CogToM-CST: An implementation of the Theory of Mind for the Cognitive Systems Toolkit

Fabio Grassiotto[1][a], Esther Luna Colombini[2][b], Alexandre Simões[3][c], Ricardo Gudwin[4][d] and Paula Dornhofer Paro Costa[4][e]

[1] *Hub de Inteligência Artificial e Arquiteturas Cognitivas (H.IAAC), Eldorado Research Institute, Campinas - SP, Brazil*

[2] *Institute of Computing, University of Campinas (UNICAMP), Campinas - SP, Brazil*

[3] *Institute of Science and Technology, São Paulo State University (Unesp), Sorocaba - SP, Brazil*

[4] *School of Electrical and Computer Engineering, University of Campinas (UNICAMP), Campinas - SP, Brazil*

Keywords: Autism, Cognitive Architectures, Artificial Intelligence.

Abstract: This article proposes CogToM-CST, an implementation of a Theory of Mind (ToM) model using the Cognitive Systems Toolkit (CST). Psychological research establishes that ToM deficits are usually associated with mind-blindness, the inability to attribute mental states to others, a typical trait of autism. This cognitive divergence prevents the proper interpretation of other individuals' intentions and beliefs in a given scenario, typically resulting in social interaction problems. Inspired by the psychological Theory of Mind model proposed by Baron-Cohen, this paper presents a computational implementation exploring the usefulness of the common concepts in Robotics, such as Affordances, Positioning, and Intention Detection, to augment the effectiveness of the proposed architecture. We verify the results by evaluating both a canonical False-Belief task and a subset of tasks from the Facebook bAbI dataset.

1 INTRODUCTION

The objective of this work is to propose a novel cognitive architecture that implements a computational model for the Theory of Mind using the Cognitive Systems Toolkit (CST) and its reference architecture (Paraense et al., 2016). Our earlier work defined the basis for such an architecture (Grassiotto and Costa, 2021).

Our main motivation is the Autism Spectrum Disorder (ASD), a biologically based neurodevelopmental disorder, and the psychological models proposed in the last 30 years to explain the reasoning behind the social interaction issues typically experienced by autistic individuals (Klin, 2006). ASD is characterized by marked and sustained impairment in social interaction, deviance in communication, and restricted or stereotyped patterns of behaviors and interests (Organization et al., 1993).

[a] https://orcid.org/0000-0003-1885-842X
[b] https://orcid.org/0000-0002-1534-5744
[c] https://orcid.org/0000-0003-0467-3133
[d] https://orcid.org/0000-0002-9666-3954
[e] https://orcid.org/0000-0002-1457-6305

Research in technologies for ASD has had a focus on the diagnosis, monitoring, assessment, and intervention tools, interactive or virtual environments, mobile and wearable applications, educational devices, games, and therapeutic resources (Boucenna et al., 2014; Picard, 2009; Kientz et al., 2019; Jaliaawala and Khan, 2020). Among the current efforts for helping people in the autism spectrum, there is a lack of Computational assistive systems for helping them with their impairments in social interactions.

Our understanding is that these systems should be designed to analyze environmental and visual social cues not readily interpreted by those individuals in the spectrum, providing expert advice on the best alternative for interaction, and improving social integration outcomes.

Cognitive architectures, we believe, can help bridge the gap by creating computational modules inspired on the human mind that are involved on the process of social interaction. Such a cognitive architecture should be able to create assumptions (that we will be calling *beliefs*) about the environment and situations to provide expert advice.

The British psychologist Simon Baron-Cohen proposed, in his doctorate thesis, the mind-blindness

Grassiotto, F., Colombini, E., Simões, A., Gudwin, R. and Costa, P.
CogToM-CST: An implementation of the Theory of Mind for the Cognitive Systems Toolkit.
DOI: 10.5220/0010836300003116
In *Proceedings of the 14th International Conference on Agents and Artificial Intelligence (ICAART 2022) - Volume 3*, pages 462-469
ISBN: 978-989-758-547-0; ISSN: 2184-433X

theory of autism, later published as a book (Baron-Cohen, 1997). His work proposed the existence of a mindreading system and established that the cognitive delays associated with autism are related to deficits in developing such a system. This mindreading system is directly related to the concept of Theory of Mind (ToM) as the innate ability to attribute mental states to oneself and others and to understand beliefs and desires that are distinct from their own (Premack and Woodruff, 1978).

