# Recalculating: The atlas of pragmatic parameters of developmental disorders

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**Abstract**

The paper demonstrates how pragmatic features of certain developmental disorders, including Autism Spectrum Disorder, can be described in a formal pragmasemantic framework. We apply ℜeALIS, the pragmasemantic system (Alberti, Kleiber, Schnell, & Szabó 2016) which offers a formal representation for linguistically encoded speech acts and for the beliefs, desires and intentions that are present in the minds of potential interlocutors. It defines *worldlets* which include the BDI states of the speaker, as well as BDI states that the speaker assumes the hearer has, in an unlimited recursive pattern. The model is built upon the idea that the worldlets are organized in a system of multi-level tree-structures and are easily processable and accessible in communication for the intact human mind. In this formally defined system, the intensity of the different BDIs (e.g. strong/weak belief) belonging to the worldlets must be signaled by the interlocutors, using pragmatic tools. We found that pragmatic inaccuracy is detectable in ℜeALIS when it is related to inappropriate presentation of BDIs (e.g. inability to identify the illocutionary goals), poor reciprocity (e.g. ToM1 and ToM2 problems), impairment of coding/decoding (e.g. incorrect semantical and syntactical coding of the information structure) and insensitivity to intensity (e.g. the misuse of discourse markers). These symptoms can be present in any of the aforementioned disorders. Our "atlas" can illustrate that the so-called "pragmatic deficit" has a formally definable structure.

**Keywords:** BDI, pragmatics, developmental disorders, HFA, ToM

## 1. Aims

The paper discusses pragmasemantic phenomena associated with neurodevelopmental disorders. We aim at analyzing the many and diversified examples discussed in the relevant literature as communication problems, in a certain formal pragmasemantic framework – namely, ℜeALIS, – also providing their systematic description. This serves the purpose of illustrating that there is a formally definable structure behind communication disorders and pragmatic deficits. With a gradual sophistication of the system, our longer-term purpose is to help the diagnosis of the persons concerned and the intervention design for them.

Section 2 discusses the relationship between neurodevelopmental disorders and pragmatics. Section 3 is devoted to a brief presentation of the system of ℜeALIS. We do not aim

at providing entirely formal(ized) analyses; rather we sketch the logics of the system. Specific analyses are presented in Section 4. The analyses rest upon examples and cases discussed in the literature; what we do is including them in a new framework.

The first steps of a research project are summarized in the paper. We collected all the mentioned examples from three classical works (Howlin et al. 1998; Attwood 2007 and Peeters 1997) then we classified them into types according to the pragmatical problems. These types were then analyzed and illustrated. The re-analyses of the examples and cases we have selected have led us to the following conclusions. The usual practice of claiming that "there are problems concerning communication and/or mentalization behind these cases" is insufficient in itself. This practice could benefit from re-analyzing the given examples within a strictly formally defined system in order to reach such new questions as (i) and (ii). (i) Which are the sentence types the handling problems of whose intensional profiles are in the background of the particular cases? (ii) Exactly which controlling principle of everyday discourse is the person concerned not able to operate?

We are thus convinced that communication aspects of neurodevelopmental disorders should be recalculated according to stricter methodological principles and analyzed on the basis of formal definitions.

## 2. Neurodevelopmental disorders and pragmatics

### 2.1. Pragmatic involvement

We consider the following international systems used by experts in the definition and classification of neurodevelopmental disorders: Diagnostical Statistical Manual, DSM-5 (APA 2013), and The International Statistical Classification of Diseases and Related Health Problems, ICD (WHO 1992; WHO 2018). The neurodevelopmental disorders associated with pragmatic involvement which we are investigating are as follows:

- Intellectual Disabilities (Disorders of intellectual development),
- Communication Disorders (Developmental speech or language disorders, and within the latter, the currently introduced Social (Pragmatic) Communication Disorder),
- Autism Spectrum Disorder (ASD),
- Attention Deficit and/or Hyperactivity Disorder.

In this paper we have primarily chosen examples for analysis which come from highly functioning autistic persons. ASD can be characterized by a special neurodevelopmental pattern with respect to the complex system of social cognition and sociocommunicative abilities. It is a lifelong, dynamically changing neurocognitive developmental disorder currently diagnosed on the basis of behavioral symptoms, which is highly heterogeneous as regards both individuals and populations.

