

A Dynamical Systems Approach to Pragmatics Language Impairment in Autistic Children: Trapped Trajectory in a Bottleneck

Somayeh Sadat Hashemikamangar^a, Shahriar Gharibzadeh^{a,b}, Fatemeh Bakouie^{a,*}

^aInstitute for Cognitive and Brain Sciences, Shahid Beheshti University, Tehran, Iran

^bBasir Eye Health Research Center, Tehran, Iran

Abstract

Autism Spectrum Disorders (ASD) refers to a wide range of circumstances characterized by challenges with social skills, repetitive behaviours, language, and nonverbal communication. While structural language is known to vary broadly in children with ASD, pragmatic language has been claimed to be consistently impaired within this population. To have a better understanding of the language development and the related impairments, "dynamical systems theory" can be helpful. Language development, as a dynamical system, has a trajectory of variations. For the autistic individuals, we hypothesize that this trajectory reaches a bottleneck in higher-level aspects of language like pragmatics. Language development trajectory of autistic children typically passes the lower-level aspects of language such as semantic/lexicon processing. But, it slows down when reaches the higher levels like pragmatics and traps in a bottleneck. It means that the trajectory spends lots of time in this stage and cannot fully complete the stage to acquire the pragmatic competence. The time that the developmental trajectory spends in the bottleneck is related to the environmental and social conditions of the children with ASD. Appropriate intervention packages, can lower the trapping time in bottleneck by improving social and environmental circumstances and making the trajectory faster.

Keywords: Dynamical System Theory, Pragmatics Language Impairment, Autism, Trapped Trajectory, Bottleneck.

*Corresponding author

Email addresses: (Somayeh Sadat Hashemikamangar), s_gharibzade@sbu.ac.ir (Shahriar Gharibzadeh), fatemeh.bakouie@gmail.com; F_bakouie@sbu.ac.ir (Fatemeh Bakouie)

1. Language development as a dynamical system

Autism is a developmental disorder that causes a spectrum of deficits in communicating with others. Although there is a range of language abilities in children with autism, at least 63% of all 8-year-olds with ASD have language impairments [7]. The most persistent and noticeable language deficits in ASD are found within the domain of pragmatics, i.e., the appropriate use of language in social situations [3]. Pragmatic skills facilitate children's sentences production and comprehension in ways that are suitable to the language context. While structural language is known to vary greatly in children with ASD, pragmatic language has been claimed to be consistently impaired within this children, and has been regarded as a hallmark of ASD [1]. It is not surprising that many individuals with these disorders have difficulties in social communication. Therefore, a better knowledge of their language impairment leads to a better solution to their communicating problems.

Human language develops through time from birth to late childhood and adolescence [2]. Language skills change from basically recognizing of pre-linguistic actions which contain useful information, to comprehending complex pragmatic items. Language develops from lower-level processing, such as the indication of informative responses, interacting intentions, and semantic/lexicon processing, to higher-level processing i.e., syntactic analysis and pragmatics integration [2]. Based on literature, Dynamical Systems Theory (DST) could help us explain the developmental process of language and the related impairments [6]. In other words, the temporal development of language can be studied by nonlinear dynamic models. They can correctly model the complex processes the same as development, in which the change of the output is not simply proportional to the variations of the input [9].

A dynamical system consists of a state space, whose peculiarities demonstrate the state at any moment [5, 11]. It also contains a dynamical rule that characterizes the prompt future of all state variables, by giving just the present values of those same state variables [5, 11]. The state of these systems evolves through time over a state space according to a rule [5, 11]. DST deals with the long-term qualitative behavior of dynamical systems [11, 10]. DST could describe the self-organizing processes that cause developmental changes and moment-to-moment variability in children's language performance [4]. Therefore, Language development could be studied as a dynamical system with the trajectory of variation [6, 9]. It starts from recognition of pre-linguistic informative actions. When the child grows and begins learning how to get and convey the communicative messages, the trajectory reaches the stage of communication intention. Then the child learns the words and their meaning and the developmental trajectory enters the lexical and semantic stage. Afterwards, the child finds out how to make a sentence and acquires syntax. At the last level of development, the trajectory reaches the stage of pragmatic competence and the child becomes skilled at using the language [1]. The key question is what happens in the developmental trajectory of autistic children which makes them not to achieve pragmatic skills.

