Chapter 1
Introduction: Phenomena of Autistic Reasoning

List of Abbreviations

CwA	child (children) with autism. In most cases we assume high-functioning verbal individuals, unless specified otherwise
CC	control child (children), normal, typically developing children
AwA	adult(s) with autism
PwA	people (person) with autism (CwA ∪ AwA)
ASD	autistic spectrum disorder
ACS	autistic spectrum condition
AC	autistic condition
AS	Asperger's syndrome
NL	natural language
AI	Artificial Intelligence
ML	Machine Learning

In this book we evaluate the accounts and models of autistic reasoning and cognition from the computational standpoint. Autism is a development disorder characterized by restrictive, stereotyped and repetitive behavior as well as limited social interaction and communication, and narrow interest (DSM-IV, 1994). Although autism is being researched intensively, little is known about how people with autism reason. Most scientists have focused on the intuitive Theory-of-Mind reasoning (Baron-Cohen 1995), which attributes beliefs and intentions to other people to understand, predict and control behavior. A small number of studies including (Leevers and Harris 2000; Scott and Baron-Cohen 1996; Peterson and Bowler 2000; Stenning and van Lambalgen 2008; Pijnacker et al. 2008) investigated broader aspects of logical reasoning and so far the finding are not very consistent.

Let us formalize some decision-making problems from the real world and consider how humans and machines can solve them. Control humans, people with autism and intelligent machines each have characteristic limitations in solving these

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problems. One of the key question of this book is how can these limitations be characterized in terms of specific features of algorithms. That would make the current science of autism much more formal, more systematic, more concise and hopefully more efficient in terms of rehabilitation strategies.

Today, computational and psychological studies of autism are very sparse and disconnected, and in this book we try to describe their results in the unified framework. We select the studies with experimental results with models that are computationally plausible in our view. Then we describe a model of autistic reasoning that is consistent with these studies on one hand and also generalizes our own experiments with exploration and training of autistic reasoning on the other hand. The main feature of our model is that it is axiom level – based and describes the autistic syndrome from the standpoint of axioms that have not been properly acquired and therefore should be trained. These axioms are backed up by our computational frameworks for reasoning about mental states and autistic active learning. We then investigate how these trained axioms improve reasoning as a first step and the overall behavior of children with autism as a second step.

Recent psychological studies have revealed that autistic children can neither reason properly about mental states nor understand emotions (Perner 1991; Leslie 1987; Pilowsky et al. 2000). There is a strong need for efficient educational support for such children with special needs. Autism is a developmental disorder which is currently defined in terms of its symptoms (Eigsti and Shapiro 2003). The three main accounts of the psychology of autism can be outlined as follows:

Theory of mind account, which refers to the ability to infer and understand what oneself and others are thinking (knowing, believing, desiring) in order to plan one's own behavior and predict the behavior of others. This ability to reason about mental attitudes is impaired in patients with autism (Baron-Cohen 2000). This reasoning disability leads to difficulties with such mental reasoning-based forms of behavior as pretend play, problems in understanding false beliefs, and the ability to tell lies.

Weak central coherence account, which refers to the inability of individuals with autism to process information in context, even having a remarkable ability to remember details (Frith 1989, 2001). For example, autistic individuals seem to have more difficulty than controls in recalling sentences or a main plot of a story, being as good as controls at recalling unconnected word strings (Hermelin and O'Connor 1967).

Executive dysfunction account, which refers to the inability of autistic individuals to maintain appropriate problem-solving behavior (Pennington and Ozonoff 1996; Russell 1997). This is often manifested in the form of behavior that perseveres inappropriately despite changing goals (Ozonoff 1997).

In this book we mainly focus on formalization and computational implementation of the first account and develop a tool that assists the learning process of reasoning about mental attitudes. To do that, we subject the Theory of Mind (ToM) and its impairment under autism to a formal analysis, propose a formal model of reasoning about mental attitudes (adequate for such learning), and build a training tool in accordance to this model. This tool is based on a simulation of reasoning about mental states and actions by conflicting software agents. We present the deployment of the natural language multiagent mental simulator NL_MAMS for mental and emotional development of autistic children.

