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Professional Systemics Applied to the Development of Social Skills in Children with Autism Spectrum Disorder: A Case Study

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Abstract: Autism is a problem of increasing global concern. The prevalence rates of children on the autism spectrum have increased 10 to 17 percent annually in recent years with no established reason for the increase. A recent innovation in autism treatment is robot therapy, considered as an adjunct to traditional behavioral therapy. However, robot therapy involves interaction among a number of individuals with different mindsets, constructs, language and procedures, including clinicians, psychologists, roboticists, interactive behavior designers, educators, the autistic child, and family members. In this paper we describe a case study of robot therapy for an autistic child. We look at the . individuals and their interactions as a system and apply systemic concepts to the approach. Our goal is to outline a practical, effective methodology for a professional service that would benefit ASD children and their families.

Keywords: Autism, Autism Spectrum Disorder, Humanoid Robot, Socially Assistive Robot, Professional Systemics, Systemic Thinking

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1 Introduction to Robot Therapy for ASD

In this paper we discuss a problem of increasing global concern, viz. the dramatic increase of children with Autism Spectrum Disorder (ASD). Autism statistics from the US Center for Disease Control and Prevention (CDC) identify 1 in 88 American children as on the autism spectrum, a ten-fold increase in prevalence in 40 years. ASD affects over two million individuals in the US and tens of millions worldwide. Government autism statistics suggest that prevalence rates have increased 10 to 17 percent annually in recent years. There is no established explanation for this continuing increase, although improved diagnosis and environmental influences are two reasons often considered (What is Autism?, 2013).

The criteria for identifying children with ASD are communication deficits, social skill deficits, and repetitive patterns of behavior, where symptoms are present usually before the child is 3 years old. These children lack social skills that we take for granted, e.g. playing with others, eye contact, ordinary conversation, and other common social behaviors.

The autism spectrum is classified into three levels (DSM-5, 2013):

- Level 1 Requiring Support - Without supports in place, deficits in social communication cause noticeable impairments. Difficulty initiating social interactions, and clear examples of atypical or unsuccessful response to social overtures of others.
- Level 2 Requiring Substantial Support - Marked deficits in verbal and nonverbal social communication skills; social impairments apparent even with supports in place; limited initiation of social interactions; and abnormal responses to social overtures from others.
- Level 3 Requiring Very Substantial Support - Severe deficits in verbal and nonverbal social communication skills cause severe impairments in functioning, very limited initiation of social interactions, and minimal response to social overtures from others.

Treatments for ASD children include behavioral therapy and medicine. A recent innovation in ASD treatment is robot therapy with a Socially Assistive Robot (SAR) (Giullian et al, 2010), (Kim et al, 2012), (Scassellati et al, 2012), (Kim et al, 2013). Robot therapy is considered adjunct therapy to traditional behavioral therapy. ASD children are interested in electronic devices and are drawn to humanoid robots. The robot is less threatening and does not flood the child with facial expressions, gestures, and perceived disappointments. Thus, there is an opportunity to work on social skills with non-threatening humanoid robots and attempt to transfer those skills to human interaction in real settings. Robots can aid autistic children in developing social skills by capturing and maintaining attention, evoking joint attention, eliciting imitation, and mediating turn-taking.

Importantly, (Scassellati et al, 2012) observes the following: "Despite productive collaborations between several robotics and clinical groups, robotics research and clinical psychology are significantly different fields, each with its own research methods and publication standards… By the nature of the research, developing and evaluating SAR systems for autism therapy involves researchers who specialize in computational science, mechanical and electrical engineering, robot control, human-robot interaction, social psychology, and clinical research. Few research groups have total coverage of these disparate fields, so groups tend to focus on their strengths, whether they be in robot design, interaction design, or evaluation. Unfortunately, without clinical psychiatrists and psychologists, most research groups lack long- term, continuous access to protected groups such as children with autism, making it difficult to measure the benefit of design decisions. Facilitating collaborations between clinicians and roboticists is probably the only way to enable this kind of in-depth interaction study."

We see this observation as a good reason and invitation to apply systemic thinking to autism therapy with robots. The problem calls for reciprocal understanding across different disciplinary domains as well as different schools of systemic thinking. We see the system as an organization consisting of the following interrelated entities: the ASD child, parents, siblings, educator, therapist, roboticist, behavior designer, and robot operator. The system is a soft system involving stakeholders of different mindsets and also an evolutionary system whose structure and interrelations change over multiple sessions with the child [Checkland and Poulter, 2007]. We illustrate the system and the positive impacts of systemic thinking by extrapolating from a case study. The sessions with the child were performed by this author, colleagues, and the child's family in two session in February 2014.

2 A Case Study

Edgar is a 6-year old Level 1 ASD child. Edgar's siblings are Lola (5 years) and Dennis (8 years). Melissa is Edgar's mother. Dr. Nancy Charron is Professor of Special Education (SPED) at Southern New Hampshire University (SNHU) and Kristen is Dr. Charron's student. Dr. Peter Frost is an experimental psychologist at SNHU. Dr. Lundy Lewis is Professor of Computer Information Technology at SNHU and the roboticist. The robot is the NAO humanoid robot developed by Aldebaran Robotics in France (NAO, 2014).

Melissa wishes her son Edgar to learn how to order a doughnut from a menu at a real store. With this goal in mind, the organization collaborated to produce behaviors for a 1st Session with Edgar and, based on the results of the 1st session, collaborated to produce behaviors for Session 2. The sequence of behaviors and results are shown in Table 1.

