Chapter 1
Introduction
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The term Theory of Mind (ToM) refers to people’s everyday understanding of mind, or folk psychology. While we interact, we take into account the feelings, desires, motivations, intentions of other individuals. We try to understand why people say and do the things they do and predict what they are likely to do in the future. Dennett (1978) suggested that the minimal criterion for crediting an individual with a ToM is that they should be able to appreciate that others have beliefs of a simple factual nature. An understanding of false belief is seen as a crucial landmark in developing a theory of mind.

Among the many social activities that human beings practice, one of the most frequently practiced social activities is watching peoples' behavior and inferring intentions from their behavior and acting in consistence with their intentional attribution. Inferring intentions, however, is one of the most fundamental human cognition. We are less competent to understand other minds than to understand the physical world.

1.1 Intentionality
The term ‘Intentionality’ (from the Latin ‘intendere’, meaning ‘to aim at’) refers to a state of mind ‘directed’ towards an ‘object’, the thing I’m thinking about. Intentionality is not about intentions. If I have an intention, I am ‘aiming at’ doing something. Beliefs, desires, and emotions all have intentionality; they are all ‘Intentional Mental States’. An intentional mental state is a mental state with intentional content. Whenever we think of, have a belief about, or desire something, we always conceive of it in a certain way under a particular description. Intentional states represent the world in particular and partial ways. It’s like seeing something from a particular angle; we can see part of it, but not all of it. Explanation and prediction of human
behavior involves analyzing intentional states in the agent. Dennett (1978) has discussed three different stances or ways in which one can explain and predict what someone or something does. They are physical, functional and intentional stance.

The *physical stance* predicts and explains the behavior of a machine by taking its mechanical parts into consideration. The *functional stance* predicts and explains behavior by referring to the design of a machine. By taking this stance, it can be said that they behave the way they are designed to behave. Prediction can be done solely from knowledge or assumptions about system’s functional design irrespective of the physical constitution or condition of the particular object. This stance is also inadequate to explain human behavior. The *intentional stance* predicts and explains behavior of animals or persons by referring to intentional states (Brentano, 1960) such as one’s beliefs, desires and intentions, but certainly not of objects or machines (except of an intelligent computer).

### 1.2 Intentional Stance: The Conceptual Basis of Theory of Mind

Intentional prediction is made from an intentional stance. One can explain and predict one’s own and others’ behavior by ascribing beliefs and desires to them. Dennett’s intentional stance is the conceptual basis of a ToM. The branch of cognitive science that studies our understanding of the minds of ourselves as well as of others has come to be called the “Theory of Mind”. ToM involves psychological theorizing about our everyday, instinctive, “folk” understanding of the mind. First coined by Premack and Woodruff (1978), ToM refers to the ability to attribute mental states – beliefs, intents, desires, pretending, knowledge etc. to oneself and others. It enables one to understand that mental states can be the cause of – and thus be used to explain and predict – others’ behavior. ToM is very basic to the cognitive processes for social interaction and communication (Grice, 1989; Sperber & Wilson, 1995). Lack of this ability may serve as a part of the explanation for developmental disorders like autism (Baron-Cohen, 1995; Frith, 2004).
An understanding of the mind is basic to the understanding of the social world, as this allows us to distinguish between accidental and intended behavior, and between truth and deception. Attributing intentionality in self and in others to guide, manipulate, control and modify behavior is at the heart of this unique human ability (Penn & Povinelli, 2007; Saxe, 2006) of ToM. Literature in this area, however, reveals some surprising and at times some contradictory discoveries. For example, some human infants’ and non-human species’ apparently sophisticated abilities to understand mind (Call & Tomasello, 2008; Emery & Clayton, 2009) and apparently poor understanding of the mind in human children (Carpendale & Lewis, 2006; Doherty, 2009) and sometimes in human adults too (Apperly, Samson & Humphreys, 2009).