In this book we treat the ToM from the perspective of logical artificial intelligence, providing a more systematic way to characterize mental states, mental actions and how their representation is corrupted under autism. Building the adequate model of the mental world and emotions is important for teaching the individuals, whose understanding of mental world is impaired.

In our previous studies we have analyzed each of the above three accounts in terms of models of underlying reasoning. The theory of mind account has been a subject of the systematic exploration of the reasoning about mental states by individuals with mental disorders (Galitsky 2000, 2001). The ToM account has been extended to reflect the computational experience of "teaching" computers to reason about mental attitudes: an adequate formalization of the mental world has been built to represent a number of autism phenomena. These studies addressed the peculiarities of autistic reasoning about knowledge, beliefs, intentions, and about other mental states and actions. Involving the formalisms of logical artificial intelligence, and the BDI (Belief-Desire-Intention) model in particular (Bratman 1987), the system for representation of reasoning about mental states and actions has been built. Our system is capable of simulating the verbal behavior of autistic as well as control patients (Galitsky 2002b). We have also analyzed various forms of autistic reasoning about action, time, space and probabilities, and have found that their deductive reasoning skills are stronger than their inductive, abductive, and analogical forms of reasoning (Galitsky and Goldberg 2003). We developed a set of exercises and built the software implementations focusing on selected reasoning patterns, teaching autistic trainees to reason properly about mental states in accordance to the traditions of axiomatic method, since the natural ways of teaching (by example) usually do not help (Galitsky 2003). Also, it has been shown that the training of reasoning about beliefs, desires and intentions assists the emotional development (Galitsky 2001). A series of interactive rehabilitation software tools have been developed which stimulate various forms of commonsense reasoning, conversation and decision-making in autistic trainees (Peterson et al. 2004).

The second and third accounts of autism above have been characterized in terms of default reasoning (Peterson et al. 2004; Galitsky and Peterson 2005), where typical and atypical situations are treated differently, in contrast to classical reasoning.

In this book, we propose a new conceptual reasoning model for autism in which the core deficits, and other related symptoms, emerge as a result of a basic problem with symbolic reasoning. Our model attempts to provide the developmental mechanism required to explain why primary deficits related to social orientation may be the cause for autism and its broader features, and why intensive early intervention by means of stimulating reasoning about mental attitudes frequently helps to improve autistic reasoning.

Beyond the Introduction, the book is organized as follows. We firstly discuss computational models and generally accepted accounts of autism (Chap. 2) and then proceed to intuitive Theory of Mind (Chap. 3) and its formalization (Chap. 4). The reader who prefers to avoid technical details may want to skip Chaps. 4, 5, 6, and 7 and proceed to Chaps. 8 and 9.

In Chap. 5 the mental simulator NL_MAMS is presented, the system that is capable of automated reasoning within our framework of the mental world. User interface and implementation of the simulator is followed by evaluation of its reasoning capabilities and the description of its deployment for the rehabilitation of reasoning. Chapter 8 presents the NL_MAMS-assisted rehabilitation strategy and describes its evaluation. Towards the end of the book we analyze educational value of the proposed rehabilitation strategy and describe a case study. In describing the theory of mind, we will be relying on the language of logic programming, this being a convenient way to introduce the mental world both to computers and autistic children.

1.1 How Computer Scientists Can Help Individuals with Autism

The main behavioral problem of children with autism (CwA) lays in the area of reasoning, decision making, control, and cognition as reflected in their behavior and motion. These are the areas of expertise of engineers, building the reasoning, search, recommend, recognition and control systems. Today, in the second decade of the twenty-first century, these specialists and these systems are very common, and plenty of experience is accumulated on how these systems malfunctions and how they can be repaired.

