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ANNA FILIP
ARKADIUSZ BIAŁEK
MARTA BIAŁECKA-PIKUL
Jagiellonian University
Institute of Psychology

RECURSION AS A COMMON GROUND OF MENTAL, COMMUNICATIVE, AND LINGUISTIC PROCESSES

For nearly twenty years there has been an ongoing debate in international journals concerning the recursiveness of human mental processes. The main instigator of the debate and at the same time the main exponent of the term "recursion" is Noam Chomsky. According to him, recursion is an exclusive property of the syntax of the so-called "internal language of mind" (*I-language*). This conclusion has been contested by researchers claiming that recursion can also be observed in: communication, theory of mind, the syntax of complementation, or pragmatics. The article presents some arguments in favor of understanding recursion as a common ground of all the above phenomena as long as they are analyzed from a developmental perspective, with the dynamics and sequentiality of the constantly occurring processes and changes taken into account.

Keywords: recursion; theory of mind; syntax; pragmatics; development.

Address for correspondence: ANNA FILIP – Jagiellonian University, Institute of Psychology, ul. Ingardena 6, 30-001 Kraków; e-mail: ankaff@gmail.com

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Introduction

Reflection and research on the broadly understood relationship between thought and speech, conducted for a long time in developmental psychology (Piaget, 1923/2005; Vygotsky, 1934/1989; cf. Carruthers, 2002), has recently been strongly dominated by analyses of the relations between theory of mind and linguistic competence, particularly syntax (cf.: Slade & Ruffman, 2005; Villiers & Villiers, 2014). The term "theory of mind" (ToM) is usually associated with the names of Premack and Woodruff (1978), who used it to refer to the capability of attributing (to oneself and to others) internal states not directly observable in behavior but enabling the prediction of behavior. Studies on the development of ToM often concern so-called first-order beliefs (e.g., "He thinks that the ball is in the box") as well as second- and higher-order beliefs ("She thinks that he thinks that the ball is in the box"; so-called more mature ToM). The ability to use them to predict behavior gives ToM a *representational/mental* character and emerges around the age of 4 and 6, respectively (Perner & Wimmer, 1985; Parker, MacDonald, & Miller, 2007; Miller, 2012). Taking place in the first four years of life, and then between the age of 4 and 6, the development of ToM is significantly conditioned by the development of language – particularly syntax (Villiers & Pyers, 2002; Juan & Astington, 2012; Milligan, Astington, & Dack, 2007). Scholars (Villiers, Villiers, & Roeper, 2011) attribute a key role particularly to the syntax of complementation with mental verbs, the command of which predicts more mature ToM (Astington & Jenkins, 1999; Hale & Tager-Flusberg, 2003; Villiers & Villiers, 2014).

The issue of syntactic competence is the most strongly related to the conceptions proposed by Noam Chomsky,[1] whose investigations, for some time now (Hauser, Chomsky, & Fitch, 2002), have focused around a characteristic property of syntactic processes, which make the human language system unique. This characteristic property is *recursion*, also referred to as *recursive property*, which makes it possible to combine individual components in various configurations into a potentially infinite set of hierarchical structures. As linguistic realizations, structures of this kind may take the form of "recursively nested," self-embedded sentences (p. 1577), such as object clauses. As representations – they can func-

[1] A more recent perspective in cognitive linguistics also devotes much space to this issue, but discussing it would go beyond the formal framework of the current paper. We refer the reader to publications such as: Tabakowska, E. (Ed.) (2001). *Kognitywne podstawy języka i językoznawstwa [Cognitive foundations of language and linguistics]*. Cracow, Poland: Universitas; W. Langacker (2009). *Gramatyka kognitywna [Cognitive grammar]*. Cracow, Poland: Universitas, or: J. R. Taylor (2007). *Gramatyka kognitywna [Cognitive grammar]*. Cracow, Poland: Universitas.

tion, for instance, in the form of beliefs about beliefs about beliefs, etc. In both cases, what takes place is so-called "nesting," or "embedding" of one structure in another, and potentially in a third, fourth, and fifth (e.g., "She thinks that she thinks that they think that…"; Dunbar, 2016). Chomsky explains that recursion **processes** should not be confused with their outcomes: syntactic **structures** of complementation realized in language (recursive clauses) or mental representational **structures** (recursive representations/beliefs). Nevertheless, Chomsky's position in 2002 was that it is language and its syntax that constitute the only cognitive plane on which recursion can manifest itself.