Table 1: Synopsis of Two Sessions

	Sequence of Behaviors	**Results**
Session 1 2/16/14	Introductory behavior (Hello Edgar. How are you? Good to meet you…)	Edgar is immediately drawn to the robot and is happy.
	Do what I do behaviors, e.g. raising hands, waving, sitting, wiping forehead, and others, with everybody in the room imitating the robot	Edgar withdraws, going to a corner to play a video game. Subsequently, everybody is asked to leave the room except Edgar's mother, his siblings, and the robot operator.
	(unplanned) The robotic version of the music game Simon was introduced by the robot operator	Edgar's siblings begin playing the game, Edgar is drawn to it and begins playing the game as well.
	The ordering doughnut behavior	Edgar imitates the behavior "Can I please have a chocolate glazed doughnut" several times albeit softly and without confidence.
Session 2 2/22/14	Introductory behavior, reinforced with encouragement to speak loudly and clearly and make eye contact	Edgar is attentive and eager. Only Edgar's father, Kristen, and the robot operator are in the room.
	The music game, this time planned	Edgar has a blast. He speaks loudly, and begins asking for the doughnut routine unprovoked.
	The ordering doughnut behavior, modified to encourage speaking loudly and clearly, making eye contact, and saying Thank You.	Edgar repeats the phrase "Can I please have a chocolate glazed doughnut" several times loudly and clearly, and practices Thank You.

After both sessions, Edgar was taken to a doughnut store to transfer the ordering skill to a real setting. In both cases, Edgar ordered the doughnut successfully, as was hoped. After the 2nd session, Edgar ordered the doughnut loudly and with confidence, making eye contact, and saying Thank You. These results are encouraging, but they are anecdotal, i.e. a one-shot experiment lacking scientific, quantitative backing. Plans are underway to set up a more scientific experiment under the guidance of the experimental psychologist with a classroom of a dozen ASD children rather than one child. The analysis of the current experiment via systemic thinking will instruct the later rounds of experiments.

2 Preliminary Analysis and Outlook

We consider the system as iterating over preparation, execution, and post-analysis. The post-analysis informs subsequent preparation for the next iteration. Figure 1 shows the total system and the subset of participants in yellow for Session 1 preparation. The participants for Session 2 execution were Edgar, Father, SPED student, and robot operator.

Edgar	Mother	Father	Sibling 1	Sibling 2	Humanoid Robot
Experimental Psychologist	Behavior Designer	Behavior Implementer	SPED Professor	SPED Student	Robert Operator

Figure 2: Participants in Session 1 preparation in yellow

We focus on understanding how the elements in the system affect one another and how the interactions of the elements produce emergent behaviors. Although a complete analysis cannot be given here, initial key observations and questions are below.

1. What are the real and desired emergent behaviors of the system during each evolutionary phase? For example, due to weather and illness, the degree of communication during Session 1 preparation was less than desired. This suggests that an additional system element is “environment” with interactions and properties thereof.
2. Edgar withdrew during the Do What I Do behaviors of Session 1. The mother indicated that too many participants were involved, after which all participants except mother, robot operator, and siblings left. The robot operator introduced the music game and the siblings began playing it. Edgar then joined in. These interactions informed Session 2 preparation. Should “session plan” be part of the system or an emergent behavior?
3. During the night after Session 1, Edgar cried continuously. It was discovered the next day that Edgar had strep throat. Mother suggested that his health probably affected his interest during Session 1 negatively. This point suggests further that health and other properties of system elements should be considered in interactions.
4. A second university student not involved in the system, who is Level 1 ASD but highly mature, functional, and intelligent, suggested he become part of the system to provide insight into preparation and analysis. What would be the expected outcomes of the introduction of this element and its interactions with other elements?

In conclusion, the results are anecdotal and require more formal experimentation to understand the merits of robot therapy for ASD children. Regardless, the approach benefits from systemic thinking. More study and work is needed in this area, e.g. constructive critique (Metcalfe, 2007), recognition of learning obstacles (Reyes, 2008), and abstraction, common language, and attitude (Gershenson et al, 2013). Our goal is to outline a practical, effective methodology for a professional service that would benefit ASD children and their families.

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Dr. Lundy Lewis is the Christos and Mary Papoutsy Distinguished Chair in Ethics and Social Responsibility and Professor of Computer Information Technology at Southern New Hampshire University in the USA. His current research investigates the use of technology to address complex social issues such as Autism Spectrum Disorders, Post-Traumatic Stress, and elderly care. His 1986 dissertation was one of the first efforts to understand how intelligent computers might have a sense of ethics in order to make decisions about doing the right thing. His lifelong scholarly activity has revolved around the application of Artificial Intelligence methods to practical business problems and the building of systems, e.g. using AI in business intelligence, situational reasoning, enterprise management, video games, and robots. He holds thirty-five US patents involving technology and has been a Principal Investigator on several multi-year projects for the US Department of Defense and the Australian Research Council. He is the author of several books on enterprise management: Managing Computer Networks: A Case-Based Reasoning Approach (Artech House 1995), Service Level Management for Enterprise Networks (Artech House, 1999), and Managing Business and Service Networks (Kluwer/Plenum Press, 2001). He has published extensively in journals and conference proceedings. He is co-founder and Chief Technology Officer of three technology companies.