In the developmental disorders, some form of pragmatic involvement can be observed, in close connection with involvement of social behavior. In spite of the highly different behavioral phenotype and neuropsychological background – for instance, social isolation, typical of ASD,

or excessive sociability, typical of Williams syndrome – these problems are similar. Typical pragmatic problems in developmental disorders are (Cummings 2014):

- conversational/contextual irrelevance,
- conversational impairments,
- impairments of social use of language,
- mindblindness,
- impairment of understanding intended meaning,
- difficulties with integration, decoding and encoding of suprasegmental features, metacommunicative signals, and non-verbal communication
- poorer narrative competence,
- difficulties with presuppositions and inferences,
- excessive number of stereotyped phrases,
- difficulties with context (overdependence and/or insensitivity to contextual features),
- difficulties with the use of deictic expressions.

In developmental disorders, involvement of pragmatic competence may be of different degrees, the areas involved, as well as the difficulties that can be observed may also be diverse, but there is a high degree of overlapping. As for qualitative and quantitative differences, not only particular disorders may be dissimilar in both respects, but there is also immense variability within particular disorders.

Structural and connectional properties of the nervous system, due to biological and environmental factors, show extraordinary variation, which is also observable in development. The functioning of the nervous system in developmental disorders cannot simply be regarded as a halting of progress in infancy but it should rather be construed as a simultaneously qualitative and quantitative deviation from the characteristics of typical development.


### 2.2. Pragmatic approach

In pragmatic research, work on classical topics such as speech act theory, implicature, or communicative intentions is being extended with new research topics such as neuropragmatics. Under the umbrella of neuropragmatics, acquired disorders as well as developmental ones are inspected from a pragmatic point of view. Our research can be related to this type of approach, at least to a certain extent. We provide analyses of pragmatic difficulties observed in different developmental disorders in the framework of ℜeALIS but we do not intend to formulate reasons and explanations concerning the structure and physiology of the nervous system. In the course of modelling pragmatic competence, we are working on the creation of an atlas in the system that ℜeALIS offers, in which the pragmatic involvement of different developmental disorders is captured by means of a formal apparatus and localized in the formal system.

The pragmatic approach of our ℜeALIS framework is simultaneously pragmalinguistic and sociopragmatic (Leech 1983). On the one hand, the description of pragmatic competence rests upon interlocutors' minds, mental states, conventionalized language knowledge and abilities they have. On the other, however, the consideration of social context and reciprocity also plays a distinguished role in both the description and the success of communication.

## 3. ℜeALIS

### 3.1. Novelty

The acronym stands for *Reciprocal and Lifelong Interpretation System*. The approach primarily aims at formally capturing the pragmatic module of language without separating it from other modules. Partly due to language technological motivation, formal, computer-encodable analytical models have now been constructed for most language modules, namely, phonology, morphology, syntax and semantics (see Alberti & Kleiber 2010; Alberti & Nőthig 2015). Pragmatics, until just recently, was held to be an area where it is beyond hope to provide formal(ized) results, given the immense role that world knowledge and stylistic specialties play. Endeavors towards modelling pragmatic knowledge in a computer-encodable manner have recently been presented in the ℜeALIS framework (Szeteli, Alberti, Kleiber, & Dóla 2018); and in general it has belonged to the distinguished aims of the ℜeALIS approach to offer language-technologically functioning pragmasemantic models since Alberti and Kleiber (2010).

ℜeALIS defines a permanent and lifelong building information-structure by the mathematical definition technique of simultaneous recursion with a distinguished point of "birth". At this point there is no information, only some built-in knowledge about how information should be collected and how an information system can be built. The information is assumed to derive permanently, from the point of its "birth", from experiences we have in the world surrounding us – a crucial part of which is experiencing the utterances around us. That is why ℜeA<u>LI</u>S models information acquisition in a lifelong manner.

As for reciprocity, referred to by the first two characters in <u>ℜe</u>ALIS, our point of departure is that only one part of the information acquired pertains to states and events of the outer world. Most information pertains to other conceptualizers of the world, that is, other communicating agents. Besides including in a system their own BDI attitudes – *beliefs, desires, intentions*, known form mind theory (Baron-Cohen 1995) – agents in communication acquire and store information on each other's BDIs. Moreover, they align the content and the form of their utterances with what they assume that their listeners hypothesize, aspire, intend and assume them, the speakers, to hypothesize, aspire and intend. Reciprocal reflection of information is hypothesized in ℜeALIS, in a theoretically unbounded recursive manner. Compared to earlier systems, the innovation of this formal approach is that the global world model also contains mental states as recursively developing units: environment mirroring "prisms". This way ℜeALIS (see Alberti et al. 2016) makes possible the formal semantic capturing of what is intensively discussed in mind theory as *mentalization*. Those who use the ℜeALIS framework should be aware of the fact that this is not only a possibility but also an obligation: formulating hypotheses on the mind that operates communication should be associated with regarding as, and accounting for, the resulting system as a model of the human mind.