The above view as well as the paper in which it was presented became the subject of an intense debate, which has been going on for fifteen years now (Pinker & Jackendoff, 2005; Jackendoff & Pinker, 2005; Tomasello, 2014/2016; Perner & Esken, 2015). However, in the Polish scientific literature it is only mentioned in single texts, mainly in the fields of philosophy and anthropology (Wołkowski, 2010; Wróbel, 2002) as well as linguistics and psycholinguistics (Berko Gleason & Ratner, 2005; Michalik, 2011). Meanwhile, the number of opinions voiced worldwide challenging Chomsky's view is the largest in the field of research on ToM development, devoted to: (1) its earliest manifestations (social interaction research, e.g., Behne, Carpenter, & Tomasello, 2005; Tomasello, 2007); (2) its links with the emergence of the syntax of complementation (studies conducted on normally developing as well as clinical populations, e.g., Schick, Villiers, Villiers, & Hoffmeister, 2007; Banreti, 2010); and, finally, (3) its acquisition and use in communication (analyses based on discussions in the field of pragmatics, e.g., Evans & Levinson, 2009; Levinson, 2013). The developmental approach – focused on the sequence of changes in a process and therefore requiring the observation of its first manifestations, its transformations, and, finally, the emergence of its mature form – may show and explain why, when, and where the signs of recursive mechanisms should be sought, also on planes of functioning other than the purely linguistic one, which Chomsky opts for. Since what is discussed here is a property of *processes*, adopting a developmental perspective makes it possible to follow the dynamics of changes and relations between manifestations of recursion in various forms of behavior, involving different planes of human functioning to various degrees, at various stages of life (cf. Miller, 2011, pp. 7-11). The developmental approach revealed, for instance, that embedding processes manifest themselves in competencies anticipating and/or influencing the development of syntax and inference of beliefs (e.g., Low & Perner, 2012); it enabled scholars to coin the concept of so-called "recursive ToM" (Caillies & Le Sourn-Bissaoui, 2013), whose development is strictly related to

the development of syntactic competence. However, the debate of proponents of the developmental approach in research on ToM development and pragmatics with the theory of recursion (exclusively) in language very seldom addresses the issue of how, in essence, language can or should be understood based on Chomsky's ideas.[2] To begin with, it is worth stressing that our aim is to present arguments in favor of the thesis that a detailed analysis of Chomsky's theory makes it possible to show his opponents' views as complementing it rather than contrary to it.

In the main part of the paper we will discuss the key arguments in favor of the thesis that recursion is the common ground of language, ToM, and interaction, which requires – in the first place – an orderly discussion of the recursiveness of syntactic processes as understood by Chomsky. The aim of the following parts of the text will be, on the one hand, to supplement Chomsky's position with developmental and communicative approaches, and on the other – to relate the findings of research based on these approaches to the theory of recursion in language. A critical summary of the whole paper will show why it is possible to explain the ToM–syntax relationship by referring to the theory of recursion and adopting a developmental perspective.

The recursiveness of linguistic processes

Chomsky's name is usually associated with concepts such as: language acquisition device (LAD), universal grammar (UG), and transformational generative grammar (TGG; cf.: Kurcz, 2011; Berko Gleason & Ratner, 2005). All of them are rooted in the theory according to which humans are equipped with inborn grammatical knowledge, manifesting itself in the ability to build and understand sentences (Chomsky, 1965/1982). Chomsky sees language as a potentially infinite set of **sentences** – grammatically correct sequences built of a finite number components (letters/sounds, words). Even when presenting the first version of his theory (Chomsky, 1957), he stated that generating and transforming them was possible thanks to "recursive devices of some sort" (p. 24), available to the grammar of language but unidentified. In 1965, he provided a more detailed description of the rules (phrasal and transformational) enabling the formation of structures, and their two main types (cf. below) are closely related to the author's distinction between **competence** and performance. This is a distinction between

[2] This may be partly due to the diversity of terms used by Chomsky and to his inconsistent application of these terms, such as: language, linguistic competence, linguistic performance, or even recursion, etc. (cf.: Jackendoff & Pinker, 2005; Wróbel, 2002).

innate mental capacity enabling language acquisition – and language realization: practical use of language in specific situations. Chomsky writes that grammar should provide "a description of the ideal speaker-hearer's intrinsic *competence*," and "linguistic theory . . . is concerned with discovering a *mental* reality underlying *actual* behavior" (p. 4, 1965; emphasis ours).[3] With time, the author reached the conclusion that the essence of universal grammar should be the study of the nature of human faculties (Chomsky, 2000, p. 27) – the position which he elaborated on, for instance, in *The Minimalist Program* (1995) and which allowed him to specify how and thanks to what language structures come into being.