Research has shown that individuals with ASD show deficits in ToM (Kimhi, 2014; Baraka et al., 2019; Baron-Cohen, 2001). The deficits can be demonstrated in several test tasks, in particular false-belief tasks, i.e., test tasks designed to evaluate children's capacity to understand other people's mental states (Baron-Cohen, 1990).

This work contributes to the literature by proposing CogToM-CST, a novel cognitive architecture designed as an assistive tool for individuals in the autism spectrum, by implementing a computational ToM mechanism.

2 RELATED WORK

2.1 The Cognitive Systems Toolkit (CST)

The Cognitive Systems Toolkit is a general toolkit for the construction of cognitive architectures (Paraense et al., 2016). Inspired by Baars's Global Workspace Theory (GWT) for consciousness, Clarion, and LIDA cognitive architectures, among others, CST uses many concepts introduced there (Sun, 2006; Baars and Franklin, 2009).

GWT establishes that human cognition is achieved through a series of small special-purpose processors of an unconscious nature (Baars and Franklin, 2007). Processing "Coalitions" (i.e., alliances of processors) enter the competition for access to a limited capacity global workspace.

The core concepts in the CST Core architecture are *Codelets* and *Memory Objects* as can be seen in Figure 1.

Codelets are defined as micro-agents, small pieces of non-blocking code with a specialized function, designed to be executed continuously and cyclically for the implementation of cognitive functions in the agent mind. Codelets are stored in a container known as the *Coderack*.

Memory Objects are generic information holders for the storage of any auxiliary or episodic information required by the cognitive architecture. Memory Objects can also be organized in *Memory Containers* for grouping purposes.

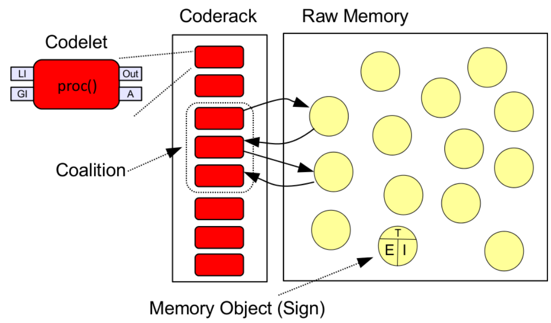

Figure 1: The CST Core Architecture. From https://cst.fee.unicamp.br/.

In the CST Core, there is a strong coupling between Codelets and Memory Objects. Memory Objects are holders for any information required for the Codelet to run and receivers for the data output by the Codelet. In a similar fashion to Codelets, all Memory Objects and Memory Containers are stored in a container known as the *Raw Memory*.

2.2 Autism and False-belief Tasks

CogToM is inspired by the long-term goal of designing an expert system to assist people in the autism spectrum to help out with social interaction. To that purpose, it is essential to understand one of the key deficits observed in autistic individuals by psychologists: the performance in False-Belief Tasks.

False-Belief tasks are a type of task used in the study of ToM to test children. The objective of the test is to check if the child understands that another person does not possess the same knowledge as herself.

Baron-Cohen and Frith proposed the *Sally-Anne test* as a mechanism to infer the ability of autistic and non-autistic children to attribute mental states to other people regardless of the IQ level of the children being tested (Baron-Cohen et al., 1985).

In the test, a sequence of images (Figure 2) is presented to the children. Starting the sequence, in the top rectangle, two girls (Sally and Anne) are in a room, with a basket (Sally's) and a box (Anne's). Sally takes a ball and hides in her basket (second rectangle), then leaving the room (third rectangle). After that, Anne takes the ball from Sally's basket and stores to her box (fourth rectangle). Sally then returns to the room (fifth rectangle). The child is then asked, "Where will Sally look for her ball?". Most autistic children answer that Sally would look for the ball in the box, whereas control subjects correctly answer that Sally would look for the ball in the basket.

Figure 2: The Sally-Anne test for false-belief. Adapted from (Baron-Cohen et al., 1985), drawing by Alice Grassiotto.

The results presented in the article supported the hypothesis that autistic children generally fail to employ ToM due to the inability to represent mental states. The downside of this is that autistic subjects cannot attribute beliefs to others, which brings a disadvantage to predicting other people's behavior. It is thought that this lack of predicting ability causes deficits in the social skills of people in the autism spectrum once it hinders their ability to face the challenges of social interaction.

