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LANGUAGE IN TYPICAL DEVELOPMENT AND AUTISM: SOME IMPLICATIONS FOR TREATMENT

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ABSTRACT

Language acquisition, both in typical development and in autism, depends on a complex interweaving of predis-positions and experiences and on the progressive improvement of motor skills that, increasingly refined, play an important role in forming new neuronal connections necessary for language development. The inability of chil-dren with autism to integrate all these skills may cause them difficulties in understanding and expressing them-selves through speech. These difficulties are often addressed using highly structured strategies that do not easily promote generative responding; they can be used to teach specific responses rather than generalized repertoires.

In this article, we provide a summary of research on language in typical development and autism, with a focus on morphosyntax, Relational Frame Theory and their possible implications for language treatment.

Keywords: Language, Morphosyntax Learning, Autism, Relational Frame Theory.

1. INTRODUCTION

As we have seen, language acquisition depends on a complex interweaving of predispositions and experiences and on the progressive building of movements that, corrected and refined, exert an important role in forming neuronal connections, conditioning learning, and underlying language. Studies on the relationship between brain areas and language indicate that the areas of the cerebral cortex that process sensory information and control movements are also involved in different aspects of brain organization (the structure of sensory and motor circuits, processing mechanisms, representation, etc.:): for example, phonetic and grammatical structures could have evolved based on the perceptual and motor systems of the brain and would have adapted to the brain structure rather than representing an autonomous adaptation. In other words, the language system relies on complex coordination with other systems and brain areas related to object representation, perception, and motor skills. The inability of some children, including those with autism or other intellectual disabilities, to integrate all this information could be the cause of their difficulties in understanding and expressing themselves through speech. It is no coincidence that a conspicuous motor deficit always corresponds to a very marked difficulty at the level of expression (dyspraxia) (Guenther, 2016).

2. A brief description of typical language development

The individual is born with a highly structured sensory organization capable of actively selecting stimuli from the environment through a variety of channels (visual, tactile, and so on) and possesses a complex signaling system based on elements such as, for example, smiling, crying, vocalization, or non-food sucking. Among these signaling systems, crying takes on a communicative function through the repeated association between crying and the rushing of an adult (responsive conditioning) (Murray, Eardley, Edginton, Oyekan, Smyth & Matusz, 2018; Oller, Caskey, Yoo, Bene, Jhang, Lee, Bowman, Long, Buder, Vohr, 2019; Maitre, Key, Slaughter, Yoder, Neel, Richard, Wallace & Murray, 2020).

Thus, prelinguistic communicative development is characterized by two stages: 1) pre-intentional stage, in which the child produces behaviors (crying, smiling, vocalizing, etc.) that may take on the value of signals for the adult interlocutor but do not yet have this value for the child (e.g., when the infant initially cries because he is hungry and the mother rushes to feed him: the mother has no doubts in interpreting the crying as a need for help or hunger gratification and acting accordingly, but the baby is not aware at first that it is producing a communicative signal; it will be so only after the mother's crying-presence association is established); 2) intentional phase, in which the infant knows that he is producing behaviors that have signal value for him and produces them in order to meet his own needs (e.g., the infant who turns his head left and right in search of the breast, opens his mouth, sticks out his tongue, if he is not satisfied and fed will start crying (intentional behavior) until the mother intervenes to feed him, correctly interpreting the crying as a request (Camaioni, Volterra & Bates, 1986; Camerom-Faulkner, Malik, Steele, Coretta, Serratrice & Lieven, 2021).

The basic elements of language acquisition are present from the earliest weeks, partly because the human auditory system is already substantially mature at birth, beginning to function in the mother's womb as early as around the 30th week of gestation. The ability to discriminate and recognize acoustic stimuli has been evidenced in the first 2-3 days after birth; at 2-3 weeks, infants can extract phonological units, i.e., distinguish very similar phonemes (e.g., “ba”, “pa”) and, as early as the second day of life, the vowels ‘a’ and ‘i’ (Michnick Golinkoff & Hirsh-Pasek, 2000; Wu, Hou, Peng, Yu, Oppenheim, Thierry & Zhang, 2022).

Infants prefer parental speech over strangers, preferring maternal speech as early as three days old. This may result from learning acoustic stimuli of maternal origin as early as the last months of the fetal period. The number of words a child hears is one of the most influential factors in language development (Bergelson, Soderstrom, Schwarz, Rowland, Ramírez-Esparza, Hamrick, Marklund, Kalashnikova, Guez, Casillas, Benetti, van Alphen & Cristia, 2023).