However, already when expanding the theoretical framework of universal grammar, Chomsky focused on the *language faculty*; according to him, what is responsible for the use and comprehension of language is specialized innate capacities rooted in the architecture of the brain. One of them is the so-called "I-language" (internal language), understood as a mental generative procedure responsible for the emergence of linguistic expressions – arrangements with certain phonological, semantic, and other properties. They should be thought of as sets of instructions for two performance systems in which language is embedded. Instructions from the phonological level – the phonetic form of the expression – are aimed at the articulatory–perceptual system, while the semantic level (the logical form) is linked with the conceptual–intentional system. The above distinction refers to **how** the *I-language* works, whereas the distinction pertaining to **what** is involved in its operation is the division of language into the lexicon and the computational system. In order to generate structures, the computational system implements operations such as the *Select* and *Merge* of appropriate components, supplied by the lexicon. Their implementation gives rise to **deep structure**, which is a set of elements representing categories (e.g., phrases and their components – verb, noun, etc.) that are selected from the lexicon thanks to the operations of the computational system. In the framework of the deep structure, the above elements are replaced with appropriate words, and the obtained whole, through transformation, gives rise to various forms of **surface structure**, which in turn is translated into linguistic realizations (spoken or written). The structure generated out of elements of the lexicon and through the operations of the computational system is thus converted into phonetic and logical forms: elements and pieces of information from one level (e.g., deep structure) are matched with elements and pieces of information from further levels (e.g., surface structure, pho-

[3] The following terms occur interchangeably, though not always consistently, in Chomsky's works: "competence / faculty / grammaticalness / linguistic knowledge / I-language" vs. "performance / realization / language use / E-language" ("internal language"; cf.: Chomsky, 1995, 2000).

nological and logical form). Consequently, every linguistic expression constitutes a sequence of representations from particular levels and encompasses also their transformations as well as interrelations. All the sequences described are generated by the I-language, and above all – by the computational component distinguished in it, the essence of the faculty of language.

In 2002, the I-language was further divided into the so-called **faculty of language in the narrow sense** (FLN) – the aspects of language that are specific only to language, and the remaining aspects of language – the so-called **faculty of language in the broad sense** (FLB). The key role was attributed to FLN, which is the mental computational core generating internal representations and linking them with performance systems: sensorimotor (via the phonological form) and conceptual–intentional (via the semantic form). The essence of the functioning of FLN is precisely recursion, making it possible to build a potentially infinite set of expressions from a finite number of components (conceptual elements supplied by the lexicon). Recursiveness was attributed to the processes of **narrow syntax**, as concerning transformations that occur on the way from the deep structure of an expression to its logical form. This means that processes mediating the transfer of the expression thus produced to performance systems, processing and converting it into a linguistic realization, should be recursive too. The consequence of recursion at the I-language level is the possibility of building potentially infinitely long expressions – theoretically, it is possible to expand each of them, for instance by embedding it in another one. However, its realization (performance, e.g. in the form of an embedded sentence "He thinks that . . ."; cf. Hauser, Chomsky, & Fitch, 2002, p. 1571) is affected by FLB limitations – organic (e.g., lung capacity) or cognitive (e.g., memory capacity). Clarifying his views, Chomsky explained that although it was hierarchical (not linear) relations that were crucial to the computational system and its recursive operations, recursion was not to be equated with the hierarchical **structure** of the expression itself or with its realization in the form of a sentence (Fitch, Hauser, & Chomsky, 2005; Hauser et al., 2014). Recursiveness remains a feature of syntactic operations of the internal language of mind, operating on ideas or concepts, which are identified, for instance, with words or expressions at the level of linguistic realization. This means that language understood as a system of verbalized linguistic realizations is a different thing than language understood as the I-language – the abstract mental procedures that underlie linguistic realizations and may (but do not have to) manifest themselves in them.

Chomsky's theory has been the subject of numerous controversies and debates, which focus mainly on recursion understood as hierarchical embedding.

The most extensive debates concern the assumption of language being the only plane allowing the recursiveness of processes and structures – Chomsky believes that **linguistic** thinking influences our entire experience, equating the internal component of the mind with **linguistic** competence and attributing recursion to linguistic competence exclusively (2000; Hauser, Chomsky, & Fitch, 2002). This perspective faces opposition from the sociointeractive and pragmatic approaches, placing emphasis on **communicative** competence. Communicative competence comprises a broader array of means of communication, based on biologically conditioned, uniquely human faculties connected with ToM (cf.: Kurcz, 2011). A review of key conclusions that follow from developmental perspectives and studies will show when, where, and why, according to their authors, it is legitimate to speak of the earliest manifestations of recursive mental processes as well as how their development is related to the development of syntax and verbal forms of communication based on dialog.

