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Application of Concept of Theory of Mind in Understanding Neurodevelopmental Disorders

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Theory of mind impairments is seen in various neurodevelopmental disorders. Neurodevelopmental disorders are impairments of the growth and development of the brain or central nervous system. This also refers to the disorder of brain function that affects emotion, self-control, learning ability, and memory and that unfolds as the individual grows. India faces a great burden of neurodevelopmental disorders due to dual challenge of genetic and acquired disease burden posed by nutritional, infectious, toxic, and traumatic insults. Various neurodevelopmental disorders, such as autism spectrum disorders, attention deficit hyperactivity disorder, developmental language disorders as well as acquired disorders of the right brain (and traumatic brain injury) impair Theory of mind. Theory of mind in everyday parlance is one of the subcomponents of social cognition, which embraces all the skills required to manage social communication and relationships in humans. Impairment of Theory of mind ability is often seen in children even in cases with a normal or high level of intelligence and other cognitive abilities. Ayurveda implies that whatever affects the body has its effects on the mind and vice versa. When critically viewed the Manovishayas like Chintya, Vicharya, Oohyam play a key role in the thought process, aim fixing, task completion and other behavioural patterns. Thus, eccentricity of Manovishayas can lead to behavioural abnormalities like Manovibrama, Budhivibrama, Anavasthithachithatwa, etc. Hence, the study of connections between fundamental neurophysiological mechanisms and highly complex social behaviour, such as Theory of mind which will enable us to better understand the respective roles of innate predisposition and cultural learning in human life. Studies in the social, cognitive, and affective sciences currently seem to be the most fruitful approach to successfully contrasting both the mind body dualism which is an integral part of Ayurveda in understanding the neurodevelopmental disorders.

Keywords: Neurodevelopmental, Theory of Mind, Ayurveda, Autism ADHD

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Introduction

People are more than physical bodies. We are more than dynamic bags of skin that can be seen, heard and weighed. In the adult framework; persons also have beliefs and intentions that lie below the surface behavior. One cannot directly see, taste, smell, or hear mental states, but it is an essential part of our ordinary adult understanding that other people have them. TOM refers to the ability to infer mental states (e.g., beliefs, desires, intentions, imagination, emotions) that cause actions. An individual with a TOM is able to reflect on the content of his/her own and others' minds.**[2]** It gives rise to the awareness that others have a mind with various mental states including beliefs, intuitions, plans, emotion, information, desires and intentions and that these may differ from one's own.**[3]** The development of TOM starts by convergence of several important developmental milestones, such as true understanding of joint attention, deliberate imitation and the ability to track a speaker's intention during learning and decoding of words. Also, language and pretend play, which includes 'joint proposals', 'role assignment' and 'metacommunication about a scenario' significantly facilitate TOM development.**[4]**

Developing a full TOM requires the presence of several of the executive functions (EFs), such as processes of analysis, inference, inhibitory control and cognitive flexibility. Despite a close association between EFs and TOM, they are discrete functions.**[5]** There are three principal theoretical accounts of TOM mechanism which are the Theory, Simulation Theory and Modularity Theory.**[6]** The development of TOM ability has important consequences for children's social communication, interactions and behaviour, for example, in conversations, negotiations, games and friendships, which involve interpersonal sensitivity in real social settings including home, school and the work environment.**[7]** TOM understanding is of utmost importance in deceptive contexts, such as the ability to mislead people, hide things, conceal information, keep a secret and lie, also succeeding in detecting these strategies when others use them; in fact, deliberate deception is one of the earliest signs of TOM development.**[8]** TOM competence may be important for success in school because children's social skills are associated with their academic achievement.**[9]**

TOM impairment describes a difficulty someone would have with perspective taking. This is also sometimes referred to as mind blindness. This means that individuals with TOM impairment would have a hard time seeing things from any other perspective than their own.**[10]** TOM deficits have been observed in people with autism spectrum disorders, people with schizophrenia, people with attention deficit disorder and people with dementia.**[11]** TOM testing started with the study of autism, and to date, more than 30 experimental tests have been developed for measuring TOM in children. The most famous are false belief tasks.**[6]**

There are a number of studies attempting to elevate children's performance in TOM tasks with controlled training procedures. One of first studies showing success in training children's TOM comes from Kloo D *et al*.**[12]** The aim of this work is to study TOM as regard its development, clinical significance, deficits, assessment and training for it.