The last two characters in the acronym refer to the concept of an *interpretation system*. How ℜeALIS extends the traditional concept of formal, model-based interpretation is as follows. Not only the truth value of a sentence should be calculated, but a decision should also be made concerning the worlds – "worldlets" – against which the sentence to be interpreted

should be evaluated. In the on-going discourse, we open, define and alternate several worldlets, which are parallel to or built on each other. In these alternative worldlets, different events may be taking place, since one worldlet consists of "my" beliefs, another one of "your", the listener's, beliefs, whilst a third worldlet contains information on actions taking place in a novel which we are just discussing. In the course of communication, the truth of a given proposition will always be evaluated in the worldlets in which the grammatical and other linguistic cues used in the given sentence place the proposition.

We conclude the subsection by pinpointing what sets the ℜeALIS approach apart from others that also strive for the description of interlocutors' intentions, relative credence levels, and source-for-commitments roles: that is, purely cognitive approaches (e.g. Fauconnier 1994) and common-ground based (Stalnaker 2002) formal approaches (e.g. Farkas and Roelofsen 2017). As discourse situations are modeled in ℜeALIS in a way that interlocutors are represented as each-other-building lifelong discourse representation structures by the mathematical technique of *simultaneous recursion* (Alberti 2000), Maier's (2016:476) words on the scientific status of "cognitive DRT" precisely hold true for ℜeALIS: "What is often glossed over in such linguistic applications – even in many analyses of attitude ascriptions … – is Kamp's (1981) original motivation of reconciling Fregean formal semantics with a traditional, Lockean cognitive theory of communication in terms of speakers' and hearers' mental states. To this end, Kamp in his original presentations actually describes DRSs as representations of the mental state of the hearer, rather than of the more abstract notion of a Stalnakerian (e.g. Stalnaker 2002) common ground. What sets this cognitive conception of DRT apart from purely cognitive theories like Fauconnier's (1994) Mental Spaces, is that the DRS language has a precise syntax and model-theoretic interpretation. Hence, in addition to its cognitive interpretation, a DRS also represents the actual truth conditions of a sentence or discourse. Linguists have since stripped DRT of its cognitive interpretation. But Kamp and a few others have kept it alive, even extending DRT to a full-blown representational theory of attitudes…"

### 3.2. *Pragmatic errors*

In successful dialogues or discourses, interlocutors are assumed to perfectly apply all components of the formal system sketched above. Pragmatic errors or disorders can be regarded as stemming from the imperfect functioning of the components. By inspecting these components step by step, it can be taken into consideration what potential error types can be accounted for with the aid of the ℜeALIS structure.

A potential error type is when the speaker or the listener does not raise hypotheses as to beliefs, desires and/or intentions, or raises unsound ones. This type of error or deficiency may pertain to someone's own BDI system (e.g., the given person does not recognize or realize their own real beliefs) or to their partner's BDI. In this latter case, reciprocity is violated, which is a typical instance of problems with mentalization. It is also a logical possibility that the interlocutor is not able to build parallel worldlets, or they are not able to choose among them.

There may emerge less fundamental types of pragmatic error, either in everyday communication, or in the course of language acquisition. It is a logical possibility that the given

BDI-profiles are mutually recognized appropriately but their linguistic encoding does not succeed according to the relevant pragmatic rules. ℜeALIS defines the major sentences types (declarative, imperative, interrogative) by providing intensional profiles for the definitions. They decide how given sentence types can conventionally be associated with the speaker's and the listener's beliefs, desires and intentions, and "permissions"/authority concerning the information in question (who is able, authorized and/or in a position to obtain, or to distribute, certain pieces of information, or to carry out the action referred to in the given sentence).

Words such as *persze* 'sure', that is, morphological discourse markers, and special intonation patterns make possible an even more sophisticated fine-tuning. By these means certain elements of the basic BDI-profiles can be made more intensive/dominant or less intensive, or can even be completely overridden. ℜeALIS does not only encode the type of attitude but also the degree to which the listener is sure that the given attitude is there, or, say, to what extent, the listener is assumed to long for something or "be in the possession of" a piece of information. ℜeALIS as a formal system uses a scale for these degrees. Certain discourse markers can definitely be characterized by the pragmasemantic contribution that they are responsible for setting certain scale degrees. Due to space limitations, however, we are now not in a position to discuss in detail this "fine-tuning" pragmatic toolbox and to scrutinize the following straightforward conjecture: those who suffer from communication disorders cannot, or can only partially, have recourse to this useful apparatus.