The recursiveness of ToM processes

ToM studies may consist in direct and indirect measurement (Low & Perner, 2012). Direct measurement is based on the assessment of children's verbal answers to questions concerning, for example, predictions and explanations of the behavior of another person (story character) based on his or her belief about reality (e.g., false belief, in the case of false-belief tasks, FBT). Indirect measurement makes use, among other things, of the so-called violation-of-expectation paradigm and the assessment of looking times – longer in the case of action or behavior inconsistent with what should be expected. This kind of procedures are used in the study of preverbal infants, with the assumption that looking at activities that someone should not engage in given the knowledge they have (what they have or have not seen) for a longer time is a sign of surprise at behavior inconsistent with the belief attributed to that person. Research results show that even though two- or three-year-old children do not give correct answers in direct measurements, in infants from seven to fifteen months of age longer looking times are observed in the case of looking at activities inconsistent with the doer's knowledge (Kovacs, Teglas, & Endress, 2010; Onishi & Bailargeon, 2005). There are two leading but opposing interpretations of this discrepancy. According to one of them, mental processes necessary to attribute beliefs to other people take place even at very early stages, but children cannot fully use their effects due to limitations connected not so much with the content of their knowledge as with other cognitive competencies or task requirements preventing the manifes-

tation of that knowledge (cf.: Coull, Leekam, & Bennet, 2006; Read, 2008). According to the second interpretation, the difference stems from the operation of two distinct cognitive mechanisms responsible for the correct performance of verbal and nonverbal ToM tasks (cf.: Schneider, Nott, & Dux, 2014; Heyes, 2014). In the latter case, the fact that children do not give correct answers to FBT questions until the age of four is interpreted as a sign of the functioning of so-called explicit ToM – fully conscious thought processes, which translate into declarative knowledge about subjective goals and intentions underlying subjective beliefs and guiding behavior. Its developmental antecedent is considered to be implicit ToM, which – especially according to representatives of the so-called "cognitively rich" interpretation of the competencies that make it up (cf.: Białek & Filip, 2013) – is recursive (cf. Tomasello, 2014). The phenomena attesting to this include the recognition and sharing of intentions, role reversal, or the performance and understanding of pointing gestures gestures, which conditions participation in situations of communication and cooperation as early as between 12-14 and 18 months of age.

And so, it is believed that as early as 9-12 months of age infants understand other people's intentions in terms of internal representations of desired goals guiding behavior (Carpenter, Nagell, & Tomasello, 1998). What is more, they are able to use this understanding in their own behavior – e.g., differentiating behavior according to whether a person is **unable** or **unwilling** to give them a toy (Behne et al., 2005). Intention recognition is considered to be a precondition of joint engagement – a situation in which the individuals participating in it share the knowledge of experiencing it together (Tomasello, 2007). It is the basis for the emergence of the ability and motivation to share intentions – which are crucial to communication and cooperation because they also make it possible to understand the complementariness of the roles of the communicating or cooperating parties. Studies on the above competencies show that at the age of 12-14 months, based on the previously played game of hiding and seeking an object, infants correctly interpret an adult's gesture as suggesting the places where the object is hidden (Behne, Carpenter, Call, & Tomasello, 2005); the infants themselves indicate the object sought by the adult more often if they previously saw that the adult did not notice where the object fell (Liszkowski, Carpenter, & Tomasello, 2008). This means they distinguish behaviors devoid of communication intentions from behaviors not devoid of such intentions. According to the researchers, the fact that between the age of 12 and 18 months children tend to alternately adopt their own and another person's roles in joint activity attests to their understanding of both roles and to their having a kind of "bird's-eye view"

of the whole situation – within the framework of representation created from the third-person perspective (Carpenter, Tomasello, & Striano, 2005). According to this "cognitively generous," "mentalistic" interpretation, already at the stage of the development of implicit ToM children engage in recursive, embedded reasoning involved in shared intentionality (e.g., "You can see than I can see..."). We sometimes speak of "we-intentionality" here, implying that individuals **jointly and recursively** (as cited in Perner & Esken, 2015) take into account each other's representations of final (desired) states. For instance, performing/interpreting a gesture pointing to the place where the object is hidden is tantamount to children passing on/interpreting the following intention: "I want you to know that the object is still in place X." This means that, already at one year of age, they use implicit ToM for recursive reasoning such as "Y wants me to know that X" and for the evaluation of their own behavior from Y's perspective – "[I think] Y wants me to think that X." It is believed (Tomasello, 2014/2016) that only humans are capable of recursive inference about other people's and their own intentions – of interpreting other people's internal states with regard to their own internal states and, on that basis, of coordinating joint activities involved in communication and cooperation. This enables them to represent the same situations/objects from different perspectives as early as the preverbal stage of development. It can be suspected that the emergence of language productions, particularly object clauses, makes it possible for the recursive ToM competencies present already at the beginning of the second year of life to become explicit (through linguistic realization). The recursive property of very early mental processes begins to manifest itself also in syntax.

