, perspective taking of first person is caught attention of scientist lately.[6] The ability of first person perspective taking refers to representing and combining mental and bodily states into one common framework. What is more, first person perspective is generally known as 'theory of mind' (ToM), moreover, it is describe as evidence of employing a ToM.[7,8]

ToM which is a critical ability for human cognitive development and is an essential social skill for communication refers to understanding that others have beliefs, desires, and intentions different from the self.[9] The increasing interest in impairment of social cognition, development and evolution has led to focus on ToM.[10,11] Primarily, characteristic of ToM has been investigated in children with autism using several verbal and nonverbal tasks.[12-14] The functional brain imaging studies of ToM which present activation in temporoparietal and medial frontal regions has showed increase in order to have a better understanding of the brain basis of it to identify neural systems in children with autism.[7,15]

Because of the lack of a clear understanding of the anatomical and cognitive basis of reasoning about mental states, like beliefs, desires, and knowledge which refers to ToM, still we are not able to understand how children develop cognition, why certain forms of brain damage and mental illness result in the collapse of adult abilities and adult cognition. Because of that, it is important to study on brain areas of ToM.[16] For this reason, this study aims to give information about the research done on ToM and brain areas related with ToM in order to contribute to constitute a clear understanding of cognitive basis of reasoning about mental states as well as contributing to look at ToM with a wide view.

In order to fill the gap about the studies which review research on ToM in the literature, databases including Google Scholar, JSTOR, PsycINFO, ScienceDirect, PubMed and databases of the University of York library were used to search the key words including "theory of mind", "fMRI", "MEG", "PET" and "EEG".

NEUROIMAGING STUDIES OF THEORY OF MIND

Theory of mind is a primary research topic during the last 25 years. Recently, brain imaging techniques such as electroencephalography (EEG), positron emission tomography (PET), magnetoencephalography (MEG) and specially functional magnetic resonance imaging (fMRI) have became a latest method for theory of mind studies.[17] The studies have shown activation ("activation"used to refer to "detect increased activation" and taken how the articles used this word) of a range of frontal regions.[18] Additionally, most of neuroimaging studies found multiple and complex brain activities especially in the medial region which located in the prefrontal cortex.[19] Besides, neuropsychological patient studies are also used to understand of the neuroanatomical realizations of ToM abilities.[20]

ToM studies provided consistent results in spite of using cognitive activation paradigms like nonverbal and verbal tasks and different imaging techniques. The results have showed that three

main areas, the posterior superior temporal sulcus (STS), the medial prefrontal cortex (mPFC) and the temporal poles, associated with the processing of ToM stimuli.[9] It was thought that these findings about the activation of these areas can be thought as an evolution from pre-existing processes such as the capacity of representing goal-directed actions, the capacity of recognizing the difference between living and non-living things and the capacity of differentiating between acts of the self and the others.[21] On the other hand, Leslie pointed out that functional imaging studies which aimed to isolate the neural basis of the ToM mechanism showed limited areas of the brain were responsible for it like the superior temporal sulcus (STS), the anterior paracingulate cortex and the temporal poles.[22]

In the first PET studies on ToM, activation in the left middle and superior temporal gyri and in the left medial frontal gyrus were determined when it was compared that the normal subjects were making assumptions about the others' thought and the physical world. In addition, other early studies with PET which compared the subjects' assumptions of physical stories, the stories related with ToM and the unrelated stories found activation in left medial frontal lobe when subjects were making assumptions of ToM stories.[23]

On the other hand, a few functional imaging studies that using fMRI and PET have found increased neural activity in the anterior cingulate cortex associated with left hemisphere in ToM conditions.[24-26] In their study Vogeley found out similar findings that showing activation of the anterior cingulate cortex in ToM conditions.[26] However, they observed right hemisphere dominance. On the other hand, Gallagher similarly found out right-sided activation of the anterior cingulate cortex in their study with fMRI.[27]

In addition, a few PET imaging studies which were done while the subjects were completing different type of ToM tasks have shown activation in temporal lobe structures which is bilateral or localized to language areas of the left hemisphere.[28]

Several ToM studies that used fMRI found activation mainly in medial prefrontal cortex.[27,26] However, some latest studies with fMRI detected strong brain activity in temporo-parietal junction.[29] In their study with fMRI, Gallaher found activity peaks in Brodmann areas including 8/9, 32 and the frontier of 10. Additionally, Fletcher and Goel reported activity in the same areas as well as in the temporo-parietal junction.[24,27,30]

As neuroimaging technics, brain lesion studies bring information about which parts of brain are associated with ToM. For instance, studies with neurological patients with intact frontal cortex provide evidence in favour of media frontal region is necessary for ToM tasks. In addition, several studies found out that the patients who had frontal lesions had difficulties with the tasks about ToM.[21,31]

In most of the studies which compare the brain activity between normal subjects and clinical groups have been made with PET or fMRI. In their study, Park used MEG and found out different brain activation between the normal and the patients with schizophrenia.[32]

CONCLUSION

The neuroimaging studies described above attempt to identify where ToM process happens in the brain. It is obvious that ToM process is a very complex cognitive function which includes multiple brain areas instead of a single critical area. All neuroimaging studies have showed that there is not a single area for ToM. Several brain areas are responsible for ToM, however, they function independently.[33] On the other hand, there are keys now to improve hypotheses that can lead future experiments.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

This study is entirely author's own work and no other author contribution.

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