Examples of abilities that are linked to the capacity of understanding each other mental states are, among others, the ability to empathize and the skills of coordination and cooperation (Schaafsma et al., 2015; Sally and Hill, 2006). ToM allows us to generate expectations about the behavior of others and, based on these expectations, guide our decision-making process.

2.3 Baron-Cohen Mindreading

Since it is generally accepted that the failure of employing a theory of mind causes deficits in the social skills for people in the autism spectrum, we defined our approach as the implementation of a computational model equivalent to the inner workings of ToM in humans.

Thus, our proposal for the CogToM cognitive architecture will follow a biologically-inspired model based on the mindreading model proposed by Baron-Cohen (Baron-Cohen, 1997), as can be seen in Figure 3.

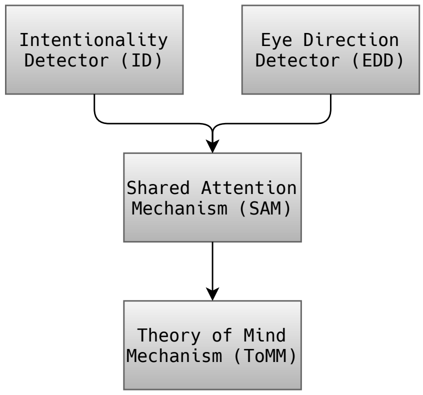

Figure 3: The ToM Model extracted from (Baron-Cohen, 1997).

This model seeks to understand the mindreading process by proposing a set of four separate components:

- **Intentionality Detector (ID)** is a perceptual device that can interpret movements and identify agents from objects, assigning goals and desires to them.
- **Eye Direction Detector (EDD)** is a visual system able to detect the presence of eyes or eye-like stimuli in others, to compute whether eyes are directed to the self or towards something else and infer that if the eyes are directed towards something, the agent to whom the eyes belong to is seeing that something.
- **Shared Attention Mechanism (SAM)** builds internal representations that specify relationships between an agent, the self, and a third object. By constructing such representations, SAM can verify that an agent and the self are paying attention to the same object.
- **Theory of Mind Mechanism (ToMM)** completes the agent development of mindreading by representing the agent mental states that include, among others, the states of pretending, thinking, knowing, believing, imagining, guessing, and deceiving.

The components of the mindreading model are not isolated as there are interactions required to build the internal representations of EDD, SAM, and ToMM.

3 AFFORDANCES

The psychologist J.J. Gibson introduced the concept of Affordances in his 1979 work where he defines the affordances of an environment as what is offers to an animal, what provides or furnishes, either for good or evil (Gibson, 2014).

Since then, this concept has been extended by researchers in the AI field, as described by (McClelland, 2017). Researchers have found applications for affordances in robotics as a process to encode the relationships between actions, objects and effects (Montesano et al., 2008; Şahin et al., 2007). Classic examples are that a ball might afford to catch, or a box might hide something inside.

For CogToM, the concept of affordances has found use in the environmental analysis to assign properties to objects and the environment it is currently situated.

4 INTENTION DETECTION

In the field of robotics, Intention Understanding is seen as a requirement for human-machine interaction (Yu et al., 2015). By understanding environmental cues, a robot can deduce the possible human intention by considering the relationship between objects and actions. Some models for this were proposed using affordance-based intention recognition. One example of Intention Understanding is to detect if Sally, in the Sally-Anne test described earlier, intends to put her ball inside her basket.

The CogToM architecture proposes using external systems capable of understanding human intention to augment the environmental analysis it requires.

5 PROPOSED ARCHITECTURE

5.1 CogToM-CST

We design this cognitive architecture using the CST toolkit as an agent that implements decision-making functionality to implement an AI *Observer*. The objective of this *Observer* is passing a false-belief task by implementing the mindreading model and integrating it with the processing of affordances and intentions. It relies on inputs as an external system, in the form of a visual camera system capable of identifying agents and objects, eye direction, and human intention and positioning. Affordances are seen as properties of the entities (objects and agents) in the system.

The outputs of the system (*Beliefs*) are textual representations of the mental state of an agent as perceived by the *Observer*.

5.2 CST Components

Using the CST Toolkit, the architecture is modeled by defining Codelets and Memory Objects, according to Figure 4. A correspondence between the computational architecture to the mind model is illustrated in the figure through a color scheme. Red blocks correspond to Baron-Cohen's ID module as shown in Figure 3, green blocks correspond to EDD module, blue blocks correspond to SAM, and pale yellow blocks correspond to ToMM.