The concerned group also experiences difficulties in doubling BDI-profiles (Oishi 2016), upon which our very fundamental human manifestations rest, such as telling huge lies, white lies, bluffing, behaving politely, or pretending being polite. Doubling BDI-profiles is required since in the course of the above-listed speech actions the interlocutor should keep a count of an alternative addresser-role profile parallel to their factual mental/information state. As a listener, one should also be prepared for situations in which what can be decoded as an addressee-role profile does not necessarily provide a true and fair view of the speaker's mental/information state. The straightforward "null hypothesis" in this area is that those suffering from communication disorders experience difficulties as listeners, too.

In the ℜeALIS approach, the chief aim is to formally account for the typical – "grammatical" as well as pragmatically well-formed – use of human language. However, parallel to this primary aim, it can also serve as an important test for the adequateness of the system, in its attempts to account for not yet fully fledged stages of the human mind, as well as mind structures that are not neurotypical.

The ℜeALIS theory will obviously benefit from these analyses. On the other hand, we are also convinced that the elegant formal-pragmasemantic descriptions potentially resulting from these investigations will also be useful to experts of first language acquisition and individual language development as well as those dealing with atypical patterns of pragmatic capacity.

## 4. Analyses of atypical utterances

The potential pragmatic errors taken into account in 3.2 are exemplified in this section in both typical and atypical individual language development. It is sketched how they can be analyzed

in the system of ℜeALIS. Due to space limitations, here we cannot provide entire formalized analyses. A certain amount of formalism and marking conventions, however, should inevitably be introduced in order to make sense why it is worth creating the atlas of pragmatic disorders in the ℜeALIS framework.

As sketched in Section 3, identification labels assigned to the attitudes included in the communicating interlocutors' mental states play a fundamental role in the ℜeALIS system. These label types encode, first of all, what the speaker/addresser, at least to a certain extent, knows or believes (iB), desires (iD), and is able to do / has authority over (iA). They also encode what the speaker assumes of the listener/addressee in the same respects (iBuB, iBuD, iBuA), that is, how they mentalize the other one. A scale ⟨−5, −4, −3, −2, −1, 0, +1, +2, +3, +4, +5⟩ is used to express what can be construed as some kind of relative truth value of the given eventuality (event or state). +5 refers to certain truth in the given worldlet (sure knowledge or maximal intensity of desire, intention or authority), −5 to certain falsity, 0 to entire uncertainty, whilst the further values express in-between probabilities *mutatis mutandis*.

**Table 1:** *Attitude wordlets constituting mental states in ℜeALIS*

| Wordlet | Declarative | Imperative | Yes/No question |
|---|---|---|---|
| iB: iBuB | iB = +5; iB$\underline{u}$B ∉ {−5,+5} | iB = −5 = iB$\underline{u}$B | iB ∉ {−5,+5}; iB$\underline{u}$B ∈ {−5,+5} |
| iD: iBuD | $\Sigma(\delta_i \cdot i\underline{D}uB+, \delta_u \cdot iB\underline{u}DuB+) > \dots$ | $\Sigma(\delta_i \cdot i\underline{D}, \delta_u \cdot iB\underline{u}D) > \dots$ | $\Sigma(\delta_i \cdot i\underline{D}iB+, \delta_u \cdot iB\underline{u}DiB+) > \dots$ |
| iA: iBuA | iA… ∈ {+1, …, +5}; iB$\underline{u}$A… ∈ {+1,…, +5}; preferable relevant factor: rE = +5 | | |
| iIuI+ | iIuI+$\underline{uB+}$ = +5 | iI$\underline{uI+}$ = +5 | iIuI+$\underline{iB+}$ = ∈ {−5, +5} |

**Legends**: i (*I*): speaker; u (*you*): listener; B: belief; D: desire; I: intention; A: authority; E: experience; … rX+: (component of) outptut worldlet; <u>underlining</u>: numerically evaluated component

The table provides a reasonably simplified description of the intensional profiles of the three major sentence types in the "worldlet-label language" sketched above. We are presenting the essence informally, placing ourselves in the aspect of the speaker's ego. "As for the input knowledge in the case of uttering an eventuality e, the imperative profile can be opted for if I think (iB) so that it is (still) not true that e is taking place, which is a piece of knowledge I assume the listener, too, in the possession of (iBuB)." The declarative and interrogative profiles can be opted for if "I assume that the levels of knowledge the two of us have (iB, iBuB) are just the opposite. That is, I know the truth while you do not know, or *vice versa*." As for the D-dimension of desires, in the case of the imperative profile, the desire pertains to e itself ("I wish it took place"), whilst in the case of a declaration or a question, the desire pertains to output (post-utterance) epistemic stage of one of the interlocutors: "you should come to know e" (uB+) and "I should come to know whether e or not e" (iB+), respectively. The formulas with summation symbols express that "I assume the realization of e / the given information transfer to be in our interest, at least on the whole" (where individual interests in the sum can even be considered with weights). As the series of dots in the table show, this paper presents underspecified authority labels. These labels are responsible for the measuring of the individual interlocutors' authority over their corresponding subtasks in the realization of e / the given information transfer. In the two profiles concerning information transfer, the relevant factor of authority is whether the participant who is assumed to provide the relevant piece of information

(r = i/u, depending on if a declaration or a question is considered) is in its position to so high an extent that can only be ensured by sensory experience (rE). In the interrogative profile, the listener is minimally required to be in the possession of the truth value of e: iBuB∈ {−5,+5}.