At the same time, a high number of models for the malfunction of autistic reasoning, control and cognition has been proposed by psychologists, neurobiologists, geneticists and specialists in neural networks, specialists without a hands-on experience with respective engineering systems. The mystery of autism still has a long way to be solved, and there is a tremendous amount of inconsistencies between today accounts and models of autism. Some of these inconsistencies are, in our opinion, due to computational implausibility of some proposed models. These models can be realistic in terms of how a correct sensory or reasoning system might work, according to their authors, but indeed they look faulty to an engineer who might have tried respective architecture, failed and now knows a reason for it.

In this book we take a number of models of autism and apply a computational plausibility test to them. We attempt at combining the best of two words: computer scientists are inspired by psychological experiments on how intelligence works, and autism specialists learn from the experience of computer scientists and engineers building systems and solving problems similar to those where children with autism have deficiencies. Applying the computational plausibility criteria, we reduce the number of models of autistic dysfunctions and attempt to convert them to a form acceptable by members of computer science community.

Traditionally, strict (formalized, mathematical) thinking is considered as an opposite entity to the emotional (fuzzy, approximate) thinking and behavior. However, for autistic patients the strict rule-based learning is much easier than the direct introduction of the various forms of emotional behavior, hence the latter is achieved via the former. Therefore, we are teaching autistic kids the "mechanic" forms of mental and especially emotional behavior. Regretfully, the attempts to directly introduce the emotional interaction with the others in a natural manner (teaching by examples, imitating) frequently fail.

In this book, we want to characterize autistic reasoning patterns from the perspective of axiomatic logic, similar to how a behavior of an automatic agent is expressed. Our interest is how various forms of autistic reasoning are connected with each other and determine the observable decision-making and behavior. We will also address the issue of how can our experience with reasoning of automatic agents, accumulated in artificial intelligence, help with understanding and treatment of reasoning of autistic individuals.

In the current body of research on autism there is no accurate model for how the correct reasoning in various reasoning domains should work. There is a lack of formal interconnection between the reasoning patterns in different domains (mental, physical, spatial/temporal, probabilistic, etc.). To overcome this, we need a systematic approach to reasoning that is based on practical experience building software agents with decision-making capabilities, acting in the above domains.

Frequently, CwA are good at some analytical tasks, including reasoning and calculations. At the same time, they lack communicative and cognitive skills, and their orientation in the mental world is limited. Such children are the primary target of the methodology developed in this book, they can learn axioms directly from multiple sources including their teachers. The best teachers for them are computer scientists because they literally use a similar language of rigidity and attention to details. High-functioning CwA with advances analytical skills can then infer theorems from acquired axioms and apply these theorems to their decision-making and behavior, being guided by rehabilitation professionals. Such CwA are the part of the broader audience of computer scientists who would be happy to learn reasoning patterns from this book skipping the psychological and general humanitarian wrapper of reasoning (the latter is required by the rest of CwA for whom the boundary between reasoning and behavior is not that crisp).

1.2 Developing Deductive Reasoning Skills of Machines and Children with Autism

The issue of training to overcome various deficiencies of autistic reasoning has been addressed in a number of studies (Green 1996; Baron-Cohen 2000). There is a series of peculiar techniques developed to teach children with autism certain forms of reasoning, mainly reasoning about mental states and actions, reasoning about generic actions, default and defeasible reasoning, deductive, inductive, abductive and analogical reasoning patterns, probabilistic decision-making etc. Skills of reasoning in some of these domains are lacking in every child with autism (Howlin 1998).

Teaching by analogy is the standard technique for both junior students and adults in a majority of subject domains. However, autistic trainees experience significant difficulties learning from examples, they can imitate some forms of behavior and actions of other people but do it without understanding. Also, visual programming tools is an efficient way to introduce abstract and general programming concept, they are quite efficient for both education of programming and efficient software development (Grandin 2006). In spite of the appeal to use visual programming tools, autistic children do not learn abstract reasoning patterns from them most of times.

Hence in terms of reasoning patterns, controls learn by induction and analogy, and reinforce learning results by deduction (explicit rules) in most of real-world domain (excluding e.g. math). At the same time, autistic trainees learn by deductive rules most of the time, and other reasoning patterns play auxiliary roles only (Galitsky 2005).