Prelinguistic vocalizations, already present at birth, evolve about developing motor control of the muscles responsible for articulating sounds. Around 3-5 weeks of age, the ability to cry for attention is accompanied by the repetition of sound-like vowels (“00000h”, “AAAAAh”) usually associated with states of satisfaction. At 3-4 months, there is an increase in sound production capacity with consonant sounds. At 4-6 months, acquiring these vocalic sounds makes possible babbling, which is unrelated to the development of the phonatory apparatus, depending, instead, on central cognitive structures (Albert, Ernst & Vallotton, 2023).

Language acquisition begins very early, initially based on a phonological-syllabic analysis of speech that provides the child with information about the grammatical structure of the language that is basic to learning processes (Jusczyk, 1997). Very early on, therefore, infants develop a sensitivity to the prosodic properties of the language they are exposed to, which will later extract information about the units into which to segment language. Until five months of age, the sounds uttered by infants are quite similar across languages and only later do they differ according to the environment (the appreciation of their mother’s typical pitch precedes that of their first words): between seven and a half and ten months, infants begin to identify words in speech using a composite set of indices (this ability grows until two years of age when infants segment words in a manner quite similar to adults) (Vallotton & Albert, 2024).

We have seen that the initial abilities to discriminate, categorize, and extract regular patterns from acoustic stimuli are put very early in the service of language learning: the perceptual structure of language is determined by rhythmic indices, already audible in utero and acquired very early (Martinez-Alvarez, Benavides-Varela, Lapillonne & Gervain, 2023).

In the first year of life, the child begins to speak by employing the first holophrases, single words used to communicate an entire message (Tomasello, 2003; Hantman, 2011). The child’s vocabulary varies about age: initially, it takes 3-4 months to acquire 10 new words, while from 18 months onward, the time needed decreases radically so that by 2 years of age, the child already possesses several hundred words, mostly referring to objects.

Around 18-24 months, the child produces his first sentences by combining 2-3 words through a “telegraphic language” characterized by the absence of elements such as the article, prepositions, and auxiliary verbs, and with a grammatical structure based on ‘pivot’ words, always put in the same position and never combined with other words of the same type, and ‘open’ words, less frequent and of variable position (McNeill, 1979; Gleason & Ratner, 2024).

The child who has thus learned to speak can produce a wide variety of messages by combining a limited number of basic units (phonemes and words) of that language. In addition, in language, meaning cannot be derived from the form of sound and, therefore, must be learned and transmitted culturally from one generation to the next (arbitrariness). So, knowing how to speak means using language in a way that is grammatically correct and contextually appropriate: when and where to speak, to whom, about what, and in what way (Marini, 2018).

3. The learning of morphosyntax

The scientific community (especially linguists and psychologists) has asked for years whether language is innate, i.e., genetically determined or acquired. However, few people would deny that the brain structures dedicated to language processing are innately given (Gazzaniga, 2008). In fact, the learning/inborn debate is essentially about the question of 'whether grammatical or morphosyntactic representations are genetically prefigured or learned ex novo'.

The greatest historical proponent of language learning was Skinner (1957) with his book 'Verbal Behavior' (VB). In a manner completely alien to most linguists, Skinner classified verbal behaviours according to their control variables. Some verbal behaviours are responses to various stimulus properties of objects, people or events, others are verbal chains, and others are responses to context. Skinner also argued that verbal com-portions are learnt through operant conditioning and maintained by generalized social reinforcement.

Skinner's theory was harshly criticized by an unknown linguist at the time, Noam Chomsky. Chomsky (1959) denied VB any explanatory value for human languages. He argued that concepts such as stimulus, stimulus control or response strength were inadequate to explain human behaviour if extrapolated from the animal laboratory. Chomsky's review repeatedly pointed out important shortcomings in behavioural journals (Palmer, 2006).

In the following decades, Chomsky continued to model morphosyntax with abstract formal rules. His theories were modified several times, becoming technically more complex and psychologically less plausible over time (Rondal, 2018).

On the learned/innate question, Chomsky (1986) suggested that the basic grammatical aspects present in all languages are encoded in the genes of Homo sapiens. Bickerton (1984) added that triggered by exposure to language; genetic information is transferred to brain structures that control grammatical acquisition. This hypothesis, dubbed 'Representational Innateness' (RI), has been uncritically promoted by several psycholinguists (Pinker, 1994).

Furthermore, deciphering the language code, syntactically and morphosyntactically, is a matter of the amount of input. Chomsky has always denied this point, claiming, for example, that children who acquire language only have a minimal amount of input. But this claim was 'political': he intended to minimize learning and maximize representational nativism and its supposed genetic basis, which long ago might perhaps have been considered a reasonable suggestion. However, with the advances in molecular genetics and genetic work on developmental language pathologies, representational nativism does not exist (Piantadosi, 2023).