5.2.1 Codelets

Codelets are the processes executed within the simulation step and are modeled after the psychological model by Baron-Cohen, where each mind module corresponds to a Codelet. Codelets have local (LI) and global (GI) inputs, and provide an activation (A) and a set of outputs (O) to Memory Objects (MOs) as can be seen in Figure 5.

- **The Intentionality Detector Codelet** identifies which entities in a scene are agents or objects, based on movement and action detection, creating memories for the Agents, their Intentions, and Objects.

  This Codelet is activated by the visual identification of movement on a scene and recalls from semantic memory for object identification.
- **The Eye Direction Detector Codelet** identifies eye direction from the agents and objects created by the Intentionality Detector Codelet, creates and attaches that information to Attention Memory Objects.

  This Codelet is activated by the ID Codelet.
- **The Shared Attention Mechanism Codelet** detects shared attention from the objects created by the EDD Codelet, and then creates and attaches information to Shared Attention Memory Objects.

  This Codelet is activated by the EDD Codelet.
- **The Theory of Mind Codelet** works as an integrator of all the information from working memory and creates Belief Memory Objects.

  This Codelet is activated by all other Codelets.

The Affordances Perception Codelet and the **Positioning Perception Codelet** do not exist in the mind model. Their purpose is to create affordances and position properties for the objects in the scene

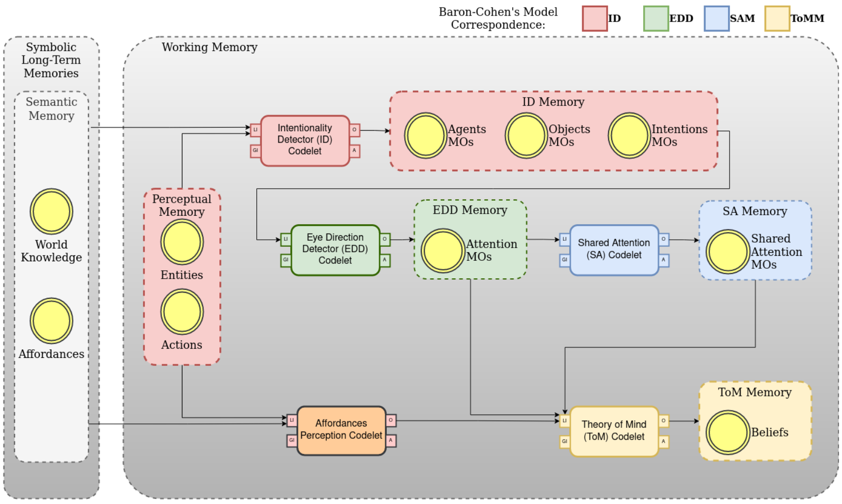

Figure 4: CogToM-CST Proposed Architecture.

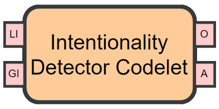

Figure 5: Example Codelet.

based on the camera input, the Agents, the Objects, and the Intentions associated with them.

5.2.2 Memory Objects

Memory for this system is modeled after the concepts of semantic and episodic memories. Memory Objects (and Memory Containers) are the generic information holders in memory that are modeled after the storage of data required for each of the modules of the mind model, as can be seen in Figure 6.

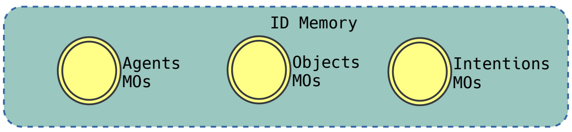

Figure 6: Example Memory Containers.

Semantic memories consist of storing world knowledge information (not in the scope of this implementation) and Affordances. All the other memories for the mind model are representations in episodic memory.

Affordances Memory Objects are Memory Objects that retain agents and objects interaction properties as a dictionary lookup.

Positioning Memory Objects are Memory Objects created from a camera input to inform the current location of agents and objects in a scene.

Activation Memory Objects are special-purpose Memory Objects used in this architecture to synchronize the execution of Codelets. The CST Toolkit was designed for multithreading, while the architecture we are modeling required sequential execution of the Codelets processes to produce the Beliefs we are looking for.