Therefore, teaching autistic trainees in any domain must be preceded by formulating exact and explicit rules. Otherwise, the teaching approach that might be adequate for a control trainee would be unacceptable for an autistic trainee, as our experience shows (Galitsky and Goldberg 2003). Teaching a new entity to a child with autism, one needs to make sure that all entities the current one refers to are fully conceptually understood. On the contrary, a child from a control group is ready to acquire a new entity in the environment where some features are uncertain, assuming she can learn them later (Fig. 1.1).

The idea of this book is to explore the similarity between formulating domain knowledge in a way acceptable by a computer and formulation of this knowledge to be acquired by an autistic trainee. We enumerate the commonalities in cognitive demands of computers and autistic trainees with respect to teaching them knowledge representation and reasoning in real-world domains:

1. All concepts have to be *clearly* and *explicitly* defined. A basis of indefinable concepts may be selected, but a programmer/teacher should be aware that a computer or trainee will not be able to freely operate and provide explanations with these concepts from the basis. For example, when taught the rules for basic mental states of the mental world (knowledge and intention), followed

Learn to reason (*formally, symbolically)* about mental states ⇒

Capable of applying rules to subjects of real world ⇒

Can understand others and behave properly in real world

Fig. 1.1 Main steps of our proposal

by the rules by derived mental/communicative actions derived from this basis, the autistic trainees are capable of explaining what is *pretending* and *deceiving* (derived) but not what is *knowledge* and *intention* (basic).

2. Definitions for concepts can be either *procedural* or *declarative*. A trainee can be taught a sequence of actions to achieve a goal, or a clause for a sequence of conditions an environment should satisfy to achieve this goal. To be capable of training in a declarative way, respective trainees' skills have to be developed. For example, if a child with autism is requested to be at the top of a rock in the middle of a puddle with a fishing pole, the child needs some skills to determine the order of operations: put on rubber boots, take a fishing pole, cross the puddle and climb the rock. In contrast to a control child who would acquire this skill independently on the basis of trial-and-error, a child with autism needs a substantial guidance to learn how to search for a proper sequence of actions independently.
3. All special cases should be addressed. For example, for an arbitrary predicate like *want* we would expect a smart trainee to operate with *want(Who, What)* with arbitrary *Who* and *What.* It is not the case for a child with autism who does not understand that other people may *want* something,

When we refer to an autistic or computer software trainee, we assume a medium-to-high-functioning individuals with autism and a standard software environment without sophisticated machine learning systems like explanation-based generalization (Mitchell et al. 1986) or inductive logic programming (Muggleton and De Raedt 1994).

In this book we will demonstrate that experimental cognitive science is relevant to a number of important AI problems in reasoning and machine learning. We focus on the domain of autistic reasoning that is a curious mixture of topics in AI and cognitive sciences. We will outline the commonalities of teaching autistic children and teaching computers (programming) to solve real-world problems, and provide a simplified illustration on how the experience of the former can be applied to the latter. Our claim is that it is significantly easier to teach control children to solve these problems than to teach children with autism, and, obviously, it is even more so for programming, where much more details have to be provided for robust functioning.

We will also demonstrate that lessons learned in teaching reasoning about mental world, adjusting one's action to an environment and can be naturally applied to improve the performance of machine reasoning in the respective domains. The conclusion will be that theoretical and experimental cognitive science of autistic reasoning might contribute to such traditionally "technical" areas as machine learning and reasoning.

1.3 Prior Work in Intelligent Systems for Autistic Education

Learning behavior in mental space based on rules, as described in this study, can be viewed as a special way of learning programming, in particular, object–oriented programming. Galvez et al. (2009) present a blended e-learning experience consisting of supplying an undergraduate student population with a problem-solving environment in which students can resolve programming exercises. The system applies an assessment for learning strategy where students are formatively assessed and also generates feedback and hints to help students to understand and overcome their misconceptions and to reinforce correctly learned concepts.