2. Trapped trajectory in a bottleneck

We hypothesize that variation in the language development trajectory of autistic children becomes very slow when it reaches the higher-level processing, such as pragmatics. In the beginning, while the trajectory is corresponding to the lower-level processing of language, the variation has average speed. As the trajectory evolves and reaches the higher-level aspects of language like pragmatics, its dynamics becomes very slow and seems it traps in a bottleneck. Based on DST, the trajectory has a slow passage through the bottleneck and spends practically all its time getting through it. Therefore, it can be concluded that the trajectory of language development in autistic individuals

with pragmatic language impairment, reaches a bottleneck in higher-level aspects of language and their language development does not complete properly to acquire pragmatic competence.

The time that the trajectory spends in the bottleneck is related to the environmental and social conditions. According to DST, exerting external force may drive the system to come out of the bottleneck; consequently, the trajectory continues its normal path. Besides, there are some intervention packages that improve pragmatic in autistic children, and understanding the language developmental process can help speech-language pathologists choose the best intervention method [12]. We suppose that these packages work as an external force. Suitable external force should be consistent with the system's intrinsic characteristics, such as natural frequency. In this regard, personalized packages which are designed in accordance with the language developmental process of autistic children can be more efficient. Moreover, the packages should consider the social and environmental conditions of the children with ASD. As reported in [8], pragmatic language interventions in which the child with ASD and their parent are actively included in an intervention have the maximum benefits.

We believe that this approach helps us model and manage pragmatics problems in autistic individuals' language. Reducing the time spent in the bottleneck with an appropriate intervention strategy, may solve the language problems. Prediction, prevention, and treatment of language impairment in autistic individuals may be achieved by minimizing that time using the effective intervention packages.

Acknowledgements

The authors acknowledge the support of the Cognitive Sciences & Technologies Council under grant number 6852.

References

- [1] C. Andrés-Roqueta and N. Katsos. The contribution of grammar, vocabulary and theory of mind in pragmatic language competence in children with autistic spectrum disorders. *Frontiers in psychology*, 8:996, 2017.
- [2] M. Catani and V. Bambini. A model for social communication and language evolution and development (SCALED). *Current Opinion in Neurobiology*, 28:165–171, 2014.
- [3] I. Eigsti, AB. de Marchena, JM. Schuh, and E. Kelley. Language acquisition in autism spectrum disorders: A developmental review. *Research in Autism Spectrum Disorders*, 5:681–691, 2011.
- [4] E. Hoff. *Language Development*. fifth ed. Wadsworth, USA, 2013.
- [5] EM. Izhikevich. *Dynamical systems in neuroscience: the geometry of excitability and bursting*. The MIT Press Cambridge, Massachusetts London, England, 2007.
- [6] SSH. Kamangar, F. Bakouie, and S. Gharibzadeh. Bifurcation theory approach to neuro-developmental language impairment in autistic children. *The Malaysian journal of medical sciences: MJMS*, 25:142, 2018.
- [7] E. Levy, E. Giarelli, LC. Lee, LA. Schieve, RS. Kirby, C. Cunniff, and CE. Rice CE. Autism spectrum disorder and co-occurring developmental, psychiatric, and medical conditions among children in multiple populations of the United States. *Journal of Developmental & Behavioral Pediatrics*, 31:267–275, 2010.
- [8] L. Parsons, R. Cordier, N. Munro, A. Joosten, and R. Speyer. A systematic review of pragmatic language interventions for children with autism spectrum disorder. *PloS one*, 12:e0172242, 2017.
- [9] LB. Smith and E. Thelen. Development as a dynamic system. *Trends in cognitive sciences*, 7:342–348, 2003.
- [10] SH. Strogatz. *Nonlinear Dynamics and Chaos, with Applications to Physics, Biology, Chemistry, and Engineering*. MA: Addison-Wesley, 1994.
- [11] RR. Vallacher, P. Van Geert, and A. Nowak. The intrinsic dynamics of psychological process. *Current Directions in Psychological Science*, 24:58–64, 2015.
- [12] EM. Whyte and KE. Nelson. Trajectories of pragmatic and nonliteral language development in children with autism spectrum disorders. *Journal of Communication Disorders*, 54:2–14, 2015.