Moreover, Chomsky always tries to confuse representational nativism with cerebral (organic) nativism, i.e. the fact that thanks to a particular genetic imprint (this time biologically real), the human brain is endowed with organic linguistic structures that mature with development but are already functional very early in life (e.g. the peripheral auditory apparatus and dedicated brain structures are fully functional already 3 months before birth). Language input already begins at that time. The brain structures are initially devoid of any grammatical content. They gradually acquire it from the input (a rather consistent input over time: millions of utterances) (Rondal, 2017).

Yet, despite impressive advances in molecular genetics, the genes encoding grammatical representations have not been identified to date. However, two genes sometimes labelled as 'linguistic' have been identified: FOXP2 and CNTNAP2.

FOXP2 is an autosomal dominant gene located on chromosome 7. FOX proteins are a subtype of transcription factor that regulates the expression of several genes involved in development (Lai, Fisher, Hurst, Vargha-Khadem & Monaco, 2001). A FOXP2 mutation causes a significant volumetric reduction in the white matter of the striatum, one of the nuclei of the forebrain basal ganglia that is connected to several cortical and neocerebellar brain regions that play an important role in sequential information processing (Vargha-Khadem, Gadian, Copp & Mishkin, 2005). The FOXP2 mutation is clinically associated with dyspraxic, dysphasic and dysgraphic verbal disorders in which marked difficulties in regulating combinatorial expression in limbic, semantic and syntactic tasks are the rule. These difficulties are associated with an under-activation of the brain areas indicated above, as confirmed by neuroimaging studies (Liégeois, Baldeweg, Connelly, Gadian, Mishkin, & Vargha-Khadem, 2003).

The second gene identified as linguistic, called CNTNAP2, is also located on chromosome 7 (Vernes, Newbury, Abrahams, Winchester, Nicod, Groszer, Alarcón, Oliver, Davies, Geschwind, Monaco, & Fisher, 2008). This gene encodes the synthesis of a protein of the neurexin family involved in communication between neurons. It is particularly expressed in the frontal and temporal lobes. A mutation in CNTNAP2 is associated with a range of disorders, including the autism spectrum, Gilles de la Tourette syndrome (characterized by involuntary movements), and delayed and impaired language development.

Therefore, there is a genetic substrate for language, but it concerns the brain processes involved in regulating sequences of events and has nothing to do with grammatical representations.

Recently, among the protagonists of the generative movement, there have been the first indications of a conceptual shift from representations to information processes that might be genetically encoded. Chomsky (1995), in the final version of his theory (The Minimalist Program), already proposed that grammar rests on two pillars: a mental lexicon and a computational component. The former is defined in a way reminiscent of the lexico-grammatical account of earlier generative formulations (Government and Binding, Chomsky, 1981). The computational component operates through a dual process: moving (displacing) and merging (mixing). Merge replaces a pair of syntactic objects with a higher-ranking binary structure (e.g., an article and a noun to form a noun phrase; a subject and a verb phrase to create a sentence).

Berwick and Chomsky (2016) hypothesize that the Merge is the evolutionary result of a rewiring of Brodmann's areas 44 and 45 in the ascending frontal circumvolution of the left cerebral hemisphere (the so-called Broca's territory), some 60,000 years ago at the dawn of Homo sapiens.

Fitch and Martins (2014) proposed a process version of the RI hypothesis named dendrophilia. They argue that the human species is genetically endowed with a sensitivity to temporally ordered hierarchical structures of the kind represented in the tree diagrams of structural linguistics (for a mathematical treatment of hierarchical structures applied to biological systems and language, see Guazzo & Tagliaferri, 1988). The human attitude to syntax, according to Fitch and Martins (2014) is based on this propensity. Noting that the same hierarchical aptitude is at work in music and in planning motor acts beyond simple reflexive actions, Fitch and Martins recommend abandoning the notion of syntax specificity.

Morphosyntax, then, can be regarded as the projection of semantic relations between words and parts of words (grammatical morphemes) onto the surface of the sentence according to the arrangements of the various languages. Relational semantics is based on lexical semantics, from which it differs; in fact, it can be seen as a structure that incorporates the meaning relations between words and groups of words in the sentence.

Several semantic-relational theories have been proposed. According to Chafe (1973), the most productive semantic relationships in natural languages proceed from structural associations between verbs and nouns (Van Valin, 2003): agents are the animate entities responsible for actions and patients (both animate and inanimate) are entities in a particular state or affected by an action or process. Basic relations can be combined to form complex semantic networks that are not naturally ordered. Their lexical realizations are linearized in the sentence surface according to the morphosyntactic exposition of the language.