The synergies, functional effectiveness and integration of behavior simulation within an e-learning environment have attracted little interest for serious research so far, despite the overarching importance of knowledge acquisition by students for fostering their innovation and creativity. Learners often fail to reach their desired learning objects due to the failure of methods to provide them with a ubiquitous learning grid. Lau and Tsui (2009) discuss how knowledge management can be used effectively in e-learning, and how it can provide a learning grid to enable the learner to identify the right learning objects in an environment which is based on the learner's context and personal preferences.

The use of ontologies to model the knowledge of specific domains such as mental attitudes represents a key aspect for the integration of information coming from different sources, for supporting collaboration within virtual communities, and for reasoning on available knowledge. In the e-learning field, ontologies can be used to model educational domains and to build, organize and update specific learning resources (i.e. learning objects, learner profiles, learning paths, etc.). One of the main problems of educational domains modeling is the lacking of expertise in the knowledge engineering field by the e-learning actors. Gaeta et al. (2009) present an integrated approach to manage the life-cycle of ontologies, used to define personalized e-learning experiences supporting blended learning activities, without any specific expertise in knowledge engineering. Also, collaborative learning serves as an important part of e-learning. It increases interactivity and accessibility to various learning resources either synchronously or asynchronously among users. Distributed interactivity through Web services thus forms the focus of (Fang and Sing 2009) who review service-oriented architecture, distributed infrastructure and highlight the need to integrate service-oriented technologies for meaningful and interactive collaborative learning processes.

The need for providing learners with web-based learning content that match their accessibility needs and preferences, as well as providing ways to match learning content to user's devices has been identified as an important issue in accessible educational environment. For a web-based open and dynamic learning environment, personalized support for learners becomes more important. In order to achieve optimal efficiency in a learning process, individual learner's cognitive learning style should be taken into account. Due to different types of learners using these systems, it is necessary to provide them with an individualized learning support system. However, the design and development of web-based learning environments for people with special abilities has been addressed so far by the development of hypermedia and multimedia based on educational content. Guo and Zhang (2009) presented a framework of individual web-based learning system by focusing on learner's cognitive learning process, learning pattern and activities, as well as the technology support needed. Based on the learner-focused mode and cognitive learning theory, the authors demonstrate an online course design and development that supports the students with the learning flexibility and adaptation.

Multiple technologies have been suggested for mental rehabilitation, including playing LEGO (Resnick 1987), video-clips together with a set of dolls (Blocher and Picard 2002), autonomous mobile robots and the interactive tool for browsing and recognizing emotional expressions. Recent advances in mobile and ubiquitous technologies provide an opportunity to efficiently and accurately capture important information preceding and associated with problematic behaviors of children with autism. The ability to obtain this type of data will help with both intervention and behavioral rehabilitation efforts. Through collaboration with behavioral scientists and therapists, Sano et al. (2012) identified relevant design requirements and created an easy-to-use mobile application for collecting, labeling, and sharing in-situ behavior data in individuals diagnosed with autism.

These computer-based tools assist the development of a wide spectrum of behavioral and cognitive skills. However, our focus is teaching reasoning about the mental world, which then naturally leads to communication and other skills (Galitsky 2002a). The goal of this book is to describe an intelligent education system that is at least capable of reasoning on its own, in contrast to the approaches mentioned above which are the infrastructures for providing access to various media.

To differentiate the proposed educational environment from existing software packages for children with autism, we address the following issues:

- The software needs to stimulate *reasoning* with an accent on rule-base reasoning. In particular, reasoning about *intention, knowledge* and *beliefs* of others should be developed after the basic entities are introduces via rules.
- The software has to be *intelligent*. This requirement is due to the fact that in contrast to conventional learning process, such software has to be capable of substituting interaction with humans in a certain degree. Frequently, autistic trainees prefer to deal with software agents rather than with humans. These software agents need to demonstrate the reasoning skills, which are expected to be developed by the learners, rather than just to introduce a domain for reasoning.
- While identifying three core deficits outlined above certainly helps in the study and diagnosis of autism, it does not provide a causal explanation of the disorder, nor does it provide a rehabilitation mechanism. It is worth mentioning a number of neural network-based models of autistic phenomena (see e.g. Cohen 1994); however there is no explicit connection between these models and reasoning or possible rehabilitation strategies.