When attempting to reconcile Chomsky's theory of recursion with the generous interpretations of implicit ToM, it is therefore legitimate to treat syntactic realizations in the form of object clauses with a mental verb as the verbal reflection of the recursive mental I-language, used in communication, interaction, and cooperation already at the preverbal stage of development. Interestingly, studies on the further development of relations between language and *explicit*, recursive ToM show that it is mainly the ability at the level of linguistic realization, consisting in using and remembering embedded object clauses, that makes it possible to predict results in false-belief tasks (FBT; Villiers & Pyers, 2002). Children's acquisition of the syntax of complementation is sometimes equated with a qualitative change in their ToM (Villiers, 2007, 2014).

The recursiveness of ToM processes and the recursiveness of syntax

Based on a meta-analysis of the results of 104 studies devoted to the relations between language abilities and ToM, it was found that syntax was a significant predictor of the development of false-belief (FB) understanding and cheating (Milligan, Astington, & Dack, 2007). The key role is attributed to object clauses, introduced by verbs referring to epistemic states ("He thinks that …").[4] The distinctive feature of this type of structures is considered to be embedding, enabling the expression of attitude towards the proposition about reality that one is delivering – propositional content (e.g., ". . . the Earth is flat") is distinguished from propositional attitude (e.g., "He thinks that . . ."). This makes it possible to consider the topic (the subordinate clause) in relation to the person (the subject). An object clause has, so to speak, a distinct "point of view" (PoV; Villiers, Villiers, & Roeper, 2011), dependent on the main clause.

Studies of children aged 3 to 5 years prove that there are strong links between understanding, remembering, or training the use of object clauses and ToM development, the direction of influence usually being from syntactic structures to theory-of-mind competencies (Lohmann & Tomasello, 2003; Hale & Tager-Flusberg, 2003). According to the authors, the fact that it is object clauses that are predictors of ToM development shows that syntactic embedding is a "tool" for the emergence and production of recursive representations that a more mature, recursive ToM is based on (Stone & Gerrans; 2008; Caillies & Le Sourn-Bissaoui, 2012). Studies devoted to it usually concern the so-called second-order representations – mental states relating to other mental states. They emerge around the age of six (e.g., Naito & Seki, 2009), and at the level of linguistic realization they can be expressed in the form of an embedded sentence following the pattern of "He thinks that she thinks that X." What is crucial here is the embedding of accounts (points of view) within the framework of one structure with a growing level of complexity, which is precisely what object clauses make possible (Villiers & Villiers, 2012; Schick et al., 2007). They serve as the so-called "representational format" (cf. Villiers, 2014), which – as soon as it becomes accessible – enables performing increasingly recursive mental processes. On the other hand, critics of the tasks used for the study of these processes (FBT) claim that their correct performance sets high linguistic requirements for subjects to meet (cf. Bloom & German, 2000). In essence, verbalizing behavior interpretations relating to someone's thoughts, thoughts about thoughts, etc. re-

[4] Memory of object clauses explains 44% of variance in FBT scores.

quires high passive and active linguistic competence – comprehension and construction of a complex object structure with a mental verb. Scholars therefore argue that all we can say is that the syntactic skills which occur earlier in the course of development predict the syntactic skills occurring later. In an attempt to refute this criticism, advocates of treating syntax as a mechanism of qualitative change in ToM development additionally cite the results of studies with adult samples – normal as well as clinical populations.