For example, ‘My wife borrowed my mobile phone to call her hairdresser’. This sentence operates from the following semantic relations: agent-action-process-patient, which lexicalized and linearized results in ‘The wife took the mobile phone’. It expands with the expression of two possessive indications (‘My wife’, ‘My mobile phone’), morphosyntactically specified by time and aspect (the ‘near past’ informing that the wife is still in possession of the mobile phone at the time of the elocution) and followed by a completive infinitive expressing the reason for the borrowing and the objective of the borrower. The latter sequence realizes an agent-action-process-patient relationship with the agent unexpressed but probably being the wife herself since the hairdresser is said to be 'his' (in the sense of 'custom).

The semantic-morphosyntactic model illustrated above suggests a left-to-right treatment of selected words in sentence production.

Chomsky (1957), however, insists that no syntactic device based on left-to-right dependencies between elements, which he likens to a Markovian[1] finite-state grammar[2], can account for the complexity of human grammar. In fact, nothing forces a left-to-right syntax to limit itself to a finite-state grammar. Higher-order Markovian can produce sequences in which element selection and grammatical marking depend on the sequence's preceding or subsequent non-contiguous elements (Manning & Schütze, 1999).

Semantic relations also play a 'buffer' role in compound sentences. A sentence such as 'The man who went to the airport was carrying a heavy duffel bag' expresses two semantic relations: agent-action-process-patient ('The man was carrying a heavy duffel bag') and agent-action-position (direction) ('The man went to the airport'). The first clause is interrupted long enough to insert the second; during the interruption, the first semantic relation is 'held' in working memory, which plays an important role in resuming the course of the first clause. Caplan (1995) documented an interval of at least a few words in speakers' sequential tracking of utterances (McHugh & Reed, 2008).

The precise mechanisms involved in children's morphosyntactic learning are still debated. Ambridge and Lieven (2015) suggest that children begin with holophrases (i.e., syn-group words that express what would typically require a sentence in adult speech) by expanding them into lexical patterns and constructions like those of adults. Children listen to and memorize strings of words such as a ball, the ball, a book, the book, a doggie, the doggie, a man, the man, etc. They then process these specimens to form two 'slot-and-frame' patterns: X and Y. With more linguistic exposure, the slots are enriched with semantic properties (for articles, the contrast between discrete and non-discrete entities) and pragmatic properties (the contrast between specific and non-specific reference).

The acquisition of basic word order follows the same path. From a certain number of stored utterances extracted from the input, children form patterns of the type: action [e.g., Daddy reads (X)] and action-

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[1]The adjective Markovian, named after the Russian mathematician Andrei Markov, describes a particular stochastic process that lends itself to modelling systems that have random behaviour in their evolution as a function of time and have no memory of previous states. It can be characterized either by a set of continuous or discrete states. In the latter case, also called Markov chain, even if the time variable belongs to a discrete set, the dependence always extends only to an earlier time unit (t_{n-1}) (Norris, 1998).

[2]Finite-state grammars are regular grammars that function as abstract computational systems. Starting with a variable on the left and a string of constants with at most one variable on the right, one arrives at a terminal string by applying a finite number of rewriting rules. These grammars have a finite number of internal configurations, each of which implies that the machine is in one of a finite number of states. Each computation begins with the initial state. There is also a specific set of final states to which the string reading must necessarily lead for the input to be accepted (Wall, 1972; Partee, Ter Meulen & Wall, 1990).

process (incomplete) [read newspaper (Y)]. The overlaps between such strings motivate them to integrate the two schemata into one (complete) agent-action-process ('Daddy reads newspaper').

4. Communicative development in the autistic child

Language acquisition in children with autism is characterized by tremendous variation in timing and manner: a minority of children show no significant delay in the onset of the various milestones in language development, while most individuals with autism begin speaking late and develop language at a significantly slower rate than others (Le Couteur, Bailey, Rutter, & Gottesman, 1989). As early as the first year of life, children are less responsive to their names and the sound of their mother's voice (Klin, 1991). By the second year, the communication of most children with autism is severely delayed, both expressively and receptively (Dahlgren & Gillberg, 1989). Parents of children with autism often describe normal language development in their children who then, around 12-18 months, lose it (Kurita, 1985). This ‘language regression’ which is a gradual process in which children do not learn new words and fail to engage in communicative routines in which they might have participated earlier, occurred when children still had relatively small expressive vocabularies and before the explosion of words, also losing some social skills (Lord, Shulman & DiLavore, 2004). Research, however, suggests that individuals with autism continue to make progress in language and related developmental domains well beyond the preschool years; in fact, comprehension and expressive skills continue to improve in these populations throughout adolescence and adulthood, although expressive skills show a greater rate of improvement (Paul & Cohen, 1984). Some children with autism, however, never acquire functional language; this may be due to several factors: IQ < 70%, age of risk diagnosis, initiation of habilitative treatment, quality and quantity of communicative performance (single words, nuclear sentences, spontaneity of communication, repetitiveness, intelligibility). Children who receive earlier diagnosis and thus better access to early intensive interventions acquire more appropriate and structured functional language.