1.4 Teaching Theory of Mind to Autistic Patients

Teaching children with autism can be overwhelming, but it also can be a triumph at the same time. The possibility to teach autistic children theory of mind has been assessed in multiple studies because of potentially important clinical implications.

If it is true that a deficit in reasoning about mental attitudes leads to impairment in social interaction and understanding of oneself and others, then an efficient method for teaching theory of mind may assist in overall autism rehabilitation. Autism training studies, including the current one, are valuable sources of knowledge regarding how improved reasoning patterns affect trainees' behavior including social interaction.

The theory of mind training studies conducted so far have shown that some individuals with autism can be taught to pass the particular tasks of reasoning about mental states (Swettenham 1996; Baron-Cohen and Swettenham 1997; Sutton et al. 1999; Scott et al. 2002). In most cases, it is natural to assume that trainees indeed apply one or another reasoning pattern rather than memorizing exact answers. Regrettably, in most cases, the studies of how individuals with autism acquire mental reasoning patterns are lacking an accurate formulation of these patterns, backed up by computational experiments. We believe the latter is essential to differentiate between mental and non-mental components of reasoning process.

Another problem with teaching particular patterns of reasoning about mental states is a verification of how children can generalize from acquired mental reasoning patterns. Because the majority of ToM training studies have not considered deductive links between the mental reasoning patterns *involved in a given thought*, it is unclear how the acquisition of one pattern should have affected others. We believe that the question of mutual dependence of reasoning patterns should be addressed from a computational perspective. Indeed, applying axioms about intention, knowledge and beliefs to be introduced, we subject their generalizations to a formal treatment and observe how they can be taught (Chaps. 4 and 8).

A number of earlier studies have focused on theory of mind tasks, demonstrating that members of high-functioning group of individuals with autism are able to pass first-order (Baron-Cohen 1989; Swettenham et al. 1996), second order and even third-order tasks (Happe 1994). Also, the tasks include interaction and conversational skills concerning maintaining the topic of conversation and adjustment of conversation topics for others, interpretation and expression of non-verbal signals, listening and expressing interest in others have been investigated.

The results of these ToM training studies are that the performance of the group which has undergone training has improved (at least with the second order tasks) with respect to controls. However, frequently children were able to apply non-mental state rules, and were not able to show the results of their training in their behavior. Only a smaller proportion of high-functioning autistic children are believed by these authors to improve their social skills as a result of training. In terms of generalization, children were able to apply acquired mental rules to other subjects and objects. However, it is still unclear what was being generalized – new knowledge about inferring mental states or a non-mental-state rule that allowed participants to pass tests. Disappointingly, children with autism can hardly transfer their reasoning skills from one mental domain to another (e.g. recognition of emotion, pretense, false belief; Hadwin et al. 1997, Fig. 1.2).

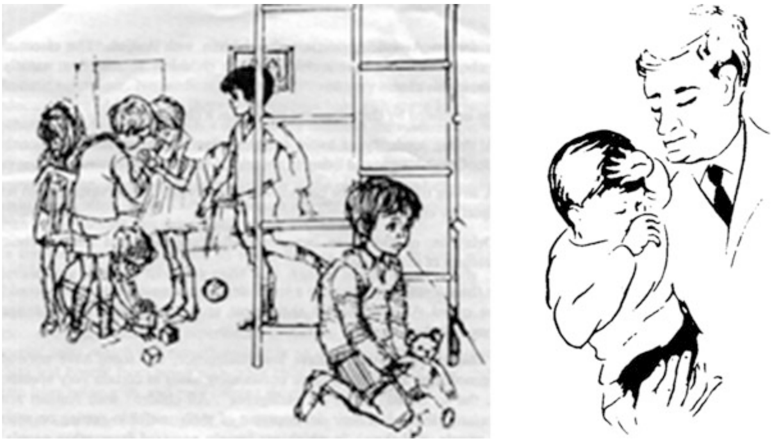

Fig. 1.2 On the *left*: a typical posture, position and avoidance of the other children. On the *right*: an autistic child is subject to repeated attempts of adult to make eye-to-eye contact (Both reproduced from Hutt and Hutt 1970)

We believe that the reasons for the rather low efficiency of the above training, in addition to autism-specific reasoning impairments, concern the consistency and persistency of the training and the thoroughness of coverage of the domain of mental reasoning. Here we discuss how to develop the experimental studies, verifying whether treatment of autistic theory of mind reasoning is efficient or not, into long-term rehabilitation strategies which are viable for a wide audience of individuals with autism.