1.3 False Belief: The Way to Theory of Mind

A belief is a mental representation of a proposition. One of the tenets of folk psychology is that a person’s beliefs are formed directly from his experiences with the world, but are independent of the world. In other words, beliefs are representations of the world that can be true or false. A belief is false when the representation does not correspond with reality. Being able to represent another person’s false belief has been viewed by many researchers as a clear indication of understanding the existence of mind and its basic properties. Some researchers even go as far as to say that understanding false belief is the “marker” or “litmus test” of children’s theory of mind (e.g., Wellman, 1990), because, the ability to represent another person’s false belief correctly requires individuals to realize that what they themselves believe may differ from what another person believes. Many other human abilities – from skillful social interaction to language, emotion and most importantly use of executive functions – are said to involve ToM. It also enables us to accurately anticipate other people’s behavior, and in so doing, it allows us to cooperate, empathize with, or deceive others (Gallagher & Frith, 2003). Moreover, the intuitive understanding of other minds that ToM enables is essential for our appreciation of pretense and the mental lives of characters in literature and other arts (Siegal & Varley, 2002). To have a ToM means understanding that a
person’s actions are determined by his beliefs, and that oneself and others may have false beliefs that do not correspond to reality. It is through our learned ToM abilities that we understand that it is a person’s false belief, and not reality, that determines his behavior (Gallagher & Frith, 2003). Theory of mind understanding and false belief understanding has often been used interchangeably in the literature.

Being able to attribute mental states to others and understanding them as causes of behavior means, in part, that one must be able to conceive of mind as a “generator of representations” and to understand that others’ mental representations of the world do not necessarily reflect reality and can be different from one’s own. It also means that one must be able to maintain simultaneously different representations of the world. In other words, it involves the development of a set of meta-representations necessary to understand false belief. Meta-representation is a process of “representing the representational relation itself” (Pylyshyn, 1978), or representing a representation as a representation (Perner, 1991). This concept has proved difficult to understand, probably because of multiple uses of a five-syllable word referring to different things in one sentence. A system of inferences of this kind is properly viewed as a theory because such states are not directly observable, and the system can be used to make predictions about the behavior of others.

1.4 Theory of Mind in the Brain

The study of mind has been quite fascinating for both the sages in the ancient times and the neuroscientists of today. Recently, neuroscientists have shown interest in the scientific study of mind. While the earlier approaches to understand mind was primarily philosophical, recent approaches look for a neuroscientific base. A fundamental question of whether mind is encapsulated in a physiological organ like brain or it is an independent entity outside the brain has been of interest to the neuroscientists. Psychological phenomena are gradually gaining visibility through an explanation of biological, physiological and chemical foundations. Everything psychological is
simultaneously biological (Gazzaniga, 1998). Study of neural science suggests that psychological components of attending, planning and acting are developmental elements of brain functions. It seems that function and mechanism complement each other. Representations of cognitive functions have physical brain structures, mechanisms and internal representations supporting them (Gazzaniga, 1998). Hence, in order to understand, predict, control and change the mind, studying the mind in relation to the brain seems logical. There are a number of paradigms of studying brain. One of the paradigms is the lateralization paradigm that studies the functional specialization of the left and right sides of the brain.

The term “cerebral lateralization” or “laterality” signifies the anatomical and functional differences between the two hemispheres i.e., the left and the right hemispheres of the brain (Wexler, 1980). The domain of laterality includes multidisciplinary approaches like psychology, neurology, physiology, biology and anthropology (Corballis, 1983). The importance of laterality in psychology lies in the understanding of behavioral processes (Hellige, 1990). Laterality researchers are engaged in finding appropriate ways to describe asymmetries in the function of the two hemispheres (Allen, 1983; Bradshaw & Nettleton, 1981; Bryden, 1982). The phenomenon of laterality can be understood in terms of structural and functional asymmetries.