However, the most significant problems in language development and acquisition in individuals with autism are the levels:

- of articulation: complex arrangements of the phonatory apparatus to achieve a given phone that are relatively common in children with low-functioning autism (Bartolucci, Pierce, Streiner & Tolkin-Eppel, 1976).
- of the lexicon: the complex of words and phrases in high-functioning individuals may be a strength, although the acquisition of words that refer to mental states or metaphors may be impaired (Van Lancker, Cornelius, & Needleman, 1991).
- of morphosyntax: the rules that govern the formation of a linguistic utterance by combining morphemes tend to be restricted in individuals with autism who often proceed at a slower pace and is related to developmental level rather than chronological age (Lord & Pickles, 1996).
- of echolalia: repetition, with similar intonation, of words or phrases that someone else has said; both immediate echolalia (turn-taking, affirmations, affirmative responses, requests, rehearsals to aid processing and self-regulation) and delayed echolalia (analyzing the linguistic forms they are acquiring) can serve communicative purposes for the speaker (Prizant & Duchan, 1981);

- of the use of deictic terms: recourse to expressions that, within an utterance, refer to the spatiotemporal situation in which the utterance itself is uttered and to the persons who utter or receive the utterance and are a reflection of the difficulties children with autism have in conceptualizing notions of self and other, as they are embedded in the change in discursive role between speaker and listener; this difficulty, which includes discursive roles, is related to impaired social-communicative functioning, particularly perspective-taking (Tager-Flusberg, 1993);
- of paralinguistics: nonverbal references for language, such as sound pitch, volume, and tone of speech of which people with autism are not only impaired but also have difficulty understanding prosodic information (grammatical, pragmatic, and affective) expressed by others (Merewether & Alpert, 1990);
- of comprehension: the ability to 'grasp' cognitive content; children with autism not only have a limited ability to integrate linguistic input with real-world knowledge but also, in some cases, may lack knowledge about social events used by typically developing children to support emergent language skills and to acquire increasingly advanced language structures (Lord, 1985);
- of pragmatics: contextual use of language about social and cultural conventions governing linguistic communication; children with autism rarely use language to comment, show off, acknowledge the listener, initiate social interaction, request information, and explain or describe events in a conversational context (Ziatas, Durkin, & Pratt, 2003).

In summary, children with autism exhibit verbal and/or social functioning characterized by the following symptoms (McHugh & Reed, 2008):

- delayed or absent spoken language development, often without gestures to compensate.
- inadequate attempts to initiate or maintain conversations (Guazzo, 2023).
- repetitive, stereotyped, or idiosyncratic language.
- the absence of imitative social play or spontaneous or “pretend” play.

Discrete Trial Teaching (DTT) and Natural Environment Teaching (NET) programs have traditionally addressed these symptoms in Applied Behaviour Analysis.

DTT is teaching by short units of instruction, the beginning of which is stimulated by the instructor suggesting correct answers in an increasingly attenuated manner as the learner acquires the skill. Correct answers are reinforced, and the latter is corrected if an error is made. Teaching by discrete trials is an effective method of instruction for individuals with developmental disorders, particularly when provided early and intensively (Guazzo, 2021). It is a highly structured form of teaching, with each response evoked by stimulus conditions in contrived environments and with limited or absent distractions. However, skills taught using DTT can teach specific responses rather than generalized repertoires.

Natural Environment Teaching (NET) is teaching in natural settings (real-life contexts and places) and involves using the child's interests and motivation to promote learning opportunities. The adult appropriately organizes and plans the setting in materials and teaching objectives. The adult, in other words, manipulates motivational operations and exploits the subject's motivation for certain reinforcers to implement curriculum goals; that is, he or she brings, under the control of natural contingencies of reinforcement, new responses or previously acquired responses (Guazzo, 2021; Sundberg & Partington, 1998). This setting, unlike DTT, is particularly suitable for the generalization of learning. Still, it is limited by the fact that the practitioner can work on a goal only as long as the child's motivation persists.