Materials and Methods

Search strategy

We reviewed papers on the theory of mind from Medline databases which are (PubMed, Medscape, Science Direct and Autism commuinity) and also materials available in the Internet from 1990 to 2016. We used theory of mind/autism and theory of mind/joint attention/executive functions/theory of mind test and communication disorders and theory of mind as searching terms.

Study selection

All the studies were independently assessed for inclusion. They were included if they fulfilled the following criteria:

Inclusion criteria of the published studies:

- Published in English language
- Published in peer-reviewed journals
- Focused on TOM and communication disorders in which TOM is impaired
- If a study had several publications on certain aspects, we used the latest publication giving the most relevant data.

Data extraction

If the studies did not fulfil the above criteria, they were excluded.

Quality assessment

The quality of all the studies was assessed. Important factors included, study design, attainment of ethical approval, evidence of a power calculation, specified eligibility criteria, appropriate controls, adequate information and specified assessment measures. It was expected that confounding factors would be reported and controlled for and appropriate data analysis made in addition to an explanation of missing data.

Data synthesis

A structured systematic review was performed with the results tabulated.

Results

The selected studied were 47 studies. The studies were deemed eligible by fulfilling the inclusion criteria. There was a high degree of heterogeneity regarding TOM importance and precursors and communication disorders that have TOM deficit.

TOM plays a big role in our life and makes our communication with others more flexible and successful and without it, communication would break down. We need it in home, school and the work environment [Table 1].**[7]** Several important developmental milestones participated in early TOM development, for example, joint attention, language, pretend play and executive functions [Table 1].**[4],[5]** Also, TOM development is strongly affected by social/environmental factors. Having siblings may also improve children's TOM performance. The extent to which there is siblings, extended family interaction and the child's social behaviour (e.g., talk about feeling states and amount of cooperation with siblings) affects the development of TOM in infants [Table 1].**[13]**

Table 1: Importance and precursors of theory of mind

References	Type of the study	Findings
Cutting and Dunn[7]	Systematic article review	TOM is important for successful communication in home, school and work environment
Connolly and Doyle[4]	Prospective study	Yes, joint attention. language and pretend play are important skills for TOM
Fine et al.[5]	Cohort study	EFs are strongly related to TOM
Yagmurlu et al.[13]	Cross-sectional study	Socially active development positively affect TOM

EFs - executive functions; TOM - theory of mind

TOM is disturbed in many disorders. It is mainly defiant in autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD) and specific language impairment (SLI) [Table 2].**[14-16]**

Table 2: Disorders having theory of mind Deficits

References	Type of the study	Findings
Baron-Cohen et al.[14]	Case-control study	85% of the normal children, 86% of the Down syndrome children, but only 20% of the autistic children passed the false belief task
Saeedi et al.[15]	Cross-Sectional Study	50% of children with ADHD were significantly lower than controls study in Sally- Anne False Belief Task
Dammeyer et al.[16]	Case-Control Study	84% of the TD children while only 33% of SLI children passed the false belief task

ADHD - Attention Deficit Hyperactive Disorder; SLI - Specific Language Impairement; TD - Typically Developed

Discussion

According to Hughes and Leekam**[17]** TOM refers to ability to impute mental states, such as, beliefs, desires or intentions to one-self and to others and to predict other people's behaviour on basis of their mental states. According to Westby & Robinson**[18]** concept of TOM was introduced in 1970s in primate research by Premack and Woodruff,**[19]** who defined TOM as ability to represent mental states of one-self and others in order to understand behaviours. Soon after they introduced term 'TOM' in primate studies, researchers applied concept to children. Early studies with children focused on determining age at which children are able to engage in false belief tasks successfully. Wimmer and Perner**[20]** found that only children over age of 3 years are able to predict actions based on correct understanding to false belief. According to Mc Glamery *et al.***[21]** three major theories have been offered as explanations for development of children's TOM: Theory Theory, Modulatory Theory and Simulation Theory. As regard to Theory, Bartsch and Wellman**[22]** reported that, a number of steps in children's progression toward adult TOM have been described. These steps argued that children begin with a desire psychology, then progress to a desire-belief psychology and finally attain our adult belief-desire psychology,