Thus belief, desire and authority characteristics serve as input criteria for using the three major sentence types. Intention characteristics (iI), however, pertain to output, that is, post-utterance mental states: "I have had recourse to the given speech act in order to make you want (iIuI+…) to carry out e [in the imperative case] / to take part in the given information transfer [in the declarative and the interrogative cases]."

### 4.1. *Difficulties with recognition and concealment of one's own beliefs, desires, intentions (iB, iD, iA, iI)*

The first step of communication is for the speaker to align the propositional content e and the formal execution (e.g. sentence type) with their own beliefs (iB), desires (iD), intentions (iI). If the speaker is not able to recognize their own belief, desire or intention, they obviously cannot communicate them appropriately. This phenomenon can be observed in everyday life in certain developmental periods of infants: when, for instance, the infant cannot recognize the tension caused by hunger, thirst or tiredness as the corresponding desire but, instead of expressing it, their reaction is a tantrum. It is a similar phenomenon in ASD when the person is unable to identify the source of tension and behaves in a way that is difficult for outsiders to understand. It is also typical that authority is assessed erroneously: for instance, the person concerned transfers a piece of information the distribution of which has not been permitted.

We could not identify any disorder concerning the recognition of own intention (iI) in either typical development of infants or atypical development (NB: difficulties with the *communication*, and not the recognition, of intentions can often be observed, see 4.4). This has led us to the hypothetical conclusion that, of the BDAI quadruple, intention has an attitude with a distinguished role. A plausible explanation for this is that intention is the *central* component of intensional profiles defining the pragmasemantic content of speech acts: the intentional attitude serves as the *action* component itself in the speech action, with the other attitudes types serving only as preconditions. It is the intentional component that pertains to the modification of the listener's mental state (…uI+…) with the purpose of creating a definite post-utterance "output" mental state.

### 4.2. *Misunderstanding communication partners' BDAI characteristics*

The present subsection deals with first-order mentalization. First-order mentalization is the recognition of a communication partner's mental state, which plays a crucial role in cooperative reciprocal communication. By continuously monitoring the partner, their background knowledge (uB, see example [1]) should be revealed, their desires (uD, see [2]) should be inferred, and their authority (i.e. their relevant capacities, uA, see [3])) should be assessed, in order to find the adequate language behavior in the course of the permanent dynamic context-dependent process of meaning construction. The first question is whether the speaker is aware

of the fact that this task of mentalization forms an integral part of communication. In other words, it is to be inspected whether they are interested in the partner's knowledge, beliefs, desires, entitlements at all, or whether they know that the partner is likely to have a different BDA-profile.

In the case of typically developing children, the functioning of this capacity for mentalization is essentially automatic and without effort in the ages of 4-5, but quite often even three-year-olds can be good at first-order mentalization. The classic test situations are the different first-order mind-theoretical tasks, which most children at these ages manage to solve. It is also noteworthy, however, that tasks concerning different mental states can be difficult to different extents, so there can be observed age-dependent differences in the acquisition of attributing desires, beliefs and knowledge to the communication partner (Wellman & Liu 2004). It is true that in ℜeALIS beliefs and knowledge belong to the same B-dimension (iBuB); nevertheless, they are differentiated based on the intensity scale, referred to in Table 1. Children are thus hypothesized to gradually acquire the attribution of both attitudes and the associated intensity degrees.

The explanations of the behavioral symptom patterns which are characteristic of autism spectrum disorders are still essentially based on cognitive psychological, cognitive causal models. One of the main explanatory factors in these models is "naïve Theory of Mind deficit" hypothesis (Baron-Cohen, S. et al. 1985). There are, however, several research results suggesting that the "Theory of Mind deficit" is not exclusive and there are even counter-examples (Pellicano 2011). As pointed out in Alberti et al. (2016), due to mathematical concepts such as iso- and homomorphism, ℜeALIS can capture the fact that, relative to the fully fledged worldlet structure in the neurotypical mind, in atypical mind types there are alternative structures reduced to numerous different extents.

In examples [1-3] below, first-order mentalization errors are considered, based on the relevant literature.