In language learning, conceptual changes have also occurred since Skinner's proposals. An interesting trend is the 'Relational Frame Theory' (RFT), which clarifies some significant aspects of human language, cognition and social behaviour (Hayes, Barnes-Holmes & Roche, 2001; Grayson Osborne, 2003; McHugh & Reed, 2008; Guazzo, 2022).

5. Relational Frame Theory in the treatment of autism

The impact of Skinner's (1957) analysis on verbal behaviour research and application has been rather limited and unsatisfactory (Sautter & LeBlanc, 2006). In fact, many scholars and clinicians have mainly focused on teaching basic verbal operants (mainly Mand and Tact) to children with developmental disorders (Sautter & LeBlanc, 2006). This limited impact may be mainly due to two factors:

1) Skinner's (1957) definition of 'Verbal Behaviour' (which views it as behaviour that is reinforced through the mediation of another organism that is trained by a verbal community to mediate that reinforcement) is too broad because many behaviours are socially mediated in this way, and the definition provides no way to distinguish verbal behaviour from any other social behaviour (Hayes, Blackledge & Barnes-Holmes, 2001);

2) Skinner's (1957) definition is not functional because it includes the behavioral history of another organism (the listener) as a distinguishing characteristic (Hayes, Blackledge, & Barnes-Holmes, 2001), leading to both conceptual and methodological confusion.

The modification to the Skinnerian definition of verbal behaviour led several scholars (Sidman & Tailby, 1982; Hayes & Hayes, 1992; Dymond & Barnes, 1995; Roche & Barnes, 1996; Dugdale & Lowe, 2000) to conduct experimental studies on equivalence classes (Sidman, 1994) and learning arbitrary relations between stimuli that led to an innovative view of human cognition and language, labelled Relational Frame Theory (RFT).

RFT, initially developed by Heyes (1989), argues that the basic element of human language and higher cognitive functions is relatedness, that is, the human ability to create bidirectional relationships between two objects, and further argues that language elucidates not only the strength of a link between two stimuli but also the type of relationship and the dimension along which these two stimuli can be related (Heyes, Barnes-Holmes & Roche, 2001). That is, according to RFT, the definition of verbal behaviour is "the action of framing events relationally", and that of verbal stimuli is "stimuli that have their effects because they participate in relational frames" (Hayes, Fox, Gifford, Wilson, Barnes-Holmes & Healy, 2001; Gross, & Fox, 2001). Thus, both speaker and listener engage in verbal behaviour: the former produces stimuli based on relationally framed events, while the latter respond based on these relationally framed events.

RFT was founded to integrate a wide range of psychological phenomena into a cohesive language and human cognition theory based on contextual relations, identifying and creating, with our capacity for relational responses and connections between stimuli (Cullinan & Vitale, 2009). It is fundamentally based on the idea that relating one concept to another through a network is the foundation of all human language. Despite the strong implication, this does not indicate that 'derived stimulus relations' are language-dependent or language-mediated. When two dependent variables are correlated, a conservative strategy is to determine whether both variables reflect the same underlying psychological process (Törneke, 2017; Presti & Moderato, 2019).

This research aimed to integrate several seemingly disparate psychological phenomena: stimulus equivalence, naming, comprehension, analogy, metaphor, etc., and rule-following. According to RFT, the central element that defines all of these, and many other inherently verbal activities, is the arbitrarily applicable relational response that is treatable as a generalized operant and thus traceable to a training history of multiple examples. Specific types of relational response are defined in terms of three properties (Blackledge, 2003):

- *Mutual entailment*: refers to the derived bidirectionality of some stimulus relations, and as such, is a generalized term for the concept of "symmetry" in stimulus equivalence; if an individual notices that A leads to B, then A will be related to B in his mind, but B will also be related to A: for example, if an individual before going out always has to get a small bottle of water, then going out will naturally make him think about getting a small bottle of water;

- *Combinatorial entailment*: refers to cases in which two or more relations that have acquired the property of mutual entailment combine. "Combinatorial entailment" is the generic term for what is called 'transitivity' and 'equality' in stimulus equivalence: if A is connected to B, and B is connected to C, then A is connected to C and vice versa; for example, if a child is told that 'fib' is another word for 'lie,' and that 'lie' is another word for 'fib', he will be able to make the implicit connection between 'lie' and 'lie' (transitivity). However, transitivity cannot be applied to all forms of relational responses; for example, if line A is perpendicular to line B and B is perpendicular to C, then A and C are equal but not perpendicular to each other (equality);

- *Transformation of function*: is a fundamental consequence of mutual and combinatorial entailment and applies when the functions of one event in a relational network are altered according to the functions of another event and the derived relationship between them: if A and C are related and B, which is related to only one or both of A and C, joins the network, the relationship between A and C may change: for example, a child associates the playroom with a fun experience to share with other children, if one day the playroom educator conspicuously reprimands the child, the relationship between going to the playroom and his or her experience may change.