The procedures applied in experimental studies with normal adults included the dual-task procedure – a task simultaneously engaging the participants in two activities (Newton & Villiers, 2007). One of them was repeating the dialog (vs. beating out the rhythm) simultaneously heard in the headphones, and another one consisted in following the course of a silent situation, based on which, at the end, a question was asked about its protagonist's false belief (FB). The fact that it was in the dialog condition (not in the rhythm condition) that more wrong answers were given is explained as stemming from the lack of access of ToM to the recursive processes of the I-language – needed for the processing of a FB in a story (even a silent one) and already engaged in the simultaneous repetition of a conversation (cf. Villiers, 2014). This is another argument in favor of recursiveness as a common property of mental and verbal processes. First of all, engagement in dialog repetition in a dual task results in a lack of access to the mental mechanisms that make it possible to capture a given content (belief) in relation to the subject/subjects, which – as has already been mentioned – is also a function of the syntax of complementation with a mental verb. Probably, mental representation of relatedness not only requires recursive I-language processes but also is supported by the outcomes of their activity from the performance level – namely, sentences. It turns out that even the processing and remembering of visual stimuli, whose similarity is based on the relations between their components,[5] improves or declines depending on whether or not the participants in the study are allowed to use language when processing them (as cited in: Villiers, 2014). This was found based on studies of adults, who did not remember the relations when they simultaneously performed a task engaging language processes as well as based on the improvement of remembering in four-year-olds who helped themselves with a language instruction in the form of a sentence. The structures of complementation making it possible to convey the content of a sentence in relation to the subject are not only linguistic competencies allowing a person to verbalize the answer – its correctness is a sign of access to the new

[5] E.g., black behind gray; red to the left and green to the right.

representational format that these structures provide. This position is additionally supported by studies on ToM in patients with aphasia, who have lost some of their language faculty in adulthood rather than before (Siegal & Varley, 2006; Banreti, 2010). Faced with a question about someone's thoughts/words, instead of using an object clause, they answer by means of *statements with "theory of mind" type embeddings* (Banreti, 2010). These are direct speech structures in which, instead of an object clause, a mental verb introduces a clause in the first-person form: a kind of "quotation" of another person's words.[6] This encouraged authors (Apperly, Samson, Carroll, Hussain, & Humphreys, 2006; Siegal & Varley, 2006) to conclude that syntax was a "scaffolding" necessary for the emergence of cognitive representation, enabling inference about the mind. In their opinion, once acquired, this competence would no longer be dependent on linguistic realization as a way of expressing that which – thanks to access to it at a certain level of development – can still be accurately represented in the mind. This is the way to understand, among other things, the fact that some individuals with aphasia can solve nonverbal second-order ToM tasks.

It is possible that individuals with aphasia use certain compensatory strategies (Banreti, Hoffman, & Vincze, 2016), which still consist in embedding, but this time in perspective embedding, not necessarily accompanied by object embedding. The use of these "repair strategies" depends not only on the available levels and potential substitute forms of representation but also on the available knowledge about social contexts and the pragmatics of communication situations (cf. pp. 18-19).

Recursion in pragmatics

Among Chomsky's opponents there are developmental psychologists (e.g., Tomasello) as well as researchers postulating that recursiveness is also a feature of complex, hierarchically structured intentional actions/behaviors (Vicari & Adenzato, 2014). Plenty of novel contributions have been made to this area by studies on the relations between human sensorimotor system, linguistic system, and other sociocognitive processes, including ToM (Goldin-Meadow, 2006; Knoblich, Butterfill, & Sebanz, 2011; D'Ausilio, Maffongelli, & Fadiga, 2013). They use neuroimaging and other techniques and show, for instance, that hearing words or sentences denoting specific actions modulates the activity of the motor cortex in hearers (e.g., "raise"/"kick" stimulates areas activated during actions

[6] E.g., instead of "She thinks that she weighs a lot" – "She thinks that… *My Goodness! How much!*" (Banreti, 2010, p. 911)

engaging the hand/foot, respectively). Interestingly, action idioms ("to kick the bucket") and indirect utterances illustrated with a picture associated with an action (e.g., "It's hot in here" plus a picture of a closed window) stimulate not only the corresponding motor areas but also those that are active during ToM tests (cf. e.g., Hauk, Johnsrude, & Pulvermüller, 2004; Raposo, Moss, Stamatakis, & Tyler, 2009). It is therefore not surprising that the increasingly influential approaches are focused on *co*-operation – on social situations and interactions characterized, among other things, by the diversity and numeric disproportion of verbal and nonverbal behaviors, their participants and the contexts in which they take place, or the means of communication used (cf.: De Jaegher, Di Paolo, & Gallagher, 2010). Anyway, language–mind–action links are an important topic in classic theories, both developmental (Piaget, 1971; Szuman, 1968) and pragmatic (Austin, 1993; Searle, 1986/1995).

In adults, cooperative communication, including the ability to represent and to adopt a perspective, can take the form of conversation based on dialog. The relations between interlocutors' utterances[7] can be based on the mechanism of multiple embedding (Levinson, 2013). This refers, for instance, to "question + answer" sequences, where the effectiveness of the exchange is determined by access to additional information, as in the following example:

Question (Q): Are there any slots left?
Answer (A): Yes, there are. When would you like to come in? **(Q1)**
Q2: What times are available?
Q3: Do you prefer weekends or weekdays?
A3: Weekends.
A2: Then it could be tomorrow morning or any time next Sunday.
A1: Then let it be Sunday, at the same time as today.