Memory Objects in **ID memory** are the agents, their intentions, and objects in the environment. Each of these entities is modeled as Memory Containers (MCs) in the architecture, producing an Agents MC, Objects MC, and Intentions MC.

Memory Objects in **EDD memory** store the attention of each agent for objects or other agents in the environment, modeled as Attention MCs.

Memory Objects in **SAM memory** store which objects or agents have the shared attention of two or more agents, modeled as Shared Attention MCs.

Memory Objects in **ToM Memory** are *Beliefs*, the main purpose of this cognitive architecture, modeled as Belief MCs.

5.2.3 Belief Construction

Beliefs in ToM Memory are modeled as text descriptions for the mental states the Observer will provide. There are two sets of beliefs the system will consider: *Beliefs* for each one of the agents in the scene, and *self-beliefs*, those associated with knowledge the Observer has about the environment.

$$< AGENT, BELIEVES|KNOWS, OBJECT, AFFORDANCE, TARGET\ OBJECT >$$

Where:

- **AGENT** is the main agent that the mental state applies to, for example, *Sally*. In the case of self-belief, the agent is the Observer itself.

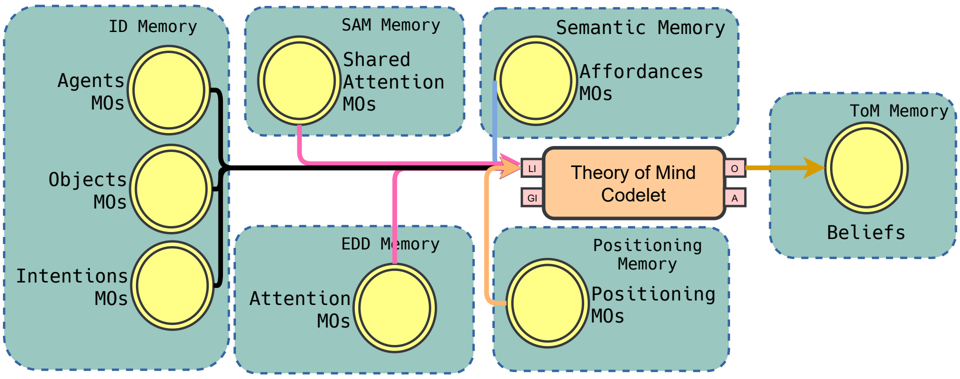

Figure 7: ToM Codelet View.

- **BELIEVES—KNOWS** is the mental state assigned to the agent. Various mental states could be considered, including pretending, thinking, knowing, believing, imagining, guessing, and deceiving. For this system, the mental state *Believe* is used for agents' beliefs, whereas the *Knows* mental state is used for self-beliefs about the environment.
- **OBJECT** is the object of the belief, for example *Ball*.
- **AFFORDANCE** is the main property, or affordance, of the object. For example, a Box may *Contain* something.
- **TARGET OBJECT** is the target object for the affordance, when applicable. For example, a Box may contain a *Ball*.

As shown in Figure 7, Beliefs are built from the ToM model proposed by the literature that provides the set of agents, objects, intentions, and attentions in the scene through the ID, EDD, and SAM modules and their Memory Containers. From this initial output, the architecture integrates the affordances from semantic memory. A single combination of an agent and one object defines a Belief object. Based on this set composed of an agent, an object, an affordance, and intention Memory Objects, a textual representation of that Belief is created in the ToM Memory as a new Memory Object.

Source code for the implementation of the CogToM Cognitive archictecture is available at (Grassiotto and Costa, 2020).

6 RESULTS

Two sets of validation tests were considered: the canonical false-belief task as described by the literature, and a subset of tasks from the bAbI dataset from Facebook Research (Weston et al., 2015). The bAbI dataset is a set of 20 simple toy tasks to evaluate question answering and reading comprehension.

Canonical False-Belief Test

Sally and Anne are in the room. Basket, box and ball are on the floor.
Sally reaches for the ball.
Sally puts the ball in the basket.
Sally exits the room.
Anne reaches for the basket.
Anne gets the ball from the basket.
Anne puts the ball in the box.
Anne exits the room, and Sally enters.
Sally searches for the ball in the room.