These three properties enable us to learn and develop new relational networks, representing one of our species' unique capabilities. Indeed, in everyday life, people deal with various objects and can relate to each other in different ways, abstract or formal. People can compare objects based on shape, size, function, value, etc. Therefore, two stimuli can be related based on many of these properties. For example, when we say that a ‘diamond’ is more valuable than a ‘zircon’ or a ‘Great Dane’ is taller than a ‘beagle’, we respond relationally. This capacity is one of the characteristics of the human brain and lays the basic building blocks for language (verbal, written and gestural). This approach explains language and cognition as arbitrarily applicable relational responses known as ‘relational frames’. Learning language is thus learning different patterns of relational frames: humans do not relate to objects based only on their physical relationship but use contextual cues or relational frames to decide how to relate. For example, if we give a child the information that a ‘Great Dane’ is taller than a ‘beagle’ and then ask him which of the two dogs is shorter, the answer will be, unequivocally, the ‘beagle’ even though he has not seen the two dogs. To give his answer, the child relied on contextual cues (‘taller’ and ‘shorter’) rather than physical relationships. Thus, the relationship taught is a learned behaviour arbitrarily applicable to any stimulus, regardless of its physical properties (Presti & Moderato, 2019).

The arbitrariness of derived stimulus relations is, therefore, parallel to the referentiality of language, in which words and their referents share few formal properties (e.g., the word dog does not resemble a flesh-and-blood dog at all). Yet, individuals often respond to them as equivalent (Sidman & Tailby, 1982). The phenomenon of deriving complex networks of relations after direct training on a few relations may explain the remarkable generativity of language and semantic network processing, which emerge in infancy and develop gradually (Barnes-Holmes, Hayes, Dymond, & O'Hora, 2001; O’Hora, Pelaez, & Barnes-Holmes, 2005; O’Hora, Pelaez, Barnes-Holmes, Rae, Robinson, & Chaudhary, 2008). During this gradual development, especially in the early stages of language acquisition, loosely constrained relational frames may be presented, and these are likely to lead to the production of linguistic errors; in later stages, after more interactions with the verbal community, these early frames become more defined: the child thus can process information in a more specific linguistic frame and may also be able to derive that other verbal forms belong to a different frame. These new, more precisely defined frames reduce the production of errors and promote the production of grammatically and syntactically correct sentences. This suggests that during human language development, there is a natural history of arbitrarily applicable relational response learning that tends to eliminate inappropriate forms of stimulus control that give rise to grammatically incorrect speech (Leader, Barnes & Smeets, 1996; Smeets, Leader & Barnes, 1997; Leader, Barnes-Holmes & Smeets, 2000).

In summary, a relational frame is a specific type of relation that combines concepts and stimuli and applies their relations to one another. RFT describes how creating a network of relations between arbitrary stimuli is possible.

6. Implications for language retrieval in autism

According to RFT, children with autism have problems in the process of relational framing (and in case they do manage to develop relations, they are, often, too rigid to be generalized) and in making reciprocal and combinatorial associations, and they also present difficulties with function transformation. Another deficit presented by individuals with Autistic Disorder is the lack of empathy and the use of the relational operant known as "deictic framing". In other words, people with autism have difficulty distinguishing between 'Me' and 'you', between 'here' and 'there', and between 'now' and 'then' (Vilardaga, 2009; Guazzo, 2022).