Two question–answer pairs are additionally embedded in the Q1-A1 sequence, also based on the mechanism of recursion – pair Q3-A3 is embedded in pair Q2-A2, and the answer to question Q1 is conditioned by the information obtained in A2, which in turn is conditioned by the outcome of the Q3-A3 exchange. As in the case of cooperation of 12- to 18-month-olds, the alternation and complementariness of roles as well as the tendency to share communicative intentions make it possible here to identify the recursive relations – the assumption being that the accuracy of these identifications conditions the achievement of the common goal (making an appointment). According to Levinson, this kind

[7] It is assumed that the unit of linguistic competence is a sentence, and the unit of communicative competence is an utterance (Gajda, 2003).

of "pragmatic embedding" argues for treating recursion as manifesting itself to the greatest extent in *language use*. The advantage of conversational (as opposed to syntactic) recursion is the possibility of achieving more complex, multiple embeddings – much more effectively processed than elaborate recursive linguistic realizations. For comparison, a syntactic counterpart of the above example of triple embedding in a "question + answer" sequence, which can be illustrated as Q1[Q2[Q3A3]A2]A1], would be a sentence such as: "The rat the cat the dog chased bit ate the cheese" (Berko Gleason & Ratner, 1998, p. 238), presented as A1[B1[C1C2]B2]A2. This, however, is not a fully adequate comparison – conversation, just like its gradually emerging structure, is, in spite of everything, an interactive process; utterances are closer in this case to complementary joint actions (Searle, 1969/1987; Clark, 1996), divided among several participants. Consequently, in the case of dialog, the effectiveness of embedding can be additionally enhanced by the cooperative communicative context: the more abstract – abstracted from this context – recursive reasoning is, the greater difficulties in appropriate interpretation can be expected (Levinson, 2013, p. 158). Still, in both cases we are dealing with the processual, recursive emergence of a structure: interactive – because it concerns conversation; intrapsychic – because it concerns reasoning about the intentions and mental states of participants in dialog, making use of the representational sentence format.

When examining the criticism of Chomsky's view in sociocommunicative and pragmatic approaches as well as research on the relations between syntax and ToM, one may have the impression that their authors tend to equate language mainly with linguistic **realizations** (sentences, utterances). This sometimes leads to erroneously equating recursiveness **processes** with their outcomes, which may be linguistically realized embedded syntactic **structures**. However, it is the developmental perspective of Chomsky's critics that reveals the multiplicity and diversity of the manifestations of the recursiveness of the I-language and its links with other planes of human functioning, including the dynamics of the changes taking place in them.

Conclusion

Syntax undoubtedly makes it possible to capture recursive mental phenomena in language, but it cannot be excluded that they occur even before the appearance of the ability to *realize* recursion in the form of object clauses. Object clauses may in turn constitute a "scaffolding" for a more mature recursive ToM, providing qualitatively new means of representation. The above findings, however, are not contrary to the postulate of recursion as a property of I-language

processes – developmental approaches make Chomsky's theory more specific by showing how and when the recursive syntax of mind can be combined with a broad spectrum of competencies in the field of communication, social cognition, or linguistic performance and pragmatics.

The presented review of theoretical approaches and research results refines and deepens the characterization of the processes that link speech and language with thinking, primarily because it demonstrates how the I-language mechanisms postulated by Chomsky are reflected in various sociocognitive phenomena. The recursive processes of combining elementary conceptual units lead to the emergence of an internal recursive structure of an expression and make it possible to "translate it" into the recursive external structure of a sentence. Therefore, if we assume that conceptual units are representations, just like goals (cf.: *The recursiveness of ToM processes*), then the internal recursive structure of the I-language corresponds to the representational third-person account of intentions and perspectives in cooperation and communication. If this is the case, then the attribution of recursive mental processes to children who do not use language yet is not at odds with Chomsky's theory at all. Treating *narrow syntax* as recursive operations on representations (e.g., goals), specific to the mental computational system (FLN), we may venture to state that implicit ToM is a special way of using the I-language and its syntax in cooperative communication, contributing to the development of the earliest verbal realizations. Thus understood, language would be a kind of representational "matrix" that enables and facilitates the forms of complex reasoning observed in children aged between 10 and 20 months as well as in adults, conditioning increasingly sophisticated recursive ways of thinking involved in functioning on increasingly numerous and diverse planes as the person develops and gains experience.[8] For Chomsky, language is the product of two factors: innate LAD and experience. LAD uses experience as *input* data and yields *output* data – which, however, are represented in the mind/brain from the beginning (Chomsky, 2000, p. 4). Developmental research on the relations between implicit ToM and language acquisition shows that dividing attention in a triad (month 9-12) allows children to establish the appropriate relationship between the referent and its name, thanks to which they learn the first words (Tomasello, 2000). It is possible that one of the functions of implicit ToM is to link the referent with the word using the recursive mental syntax of the I-language in interaction. Interestingly, the results of studies of children already