Structural asymmetry denotes the fact that the two cerebral hemispheres in the human brain are not structurally symmetrical. For example, the right hemisphere is found to be slightly larger and heavier than the left hemisphere; the slope of the Sylvian Fissure to be gentler in the left brain than in the right, and the Planum Temporale is larger on the left than the right (Foundas, Leonard & Hanna-Pladdy, 2002). Functional asymmetry refers to differential representations of certain higher functions in the two sides of the brain. This asymmetry of function is called “cerebral lateralization” and its manifestations include such diverse phenomena as language, spatial organization and handedness – the superior dexterity of one hand over the other (Springer & Deutsch, 1981).
Cephalo-caudally, the human body is nearly symmetrical and may be halved equally (barring some visceral and other organs) including the cerebral cortex. Such anatomical symmetry, however, is not reflected in human behavior involving cognition, emotion and motor action. For example, for most unimanual activities, more often we use the right hand. Likewise, our visual, auditory and facial behaviors as well as simple motor activities (like cradling) are asymmetrical. This functional asymmetry – the fact that certain higher functions are differentially represented in the two sides of the brain – in human behavior is referred to as ‘side bias’ (Mandal, Asthana & Biswal, 2008).

The term ‘side bias’ means a predominant mode of response ranging from simple hand movements to complex behavior patterns like facial expression oriented to either the left or right side from the medial plane of the body. In operational terms, side bias may be viewed as the bias reflected in the motor expression of paired organs (like hand, foot, eye or ear) or non-paired organs (like face) as a function of preference/performance or attentional/intentional factors (Mandal, Bulman-Flemming & Tiwari, 2000). Functional side bias may be broadly classified into two categories: motor and cognitive. While cognitive bias refers to bias in information processing, motoric side bias is reflected in paired as well as in non-paired organs. There are four forms of bias in paired organs: handedness, footedness, earedness and eyedness. In the present study, these four forms of bias are measured in terms of children’s performance/preference in doing various activities.

To examine ‘Theory of Mind’ as a construct, it is important to examine it from theoretical, developmental, biological, cultural and statistical underpinnings. In the present study, an attempt is made to examine ToM from theoretical, developmental and biological underpinnings keeping the cultural underpinning as a constant. The present study adheres to modular theory of ToM. Modular theories (discussed in detail in chapter 2) propose that our theory of mind is handled by mental modules or a specialized piece of mental hardware. In other words, some part of the brain is dedicated to theory of mind processing. Modular theory is a hardware version of the theory.
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Children hold concepts of beliefs, pretence, desires and so on and are able to reason with them to predict and explain behavior. However, this is not an abstract theory, but is instantiated in a particular set of neural circuits. The theory is innately specified along with core concepts like belief and desire. Modules are often considered to have been put there by evolution: Being able to predict behavior is so important that there would be pressure not to leave it up to chance or a slow process of theory building in childhood. Instead some or all of our theory of mind is hardwired and begin to operate after appropriate neural maturation and/or right environmental triggers.

There may, in fact, be several modules, perhaps in a layer, representing evolutionarily more primitive theories of mind. This could explain the developmental pattern of preschool theories of mind, as more evolutionarily recent modules mature and take over from their forebears (Segal, 1995). One attractive feature of this idea is that it explains why, with a few minor possible exceptions, theory of mind development is culturally uniform. If children were left to build a theory using more general mechanisms, considerable variation might be expected (even within cultures). It also suggests a simplistic explanation for the developmental disorder of autism.

Two striking features of autism are a deficient ToM, and a lack of pretend play and other imaginative activities. This could be because a theory of mind module is damaged or abnormal or absent in autism. Since theory of mind primarily evolved as a theoretical construct, little effort has been made to examine the construct with biological underpinnings throughout the developmental cycle. In the present study, side bias is used to examine the development of ToM in children.

1.5 Theory of Mind and Cerebral Lateralization

The developmental neuropsychological paradigm assumes that the structural and functional properties of the two cerebral hemispheres do change developmentally, but always in different manner because they develop within
the context of an ever-present lateralization of function, which is continuous with a lateralized gradient of neuronal differentiation and maturation. ToM fits into a larger view of cognition and communication that emphasizes the importance of alternative representations or interpretations (Beeman, 1998; Brownell, Gardner, Prather & Martino, 1995; Burgess & Chairello, 1996). The left hemisphere excels at selecting and processing a single dominant interpretation while inhibiting the others. In many linguistic and social contexts, the left hemispheres’ focused approach works well. However, there are differences in how two hemispheres process meaning (Burgess & Chairello, 1996; Burgess & Simpson, 1988; Chairello, 1990). The right hemisphere is more likely than the left to process or diffuse associations and low frequency alternative meanings.