In which one recognizes that what people believe, as well as what they desire, crucially affects how they behave. Theory theorists argue that experience plays a major formative role in children's TOM development. According to McGlamery *et al.***[21]** children do not acquire a theory at all, but have innate cognitive architecture that allows for the gradual and progressive development of TOM abilities. This view holds that passing TOM tests indicates unfolding of biologically scripted performance capabilities rather than acquiring anew theory. According to Goldman,**[23]** Gordon**[24]** suggests that we can predict others behaviour by answering the question 'What would I do in that person's situation?'. Also, Dilthey wrote that understanding others can occur through a process of 'feeling with' others, 're-experiencing' their mental states, or 'putting one-self into' their shoes. TOM develops over time building from foundational precursor skills to a sophisticated understanding of how mental states and behavior interact. These precursors include mainly: joint attention, imitation, language, pretend play, executive functions and environment.**[25]** Joint attention is a shared attention to goal directed and intentional action. It is considered to be one of the earliest manifestations of TOM development, emerging at the end of the first year. The relation between language and TOM is bidirectional; some authors argue that some understanding of mind is a prerequisite for acquiring language or communication. Others suggest that through verbal interactions with others, children come to understand that people have minds with contents different from their own.**[25]** Some evidence has emerged that TOM development is strongly affected by nonheritable and social/environmental factors. Having siblings may also improve children's TOM performance. The extent to which there is siblings, extended family interaction and the child's social behavior (e.g., talk about feeling states and amount of cooperation with siblings) affects the development of TOM in infants. TOM appears at substantially different times in different cultures and languages, for example, there are significant differences between Asian and Western cultures. **[13]** Several methods have been used to assess TOM. These methods are important for two reasons. First, such methods can be used to identify those children who display deficits in TOM. Second, such methods can be employed to evaluate the efficacy of TOM training programs.

The assessment of TOM in children has been predominantly confined to so-called 'false belief tasks' (e.g., Sally and Anne task and Smarties task). Such tasks intend to test children's comprehension of another person's wrong belief. **[26]** Muris *et al.***[26]** presented another important tool for TOM assessment which called TOM test. Cutting and Dunn**[7]** concluded that the development of TOM ability has important consequences for children's social communication, interactions and behaviour, for example, in conversations, negotiations, games and friendships, which involve interpersonal sensitivity in real social settings including home, school and the work environment. According to Malecki and Elliot.**[9]** TOM competence may be important for success in school because children's social skills are associated with their academic achievement. According to Saxe and Powell**[27]** neuroimaging research demonstrates specific brain regions consistently engaged during TOM tasks. Early PET and MRI research on TOM, using verbal and pictorial story comprehension tasks, revealed increased levels of blood oxygen and glucose uptake in a small, but consistent group of brain regions:

Left and right temporoparietal junction and medial prefrontal cortex

1. Medial parietal cortex (precuneus)
2. More anterior regions of the superior temporal sulcus, down to the temporal poles
3. Sometimes amygdala is identified.

Communication disorders are those having problems with both language and social interaction. Language and communication development depends crucially on being able to read the intentions of others. People do not always say what they mean; they slip, they make mistakes, they fumble. Normal adults are facile at picking up the communicative intent of the speaker and without this, communication would break down. TOM fails to develop in:

1. Autism spectrum disorder, an effective communicative exchange is achieved when both partners employ a TOM to structure ongoing discourse. Given the theoretical significance of TOM abilities for communication, it is not surprising that children with autism suffer significant impairments in this domain [28]. Baron-Cohen *et al.***[14]** concluded that 85% of the normal children, 86% of the Down syndrome children, but only 20% of the autistic children passed the false belief task.