Deictic relations are among the most complex of all relations because the speaker changes perspectives between 'Me' and 'you', between 'here' and 'there', and between 'now' and 'then', or combinations of the three types of relations: for example, a child who is asked the question "What did you do at school this morning?" must coordinate between "He" and 'You' in the question and between 'the activity' and the place (school) and the past moment (this morning). They have been divided into three levels of complexity (Villatte, Monestes, McHugh, Freixa i Baque, & Loas, 2010; McHugh, Barnes-Holmes, & Barnes-Holmes, 2004): simple (change of perspective according to a single frame; e.g., "Me-You" relationship: I play with the red ball, and you play with the blue ball; Which ball am I playing with? Which ball are you playing with?), inverted (reversal of a simple relationship, e.g., "Here-There" relationship: I am 'here' behind the table, and you are 'there' in front of the table. If 'here' were 'their' and 'there' were 'here', "Where would you be sitting?" "And where would I be sitting?") and doubly inverted (inversion of two simple relations, e.g., relation "Here-There/Now-Then": Now I am 'here' playing with the ball; I was studying in class this morning. If 'here' were 'there' and 'there' were 'here' and if 'now' were 'then' and 'then' were 'now': Where would I be 'now'? Where would I be 'then'?). Thus, the speaker will always speak from "Me/Where/Then", while the listener from "You/There/Then" will have to respond to various deictic relations to relate and respond appropriately to the listener's verbal behaviour. These relations are the basis of perspective-taking, that is, figuring out what others may be thinking or feeling (e.g., "What would you do in my place?" or "Bill had to give up a trip for the Covid; "How would I feel if I were in his place?"), as well as making future predictions about one's behaviour or that of others (Rehfeldt, Dillen, Ziomek & Kowalchuk, 2007). Deictic relations may also be able to explain the cognitive concept of Theory of Mind (ToM), whose deficit is often associated with the autistic condition. A well-known ToM task is the 'Sally and Anne' task (Baron-Cohen, Leslie, & Frith, 1985) to which the participant, to answer correctly, must be able to assume Sally's perspective: that is, he or she must reverse the "Me-You" relation (Villatte, Monestès, McHugh, Freixa, Baqué & Loas, 2010).

RFT, in addition to explaining some of the problems that individuals with autism present, offers some keys to improving the language and communication skills of these children, among them especially those based on relational frames: "coordination frames" (e.g., understanding relationships between objects: greater than, less than), "comparison frames" (larger than, smaller than), "temporal frames" (before, after), "spatial frames" (closer than, farther than), etc., but also on relationships that parents, teachers and others may use in everyday life situations, outside of a structured context (McHugh & Reed, 2008; Hughes &

Barnes-Holmes, 2016).

CONCLUSIONS

If it is bound to Chomskyan theories, linguistics will not prosper in any way in the 21st century (or later), since it is a purely descriptive discipline (which means that there will always be as many descriptive accounts as there are linguists and no experimental way to decide between thousands of theoretical proposals). Instead, the neuropsychology of language, with its solid brain and genetic foundations, will continue to thrive in the future. But it is a different discipline (data, methodology, theory building, experimental verification, etc.).

Another theory that, with its experimental basis, could provide new developments, especially for lexical learning, is RFT: once two stimuli are framed together, their relationship can be reversed, or the function of one stimulus can be transferred to the other, allowing any element to be linked to the others in complex networks (McHugh & Reed, 2008). But RFT has nothing specific to say about language morphosyntax. Lexical and morphosyntactic components are not isomorphic. For example, the stimulus function has no reverse derivational transfer in morphosyntax. Hayes and Berens (2004) point out that fundamentally, language is about framing events relationally. Framing, nevertheless, goes beyond lexical meaning.

There are reasons to believe that morphosyntactic ways of arranging semantic relations in the sentence surface are implicitly extrapolated by children from the sentences they hear (Rondal, 2011, 2018). Implicit learning is procedural learning that depends on different neural structures from those involved in explicit learning (Ullman, 2004). It is mostly autonomous concerning conscious inspection and associated with incidental learning conditions (Perruchet & Poulin-Charonnat, 2015).

Most children with autism or intellectual disabilities are deficient in implicit learning. Efficient attempts to teach morphosyntax to these children must operate at two levels (Rondal & Guazzo, 2012): a) by default from an explicit awareness of the semantic framework underlying the typical sequences of sentence constituents: this implies that explicit morphosyntactic learning based on operant conditioning and social reinforcement is all the more necessary in this endeavor; b) to be maximally effective, an intervention aimed at improving morphosyntactic development should follow seven principles:

1. it should be practiced in everyday speech, avoiding appeals to formal and functional categories, abstract rules and other metalinguistic language;
2. it should privilege the direct mapping of the pragmatic/thematic semantic framework onto the sequential and distributive patterns of lexemes and syntactic morphemes
3. the learning environment should reduce the demands placed on the procedural system by breaking down complex sequences into component parts and gradually recombining them into larger units;
4. the rhythm of speech to the child should be reduced, and natural pauses between sentences and clauses should be slightly exaggerated to emphasize the organization of the sentence surface
5. the construction of paradigmatic repertoires through analogical substitutions of lexical groups, phrases and clauses should be favored;

6. using onomatopoeic sounds, vocalizations, nursery rhymes and ditties that activate mechanically/automatically foster procedural memories of phono-articulation and prosody
7. input should be provided to emphasize the distribution of syntactic morphemes in sentences.

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