Firstly, the training has to be consistent. A totality of the first-order mental entities should be introduced first, followed by the totality of second-order entities, if acquired properly. The third-order rules should be introduced only after the trainees can consistently demonstrate not only passing the simpler exercises, but respective behavior and understanding second-order entities of others.

Secondly, in terms of persistence, the training should be attempted from the earliest possible age and as long as a trainee is interested in practicing the exercises. If no success is observed at a given age, the training should be attempted again in a few months assuming a trainee has acquired some necessary background knowledge and/or reasoning skills to adopt certain mental-state reasoning patterns failed earlier.

Thirdly, trainees would benefit from the complete coverage of mental domain, which is rather compact in comparison with other domains. The totality of basic mental entities (intention, knowledge and belief) should be introduced together with derived mental entities (including pretending, deceiving, explaining, forgiving etc.). Such coverage is assured by the formal model specifying how to derive mental entities from the basic ones; this formal model will be introduced in Chap. 4.

Similar to the theory of mind training settings introduced above, we teach individuals with autism mental entities and their combinations. However, unlike the previously mentioned studies, we use *formalized* means to teach mental entities, suggesting that they are more suitable to the peculiarities of autistic development (Peterson and Galitsky 2004).

We use the non-human (computer) resources, readily acceptable by autistic children, to introduce them to the mental world (of humans) via formalized reasoning. The paradox of our methodology is that reasoning about the mental world, usually supposed to be irrational and displayed as an emotion, can nevertheless be considered from the abstract perspective, formalized and used in training. This hypothesis (Galitsky 2002b) is used as a framework of our rehabilitation strategy to develop rational and emotional behavior in the real mental world. Traditionally, strict (formalized, mathematical) thinking is considered as an opposite notion to emotional (fuzzy, approximate) thinking and behavior. Since for the autistic trainees strict rule-based learning is much easier than the direct introduction of the various forms of emotional behavior, the latter is achieved via the former.

Our model of the human agent is based on the supposition that there are a number of standard axioms for mental entities, including emotions; these axioms are genetically set for normal children and are corrupted in the autistic brain (Galitsky 2013). The patterns of corruption vary from trainee to trainee and are correlated with the specifically outlined groups of individuals with autism. They have to acquire these axioms explicitly, by means of direct training, using the specific scenarios. Frequently, autism is not accompanied by learning disabilities, so the patents willingly participate in training programs. Our practical experience shows that using a software-based training allows us to hold the attention of autistic trainees for much longer periods than traditional means of one-to-one treatment by a human trainer.

1.5 How to Read This Book

The main targets of this book are software engineers, computer scientists and mathematicians interested in theory and practice of autism. This category of readers is expected to learn about autism and remediation strategies in their native language. Describing the problems children with autism experience in various circumstances, we describe similar problems in engineering artificial intelligence systems and try to find common solutions. Specialists in logical Artificial Intelligence should focus on Chaps. 4, 5, and 6, and machine learning and cognitive system professionals – on Chap. 7. Software engineers might find Sections 4–7 equally appealing. Computer engineers and natural scientists who are parents of children with autism can briefly familiarize themselves with Chaps. 2, 3, 4, 5, 6, and 7 and read in depth Chaps. 8 and 9.

For those who prefer to avoid the language of logic and computation, we recommend Chaps. 3, 6, 7, 8, and 9. Rehabilitation professionals can briefly look at Chaps. 2 and 3 and proceed to Chaps. 8 and 9.

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