Task 1: Single Supporting Fact

Mary went to the bathroom.
John moved to the hallway.
Mary travelled to the office.
Where is Mary? A:office

Task 2: Two Supporting Facts

John is in the playground.
John picked up the football.
Bob went to the kitchen.
Where is the football? A:playground

Task 3: Three Supporting Facts

John picked up the apple.
John went to the office.
John went to the kitchen.
John dropped the apple.
Where was the apple before the kitchen? A:office

Beliefs for the **canonical false-belief test** are provided below.

```
Sally BELIEVES Anne Exists None
Sally BELIEVES Basket Contains None
Sally BELIEVES Box Contains None
Sally BELIEVES Ball Hidden In Basket
Anne BELIEVES Sally Exists None
Anne BELIEVES Basket Contains None
Anne BELIEVES Box Contains None
Anne BELIEVES Ball OnHand Of Anne

Observer KNOWS Sally IS AT Room
Observer KNOWS Anne IS AT Outside
Observer KNOWS Basket IS AT Room
Observer KNOWS Box IS AT Room
Observer KNOWS Ball IS AT Room
```

Since Sally was not present in the room while Anne took the ball from the basket and hid it, she still believes the ball is in the basket. Therefore, the system we designed can pass the false-belief task.

Facebook bAbI Task 1 consists of a question to identify the location of an agent, given one single supporting task (*Mary traveled to the office*):

```
Mary BELIEVES John Exists None
John BELIEVES Mary Exists None

Observer KNOWS Mary IS AT Office
Observer KNOWS John IS AT Hallway
```

Introducing the concept of Observer beliefs for the location of the agent, the beliefs could be produced correctly.

Facebook bAbI Task 2 is quite similar to the first one producing similar results:

```
John BELIEVES Bob Exists None
John BELIEVES Football Pickup None
Bob BELIEVES John Exists None
Bob BELIEVES Football Pickup None

Observer KNOWS John IS AT Playground
Observer KNOWS Bob IS AT Kitchen
Observer KNOWS Football IS AT Playground
```

Facebook bAbI Task 3 requires a temporal registry of the beliefs created in each step of the simulation. The system can identify temporal succession by the internal steps of the creation of beliefs:

```
Simulation running mind step: 2

John BELIEVES Apple Pickup None
Observer KNOWS John IS AT Office
Observer KNOWS Apple IS AT Office

Simulation running mind step: 3

John BELIEVES Apple Pickup None
Observer KNOWS John IS AT Kitchen
Observer KNOWS Apple IS AT Kitchen

Simulation running mind step: 4

John BELIEVES Apple Dropped None

Observer KNOWS John IS AT Kitchen
Observer KNOWS Apple IS AT Kitchen
```

Therefore, by comparing beliefs between simulation steps, it is possible to reply to the question proposed by this test.

7 CONCLUSION

The Cognitive Systems Toolkit provides an opportunity for organizing cognitive architectures following well-defined structures. In the process of reimplementation of the proposed architecture, it became clear that the new organization offers gains for modeling cognitive systems and states.

CogToM was earlier designed as a platform to validate the viability of a computational system to pass false-belief tasks based on implementing a psychological model of the human mind, and we identified the need for integrating further information about the world in the form of affordances and human intentions. The reuse of other proposed architectures based on the CST toolkit will be of value to our research.

Even tough this system has been designed with a focus on the autism spectrum disorder, we understand that the results obtained could be applied to the fields of robotic social interaction, social agents and others.

We could reproduce the earlier results with this cognitive architecture after moving the internal concepts to this new toolkit. The system continued to be generic enough to allow for testing with simple tasks as described by the Facebook bAbI dataset.

A future plan for this architecture is to create generic components for a Theory of Mind module to reuse the implementation for other systems based on the CST toolkit.

ACKNOWLEDGEMENTS

This project is part of the Hub for Artificial Intelligence and Cognitive Architectures (H.IAAC - Hub de Inteligência Artificial e Arquiteturas Cognitivas). We acknowledge the support of PPI-Softex/MCTI by grant 01245.013778/2020-21 through the Brazilian Federal Government.

REFERENCES

Baars, B. J. and Franklin, S. (2007). An architectural model of conscious and unconscious brain functions: Global workspace theory and ida. *Neural networks*, 20(9):955–961.

Baars, B. J. and Franklin, S. (2009). Consciousness is computational: The lida model of global workspace theory. *International Journal of Machine Consciousness*, 1(01):23–32.