2. ADHD, children with ADHD appear to display inadequate social behavior (making them likely to face social, academic, familial and occupational problems during their life) and to have impaired social cognition. Social cognition difficulties in children with ADHD are specifically in emotion perception and/or processing, empathy, TOM and pragmatics.**[29]** In Saeedi *et al.***[15]** study, 50% of children with ADHD could not give the expected answer in Sally-Anne False Belief Task, which was significantly lower than controls who gave the correct answer in 86.60%

3. Hearing impairment (HI): The delay in the acquisition of the TOM in deaf children can be attributed to the lack of early conversation and minimal use of mental state language during communication than to an impaired neurocognitive structure. Studies found about 20–50% of HI children have psychological problems including TOM. **[16]**

4. SLI: Children with SLI have often been reported to experience behavioral, emotional and social difficulties. Problems in social-emotional functioning can be explained in terms of TOM. Farrant**[30]** in his study which involved 30 children with SLI and 30 typically developed children who are tested on false belief task found that, 84% of the typically developed children while only 33% of SLI children passed the test.

5. Schizophrenia: Some studies show that patients with schizophrenia are also faced with TOM impairment.**[31]** Impaired TOM in schizophrenia has been found to contribute to patients compromised social functioning in the community

6. Dementia: Common types of dementia include Alzheimer's disease, Frontotemporal dementia and dementia associated with Parkinson's disease. These may present different patterns of TOM deficits on the basis of how different neuropathological processes affect the neural bases of TOM components during the progression of the disease. Any account of how to foster efficient TOM must take into consideration the various interconnected systems that play when people reason about the minds of others such as joint attention, face and emotion recognition, pretend play and perspective taking. Studies provide evidence that joint attention skills can be taught by behavioral interventions to children with impaired joint attention especially those with autism.

Recently, researchers have begun to emphasize joint attention training for children with autism due to its relationship to the development of TOM, language and pretend play.**[32]** Joint attention training consisted of two phases:

A) Response training: in which the child was taught to respond appropriately to joint attention bids by the experimenter.

B) Initiation training: in which the child was taught to initiate joint attention with the experimenter.

There are a number of studies attempting to elevate children's performance in TOM tasks with controlled training procedures on TOM tasks. The study done by Appleton and Reddy**[33]** for training children's performance on TOM tasks in which they engaged children in conversations about false beliefs. Children in the training group watched short video clips about unexpected transfer false belief situations. Various aspects of the video scenes were discussed and the thoughts and actions of the video protagonists were explained. Four discussion sessions of 10–15 min was conducted over the course of 2 weeks. During these discussions, negative feedback was avoided. Instead, emphasis was on supporting and explaining comments. On the other hand, control group had four story book-reading sessions over the same time period. The training group performed significantly better than the control group on a deceptive box task (Smarties test) not only at an immediate post-test but also at a delayed follow-up test 2 weeks later. Also, children in the training group outperformed the control group on an unexpected transfer task (Sally and Anne test) given at the delayed follow-up test.**[33], [34]**

Conclusion

TOM is a cognitive capacity enables one to infer thoughts, beliefs, intentions and desires of his own self and of other's. Normally developing children attain TOM at roughly 4 years. The greatest growth in TOM development occurs between about 6 and 7 years of age. It is impaired in many disorders as autism spectrum disorder, ADHD, SLI, HI, schizophrenia and dementia. It can be assessed by TOM test, TOM battery task, Sally and Anne task, Smarties task and appearance reality task. It can be improved and enhanced by many interventions as joint attention training, narrative skills training and training on the above-mentioned TOM-related tasks.

TOM interventions are of particular interest to speech language pathologists because of their relationship to language learning so; it should be taken in mind. TOM intervention holds promise as a means of developing social and linguistic skills. It is reasonable to hope that by integrating TOM instruction with other aspects of language intervention and carefully tailoring instruction to each child's specific needs, speech language pathologists can successfully help children improve on TOM-related tasks, academic level and language.

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