Example [1]: *disorder in dimension iBuB, when the speaker erroneously assesses the listener's background knowledge* (Howlin, Baron-Cohen, & Hadwin 1998). A young man with good intellectual capacity, living with autism was reported to be unable to understand that the experiences he gained as an eyewitness to an event were not necessarily in the possession of others as their own experiences. He could not comprehend that his experiences were different from others'. Therefore, he would often refer to events without sharing relevant background information with his colleagues, who, as a result, could not calculate and assess the foundations of his argumentation.

Example [2]: *disorder in dimension iBuD, when the speaker erroneously assesses the listener's desire* (Howlin et al. 1998). A schoolboy was reported to annoy his mates and teachers with long and boring monologues about the technical details of his favorite car or bridge. He was only ready to speak to anyone about these topics. He could not realize that others did not share his enthusiasm about these matters.

Example [3]: *disorder in dimension iBuA, when the speaker erroneously assesses the listener's authority* (Peeters 1997). A child who had noticed a crack in a wall was reported to ask such complicated questions about the phenomenon that even an engineer would have found difficult to answer.

The corresponding literature makes no mention of any misunderstanding of the communication partner provided that they have made their intentions appropriately clear, using the corresponding intensional profile by opting for the adequate sentence type.

Example [4]: *a potential disorder in dimension iBuI, when one does not seem to realize their partner's intention* (Attwood 2007, p. 216). *"Can you count to ten?"* – this question serves as the point of departure for the description of the case to be discussed. The concerned child was reported to give the abrupt answer "Yes" to the question. The answer in the dialogue is held to exemplify a difficulty with communication typical in ASD. Based on Table 1, however, our stance is that the child who gave the answer in question had no difficulty recognizing the speaker's intention. Now the relevant eventuality is: e = [you are able to count to ten], and the worldlet against which this e should be interpreted is as follows: iIuI+iB+. Informally: "I want you to want me to learn whether e is true (where e happens to concern your counting skills)." A "yes" as an answer to the question *does* reveal the answerer's recognition of the partner's aforementioned intention. 4.4 is devoted to the discussion of the aspect in which the child's reaction may qualify as insufficient even in the ℜeALIS atlas.

### 4.3. Alternating between worldlets

As mentioned above, in the ℜeALIS terminology, the attitudes constituting mental states are represented as finite substructures of Montague-style possible worlds, referred to as *worldlets* in the ℜeALIS terminology. When desires or beliefs are interchanged with reality-based knowledge, it is to be regarded as difficulty in the handling of worldlets. This is typical of small children, even those that can be characterized by neurotypical development, and also of people who are unable to follow the changes in narrative structures.

### 4.4. Major sentence types

In contrast to the cases discussed in 4.1, in cases where the speaker has no difficulty being aware of their own BDAI-profile, as in case [4], it might still cause them a problem to encode the message appropriately, or to conceal it (by having recourse to telling lies or bluffing). With this, let us now return to [4] in order to account for the case as an encoding problem.

Let us start with a parallel example. During a job interview, one may be asked if they are familiar with spreadsheet programs. Obviously, the adequate answer does not entail opening a computer to prove one's proficiency. The interviewer, however, would also sense that there is something missing if the answer were a laconic "yes". It is expected in these cases that the interviewee should verify the truth of their answer, that is, their proficiency. It might be an adequate answer to say "I have a certificate of my proficiency in this area," which can be completed as follows: "Do you perhaps need a copy?" This way the answerer would meet the essentially Gricean principle of "provide the maximum amount of information."

The child in [4] failed to meet this principle of information maximization so in this sense he encoded his message inadequately. ℜeALIS accounts for this observation as follows. In Table 1, the underspecified label evaluation [rE = +5] within the Authority-dimension should be

specified so that a piece of information counts as the most credible, and hence most valuable, if it rests upon sensorial experiences (E). By the child factually counting to ten, the communication partner will experience (uE+ = +5) that the child is able to count to ten so they will reach the state that can be characterized by the equation [uI+ = +5]. A laconic "yes" leads to a tension between what the partner can decode as an *addressee*, which is [uI+ = +5], and what they can consider to be certain as a careful *listener* (Oishi 2016). Overall, the laconic answer does not indicate a mentalization disorder concerning intention but should qualify as difficulty in optimally conforming to the given intensional profile.