Baraka, M., El-Dessouky, H. M., Abd El-Wahed, E. E., Amer, S. S. A., et al. (2019). Theory of mind: its development and its relation to communication disorders: a systematic review. *Menoufia Medical Journal*, 32(1):25.

Baron-Cohen, S. (1990). Autism: A specific cognitive disorder of "Mind-Blindness". *International Review of Psychiatry*, 2(1):81–90.

Baron-Cohen, S. (1997). *Mindblindness: An essay on autism and theory of mind*. MIT press.

Baron-Cohen, S. (2001). Theory of mind in normal development and autism. *Prisme*, 34(1):74–183.

Baron-Cohen, S., Leslie, A. M., Frith, U., et al. (1985). Does the autistic child have a "theory of mind". *Cognition*, 21(1):37–46.

Boucenna, S., Narzisi, A., Tilmont, E., Muratori, F., Pioggia, G., Cohen, D., and Chetouani, M. (2014). Interactive technologies for autistic children: A review. *Cognitive Computation*, 6(4):722–740.

Gibson, J. J. (2014). *The ecological approach to visual perception: classic edition*. Psychology Press.

Grassiotto, F. and Costa, P. D. P. (2020). CogToM-CST source code. https://github.com/AI-Unicamp/CogTom-cst/. Last checked on Aug 27, 2021.

Grassiotto, F. and Costa, P. D. P. (2021). Cogtom: A cognitive architecture implementation of the theory of mind. In *ICAART (2)*, pages 546–553.

Jaliaawala, M. S. and Khan, R. A. (2020). Can autism be catered with artificial intelligence-assisted intervention technology? a comprehensive survey. *Artificial Intelligence Review*, 53(2):1039–1069.

Kientz, J. A., Hayes, G. R., Goodwin, M. S., Gelsomini, M., and Abowd, G. D. (2019). Interactive technologies and autism. *Synthesis Lectures on Assistive, Rehabilitative, and Health-Preserving Technologies*, 9(1):i–229.

Kimhi, Y. (2014). Theory of mind abilities and deficits in autism spectrum disorders. *Topics in Language Disorders*, 34(4):329–343.

Klin, A. (2006). Autism and asperger syndrome: an overview. *Brazilian Journal of Psychiatry*, 28:s3–s11.

McClelland, T. (2017). Ai and affordances for mental action. *environment*, 1:127.

Montesano, L., Lopes, M., Bernardino, A., and Santos-Victor, J. (2008). Learning object affordances: from sensory–motor coordination to imitation. *IEEE Transactions on Robotics*, 24(1):15–26.

Organization, W. H. et al. (1993). *The ICD-10 classification of mental and behavioural disorders: diagnostic criteria for research*, volume 2. World Health Organization.

Paraense, A. L., Raizer, K., de Paula, S. M., Rohmer, E., and Gudwin, R. R. (2016). The cognitive systems toolkit and the cst reference cognitive architecture. *Biologically Inspired Cognitive Architectures*, 17:32–48.

Picard, R. W. (2009). Future affective technology for autism and emotion communication. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1535):3575–3584.

Premack, D. and Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and brain sciences*, 1(4):515–526.

Şahin, E., Çakmak, M., Doğar, M. R., Uğur, E., and Üçoluk, G. (2007). To afford or not to afford: A new formalization of affordances toward affordance-based robot control. *Adaptive Behavior*, 15(4):447–472.

Sally, D. and Hill, E. (2006). The development of interpersonal strategy: Autism, theory-of-mind, cooperation and fairness. *Journal of economic psychology*, 27(1):73–97.

Schaafsma, S. M., Pfaff, D. W., Spunt, R. P., and Adolphs, R. (2015). Deconstructing and reconstructing theory of mind. *Trends in cognitive sciences*, 19(2):65–72.

Sun, R. (2006). The clarion cognitive architecture: Extending cognitive modeling to social simulation. *Cognition and multi-agent interaction*, pages 79–99.

Weston, J., Bordes, A., Chopra, S., Rush, A. M., van Merriënboer, B., Joulin, A., and Mikolov, T. (2015). Towards ai-complete question answering: A set of prerequisite toy tasks. *arXiv preprint arXiv:1502.05698*.

Yu, Z., Kim, S., Mallipeddi, R., and Lee, M. (2015). Human intention understanding based on object affordance and action classification. In *2015 International Joint Conference on Neural Networks (IJCNN)*, pages 1–6. IEEE.