[8] Cf.: the conception of language as an additional representational format ("mental scratchpad") as well as the faculty of storing information in a linguistic format and manipulating this information (Fedorenko & Varley, 2016).

using speech show that they establish the meanings of words belonging to different grammatical categories based, among other things, on syntactic clues (Bloom, 1996/2007).

Developmental research (Milligan et al., 2007) has shown that syntax (mainly the syntax of complementation with a mental verb) is a predictor of explicit ToM development. Experiments with adult participants suggest that the access of ToM to recursive I-language processes is crucial for the possibility of processing at the level of representations even in the case of nonverbal FBT (Newton & Villiers, 2007). This means that the lack of access to the representational linguistic format makes it impossible to think about the mental processes leading to the formation of beliefs about reality. The view of object embedding as providing ToM with a "representational tool" (Villiers, 2007) is supported by research results obtained for clinical groups. The fact that inference about the mind may take place despite the inability to linguistically express the inferences in the form of object clauses argues in favor of treating the "syntax of complementation – explicit ToM" relationship as linked with the process of development (cf. Siegal & Varley, 2006). At some stage of this inference, implicit ways of reasoning may be "rewritten" onto a qualitatively new pattern, which makes it possible to use them in complex operations of explicit ToM (cf. Karmiloff-Smith, 1992; Tomasello, 2002, p. 264). Language understood as the I-language is not involved in them – when it becomes inaccessible, these operations are disrupted, but the loss of the possibility of expressing their effects in the form of object clauses need not affect the validity of reasoning. The attribution of recursive properties to the above pattern, made possible its reinterpretation according to Chomsky's theory, makes it possible to explain why partial loss of speech in adulthood not necessarily impoverishes the complexity of thought processes. This is attested to, among other things, by the repair strategies of "perspective embedding" found in some patients with aphasia.

Also conversation can be looked at through the lens of establishing and adopting perspectives. The emergence of its embedded structure, with an appropriate hierarchy of participants' interrelated utterances, is the outcome of the processes of establishing the relations between roles and goal representations. The competence of ToM here would be the use of the syntactic mechanisms of the I-language for parallel coordination of several/many perspectives. It has been demonstrated (Levinson, 2013) that in conversation it is possible to identify higher levels of embedding than in linguistically realized syntax. It should be remembered, however, that according to Chomsky's theory recursion also concerns procedures connected with transferring expressions to the executive sys-

tem, and that such realizations are influenced by limitations from the level of the faculty of language in the broad sense (FLB). In cases when realizations take the form of compatible pairs divided between the participants in a dialog, what happens can be more accurately described as alternating emergence of individual segments making up the entire complex recursive structure. This may as well attest not so much to the conversational "advantage" of recursion as to smaller burdens/limitations imposed by FLB in situations of this kind of interactive application of recursion.[9] Nevertheless, in a verbal sentence, normal adults are capable of reasoning about a perspective embedded up to the fourth or even the fifth order (Dunbar, 2016).

To sum up, the statement that linguistic conceptual combinations enable us to represent various subjects and situations (Tomasello, 2015, p. 201) seems to be a valid description not only of syntactic realizations but also of the internal language. Looking at the recursive I-language from a developmental perspective, supplementing its theory with the communicative and pragmatic approaches, and at the same time supplementing these approaches with its theory makes it possible to understand why we can speak about recursion both in the context of the earliest manifestations of cooperative communication and in the context of complex verbal syntax as well as mature ToM or pragmatics. Recursiveness as a property shared these phenomena – characteristic of these processes and/or structures – additionally reveals how language supports the emergence of increasingly complex thought processes, particularly those involved in reasoning about the social world. In this perspective combining various theories and research approaches, recursiveness can be considered as a common ground of the competencies listed, and syntactic realizations can be considered as a mechanism leading to a change in the way of using the I-language in inference about mental states.

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[9] It cannot be excluded that certain complex language structures derive from realizations originally divided between participants in dialog (as cited in Levinson, 2013).

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