Let us now consider a case discussed in Howlin et al. (1998): a ten-year-old who lives with autism is reported to have serious difficulties making friends. According to the description, the child was clearly aware of both his own intention and the partner's desire to not make friends with him. What he was not able to do is linguistically encode, according to the conventionalized conversational rules, his intention and his frustration over being refused. Making friends is a culturally determined ritual, the acquisition of which belongs to a child's socialization. In our culture, friend making is not immediately taught but in the course of social interaction, children can acquire it. At first, these are ungainly and unsuccessful attempts. It is in the course of these attempts that children gradually turn to practiced friend makers. The acquisition of friend making obviously requires the thorough observation of the partners' interactions, including the monitoring of even the tiniest details of permanently changing intensional profiles, as well as the Oishian differentiation between the addresser role and the speaker's factual mental state. It is also presumable that the lack of the ability of emphasizing the essence also creates difficulties with (the acquisition of) friend making. As a consequence, the concerned persons will not succeed in the acquisition of the relevant communication panels, which can be qualified as a failure in encoding the intensional profiles to be applied in communication situations.

Our last comment concerns a variant of [4], again, in which the conditional mood would be used in the given question: "Could you count to ten?" In this formulation, the question has turned to similar to classic ones such as "Could you pass me the salt?" and "Could you tell me the time?" These are (polite) instructions, and answering "yes" is indeed not acceptable but an instance of not comprehending what the partner's intention is. In this case, the adequate reaction to the first utterance is counting to ten. The (seemingly slight) difference between this case and the original version of [4] can be accounted for in the ℜeALIS framework as follows. The "Could you…?" version does not provide a compositionally calculable realistic interpretation. Who intends to associate a realistic meaning with the utterance, should have recourse, again, to the Oishian differentiation between the addresser role and the speaker's factual mental state. Without going into details, we claim that some kind of rebuilding of the meaning components will give us the imperative intensional profile as belonging to the speaker's factual mental state (see Table 1). We also hypothesize that countenance and intonation also help with arriving at the imperative reading. We argue that in language, the role of different forms associated with essentially the same intensional profile is to furnish speakers with alternatives that are (im)polite to different degrees.

## 5. Conclusions

On the one hand, the investigation of the pragmatic aspect of atypical neurodevelopment has proved to help the developers of the dynamic interpretation system ℜeALIS in checking, verifying and improving its formal-linguistic toolbox. The introduction of the E-dimension in the ℜeALIS "attitude-language" ("experiences" / sensory authentication), for instance, has been supported by the neurodevelopmental analyses discussed in the paper. On the other hand, our linguistic approach has helped in differentiating Intention (as a central attitude in speech acts) from other attitudes: in the examples concerning self- and first-order mentalization discussed in the literature of atypical neurodevelopment, the aspects that are reported not to function well are related to beliefs, desires, authority, but not intention. We could also point out that certain pragmatic errors attributed to a mentalization problem should rather be attributed to a difficulties in linguistic encoding. We have intended to convince the reader that ℜeALIS makes possible a better understanding of the complex conglomerate of pragmatic/communication/ mentalization features which may "go wrong" in atypical neurodevelopment. Table 2, a simplified version of Table 1, summarizes these features, and classifies them according to the error types revealed in the paper.

***Table 2:*** *Towards an atlas of pragmatic errors in* ℜeALIS

| Wordlet | | Declarative | | Interrogative | | Yes/No question | |
|---|---|---|---|---|---|---|---|
| iB | iBuB | iB = +5 | iBuB ∉ {−5, +5} | iB = −5 | iBuB = −5 | iB ∉ {−5,+5} | iBuB ∈ {−5,+5} |
| iD | iBuD | $\Sigma(\delta_i \cdot iDuB+, \delta_u \cdot iBuDuB+) > \dots$ | | $\Sigma(\delta_i \cdot iD, \delta_u \cdot iBuD) > \dots$ | | $\Sigma(\delta_i \cdot iDiB+, \delta_u \cdot iBuDiB+) > \dots$ | |
| iA | iBuA | iA…∈ {+1,…,+5}; iBuA… ∈ {+1,…, +5}; preferable relevant factor: rE = +5 | | | | | |
| iIuI+ | | iIuI+uB+ = +5 | | iIuI+ = +5 | | iIuI+iB+ = ∈ {−5, +5} | |

The phenomena analyzed in Section 4 cannot be accounted for by referring to difficulties being aware of one's own beliefs, desires or intentions (see the uncolored cells). Being aware of the limits of authority, however, is a problematic area in atypical neurodevelopment (pink cells). Narrative changes between one's own beliefs and desires may also cause difficulties (yellow). Blue color refers to pragmatic errors pertaining to first-order mentalization. No cells are blue in the I-dimension, because the re-analyses of certain classic cases from the literature have led us to the conclusion that intension is so central a factor in intensional profiles that even neuro-atypical persons are able to recognize both their own and their partners' intentions – at least if the given intention is literally expressed. It belongs to our future plans to research into the effect of non-literal linguistic expressions and the "fine-tuning" toolbox of discourse markers.