Our daily life presents us with a variety of social scenarios, many stereotypical, even script-like and many of which are novel, and quite complicated indeed. Thus, the neural substrates underlying the process of inferring the content of mental states will vary depending on the demands of the task at hand (Brownell, Griffin, Winner, Friedman & Happe, 2000). Novel tasks that require maintaining and updating relational and ambiguous information will necessitate right-hemisphere involvement, while requirements of the more routine and script-like ToM tasks may be processed largely by left-hemisphere regions.

Kinsbourne (1982), Deglin and Kinsbourne (1996) and Arguin, Joanette and Cavanagh (1993) suggest that there would be more left activation for tasks requiring focal attention or non-conflicting syllogistic reasoning. Earlier research on cerebral lateralization and theory of mind (ToM) emphasized the role of bilateral prefrontal cortex (PFC) and the right hemisphere in ToM functions (Brownell et al., 2000, Mc Donald, 1993). Both areas have been implicated in reports on working memory, executive function, comprehension of discourse including humor, insight, interpersonal skills as well as ToM (e.g., Alexander, 1989; McDonald, 1993). The prefrontal regions are critical for ToM in that they support a person’s ability to select from among representations.
that are divorced from sensory input. The literature identifies the prefrontal regions as relevant to working memory, aspects of attention, marking for salience and selection, social decision making including ToM, conflicting information that must be maintained and evaluated with the result that the most relevant information must be highlighted and the less relevant information must be inhibited for successful inhibition to occur (Brothers & Ring, 1992).

The right cerebral hemisphere is vital for human’s ability to maintain multiple representational sets. ToM and competence in a host of other cognitive domains depends crucially on a person’s ability to refer to alternative, often conflicting interpretations of the same topic. While the left hemisphere inhibits or dampens alternatives, the right hemisphere is critical for people’s ability to maintain access to alternative representations including those involved in figurative language, jokes and stories as well as in mental states (Beeman, 1998; Bihrl et al, 1986; Shammi, 1997; Winner, Brownell, Happe, Blum & Pincus, 1998).

Lateralization process of the brain starts at the earlier ages before the child develops hemispheric dominance. It would be important to see whether ToM has a link with the lateralization process at the earliest developmental stages. The principal aim of the study therefore, is to examine ToM with its functional laterality component throughout the developmental process in the early (4-6 years), middle (9-11 years) and late childhood years (14-16 years). Put in other words, the principal aim of the study is to examine the bio-developmental processes involved in the construction of ToM.

Till date research in this area is restricted to adult brain damaged cases, which is considered to be an indirect evidence towards understanding of ToM. Learning about the brain through its disorders presents a number of problems. Two of the most important reasons may be: first, the working brain differs in as yet undefined ways from the broken brain and second, the study of broken brains to understand working ones is equivalent to studying parts
instead of processes. Further, impairment following brain damage in a given mental faculty does not necessarily implicate the functionality of a given region. Therefore, it is important to study the bio-developmental processes in the intact brain subjects. The present study, however, would correlate the findings of the clinical studies available in the literature.

1.6 Overview of the Thesis

The major objectives of the present study are twofold. The first and the foremost objective is to study the development of theory of mind understanding, and the second is to study the role of cerebral lateralization on the development of theory of mind in and beyond early childhood years in normally developing children. The three age groups of children who took part in the study have different growth gradients. Hence, the nature of the tasks used for them need to be different. This variation in the nature of task led to analyze the results in three different sections. However, the underlying task dimensions remain same for all the age groups. The discussions follow a construct-based development of ToM along with cerebral lateralization.

The general framework of the thesis is as follows:

Chapter 1 of the thesis briefly introduces two of the major concepts of the study—theory of mind and cerebral lateralization. Chapter 2 presents the review of literature in the area related to theory of mind and cerebral lateralization. Following the review, Chapter 3 leads to the rationale and objectives of the present study. Chapter 4 presents the method of study wherein the sample, measures and procedures used in the study are discussed separately for the three different groups, i.e., the early, middle and late childhood groups. Chapter 5 discusses analysis of result separately for the three separate groups. Chapter 6 is about the general discussion and conclusion that includes limitations, Implications and future directions of the present study.