Overall, the paper has presented a "pilot study", with the purpose of convincing the reader that the linguistic aspects of both typical and atypical neurodevelopment of infants and children are worth examining more meticulously from the point of pragmatic disorders than it has been assumed so far. We have argued for the application of a representationalist formal dynamic interpretation system (offering an immediate representation of the mind) called ℜeALIS in the process of differentiating between factors of first-order mentalization and metacognition, linguistic encoding and decoding, and different communication skills. A particular area of research that lends itself to use in the ℜeALIS context is conducting comparative research into

pragmatic difficulties in neuro-atypical development, focusing on the major *versus* the minor sentence types – given that the intensional profiles of the minor sentence types *ab ovo* do not contain mentalization factors.

## References

American Psychiatric Association. 1994. *Diagnostic and statistical manual of mental disorders: DSM-IV* (4th ed.). Washington, DC: American Psychiatric Association.

American Psychiatric Association. 2013. *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed.). Washington, DC: American Psychiatric Association.

Alberti, G. 2000. Lifelong discourse representation structures. *Gothenburg Papers in Computational Linguistics* 5: 13–20.

Alberti, G., and J. Kleiber. 2010. The Grammar of ℜeALIS and the Implementation of its Dynamic Interpretation. *Informatica (Slovenia)* 34(2): 103–110.

Alberti, G., Kleiber, J., Schnell, Zs., and V. Szabó. 2016. Intensional profiles and different kinds of human minds: "Case studies" about Hungarian imperative-like sentence types. *LingBAW* 2: 6–26.

Alberti, G., and L. Nőthig. 2015. ℜeALIS2.1: The Implementation of Generalized Intensional Truth Evaluation and Expositive Speech Acts in On-Going Discourse. *International Journal on Advances in Intelligent Systems* 8(1&2): 85–106.

Attwood, T. 2007. *The Complete Guide to Asperger's Syndrome*. London: Jessica Kingsley Publisher.

Baron-Cohen, S., Leslie, A., and U. Frith. 1985. Does the autistic child have a "theory of mind"? *Cognition* 21: 37–46.

Baron-Cohen, S. 1995. *Mindblindness: An Essay on Autism and Theory of Mind*. Cambridge, MA: MIT Press.

Cummings, L. 2014. *Pragmatic Disorders*. Perspectives in Pragmatics, Philosophy & Psychology 3. London: Springer.

Farkas, D., and F. Roelofsen. 2017. Division of labor in the interpretation of declaratives and interrogatives. *Journal of Semantics* 34(2): 237–289.

Fauconnier, G. 1994. *Mental Spaces: Aspects of Meaning Construction in Natural Language.* Cambridge: CUP.

Howlin, P., Baron-Cohen, S., and J. Hadwin. 1998. *Teaching children with autism to mind-read. A practical guide for teachers and parents*. Chichester: Wiley.

Kamp, H. 1981. A theory of truth and semantic representation. In J. Groenendijk, Th. Janssen, and M. Stokhof (eds.), *Formal Methods in the Study of Language*, 277–322. Amsterdam: Mathematical Centre Tracts.

Leech, G. N. 1983. *Principles of Pragmatics*. London: Longman.

Maier, E. 2016. Attitudes and mental files in DRT. *Rev. of Phil. Psychology* 7: 473–490.

Oishi, E. 2016. Austin's Speech Acts and Mey's Pragmemes. In K. Allan, A. Capone and I. Kecskes (eds.), *Pragmemes and Theories of Language Use. Perspectives in Pragmatics, Philosophy & Psychology* 9, 335–350. Switzerland: Springer.

Peeters, T. 1997. *Autism. From Theoretical Understanding to Educational Intervention*. London: Singular.

Pellicano, E. 2011. Psychological models of autism: an overview. In I. Roth and P. Rezaie (eds.), *Researching the Autism Spectrum,* 219–265. Cambridge: CUP.

Stalnaker, R. 2002. Common ground. *Linguistics and Philosophy* 25: 701–721.

Szeteli, A., Alberti, G., Kleiber, J., and M. Dóla. 2018. The World is Built with our Words to Each Other. In V. Vincze (ed.), *MSzNy-XIV,* 78–88. Szeged: SzTE.

Wellman, H. M., and D. Liu. 2004. Scaling of Theory-of-Mind Tasks. *Child Development* 75: 523–541.

World Health Organization. 1993. *The ISD-10 Classification of Mental and Behavioural Disorders: Diagnostic Criteria for Research* (10th Revision). Genova: World Health Organization.

World Health Organization. 2018. *International Statistical Classification of Diseases* (11th Revision). Retrieved from https://icd.who.int.