Adapting Autism Treatment Techniques for the Digital Age

Richard P. Zajac

Danish Institute for Study Abroad c/o Claremont McKenna College

Digitally Advancing Autism Treatment Techniques

Since the 1990s, the simultaneous increase in incidence and diagnosis of ASD has resulted in myriad initiatives in research, diagnosis, and therapy in the field. Nevertheless, in both the North American (United States and Canadian) and Danish contexts, regarding insurance coverage for ASD, applied behavior analysis (ABA) therapy remains the leading method of treatment. This traditionally labor-intensive process may be able to be effectively executed using a cross-section of digital technologies with varying levels of human intervention. Treatment of ASD, conventionally, has been a very labor-intensive process, but it can be migrated appreciably to the digital realm through effective and novel leverage of recent technological innovations.

It is imperative to consider the status quo of ABA therapy before moving into a period of exploration of possible future solutions for the treatment of ASD through the leveraging of digital technologies. The core strategies regarding ABA have remained unchanged since 1968 (Cooper, 1982). What is particularly remarkable about this is that the solution has been so elegantly simple (the systematic application of interventions in replicable modeling of behavior until the target adopts the desired outcome) that there has not been much need for progression since the original model was released (Baer, Wolf, & Risley, 1968). In many ways, this is a good thing: The researchers and leading therapists pushing this field forward have been able to continually refine the process, introduce an official certification program, and introduce certified ABA programs in over 20 languages (Cooper, Heron, & Heward, 2007). Moving forward, it would be prudent to examine which qualities of ABA programs have been most central to their effective implementations in concerns ranging from classical autism cases to individuals who have eating disorders—and other comorbid conditions that are so strong in their efficacy they have even been proven in nonhuman subjects (Pierce et al., 1994). Next, we examine the progression of traditional ABA therapy into more discrete, tailored solutions that can help train subjects in not only basic and fundamental social interactions but also more nuanced situations and key concepts such as eye contact and nonverbal communications cues.

The Relationship Development International (RDI) program has proven to be one of the most successful progressions of the original ABA program through its implementation of specific situational modeling that allows for the novel formation of brain connections novel wiring through real-world simulations of situations that might arise for an individual with autism (Gutstein, Burgess, & Montfort, 2007). It is this specific type of intervention that presents promise for those individuals who may experience difficulty with the synthesis of learned concepts into novel situational navigation based on prior experience (Karst & Van Hecke, 2012).

The benefit of RDI's potential for effective therapy in novel concept formation becomes immediately apparent when we examine an example of how its implementation can lead to an exploration of proper social cues in individuals on the spectrum. If a light bulb were burned out in a fixture, an RDI therapist might note verbally to the subject that a light bulb is burned out with a traditional (real-world or socially expected) verbal cue such as "That's too bad," pause for effect, then prompt the subject nonexplicitly with "Someone ought to change that." This strategy, of course, supposes that there is a light bulb strategically placed in the room and that the subject has already been taught the meaning of the item and the appropriate time for its use. It is this randomized system of implementation that allows for the understanding of appropriate situational behavior—not in the literal and explicit context but in the implied and inferred context—that makes RDI such an effective method of therapy (Gutstein, 2009).

With an understanding of classical and derivative therapy methods in tow, it is then vital to understand how individuals on the spectrum behave when an unfamiliar situation presents itself—and how this differs from the neurotypical norm. With individuals who are developing on what we might consider an average or expected path per the DSM-V (the de facto text on psychological developmental abnormalities) (American Psychiatric Association, 2013), we can discover how they react to these moments as they arise (Rutter, 1983). Typical individuals in the developmental process learn at an early age (generally between 18 months and 2 years of age; Golan et al., 2010) how to stitch together the mental database of situations and proper (read

"socially accepted") reactions to these environmental externalities. Based on the presence or absence of this mental matrix, we can then compare neurotypical reactions to those given by individuals on the autistic spectrum. Individuals with ASD would examine these situations from the perspective of literal interpretation, and if the new situation that arises does not mirror a previous experience to a high degree, then their default reaction will be avoidance and they will not learn to adapt and form the mental matrix of situational learning that traditionally comes naturally to individuals along the developmental process (Rourke, 1982).

The next logical step in the progression of social cue training is to go beyond literal situational inference and examine pure emotional recognition skills—a topic of equal difficulty for individuals on the spectrum (Baron-Cohen, Golan, & Ashwin, 2009). Qualitative adaptations to situations to properly follow social norms are a final element of the necessary developmental progressions necessary to restore proper social functioning. For example, even if individuals can properly recognize a cue that it is necessary to change a light bulb, they would still need to understand that it is imperative to direct the response to the inquiring individual not only verbally but also through explicit eye contact and gestures appropriate to the task or communicative subject at hand (Bal et al., 2010).

 Before examining how to transfer the process of autism therapy (classical and derivative)

to the digital realm, we must also explore the process of autism diagnosis and how that too can be streamlined and brought online. Unlike the therapy process of ABA, which is adapted globally (applied in both the Danish and the North American contexts), this process differs regionally. The United States has adopted the DSM-V (described above) as the analytical evaluation procedure for not only autism but also most other mental conditions that can be cataloged and diagnosed effectively. It is worth noting that when individuals do not meet the classical diagnosis of autism but still exhibit many of the symptoms associated with the condition, they are classified with the coding of pervasive developmental disorder-not otherwise specified (Walker et al., 2004), which allows the capacity to record a diagnosis in the ever-expanding catalog of autism-like conditions and neurological/behavioral deviations that benefit from many of the diagnostic and treatment procedures that have been developed in accordance with the progression of treatment processes of traditional autism and Asperger syndrome—now considered a part of traditional autism spectrum disorder, as of the DSM's fifth update in 2013 (Wing, Gould, & Gillberg, 2011).

In Denmark, the diagnostic procedure differs slightly in nomenclature and follows the *International Classification of Diseases* (World Health Organization, 2012). For the purposes of this paper, we will address the two cultures together because the discrete nuances are not different enough to appreciably alter the findings for how to transition classic and novel autism diagnostic methods into the digital realm. Cutting-edge research in progress at the University of Missouri's Thompson Center for Autism and Neurodevelopment is evaluating whether the Guthrie test (when an infant's heel is pricked for standard blood tests in the United States at 1 year of age and a physician measures the subsequent shout or scream) can be used to detect the deviations in vocal patterns in individuals on the autistic spectrum even before the infant becomes verbal. In the same way that an individual with Down syndrome might have detectable tonality deviations in speech, so too is it possible—or so the study underway supposes in its hypothesis—to detect the specific vocal tonality deviations that co-occur in children with autism (Zwaigenbaum, Bryson, & Garon, 2013).

Provided that the University of Missouri researchers' hypotheses are correct, it ought to be possible to complete a preliminary diagnosis of autism remotely, even as a sweeping screening process for all individuals receiving the 1-year heel prick. Thanks to the advent of technologies that allow for the transmission of high-quality audio over the Internet, such as voice over IP (VOIP), protocols are now able to facilitate this transmission of audio to a degree that is not perceptibly different from in-person recording using typical consumer/prosumer-grade hardware using standards G.711 and newer (Hiwasaki, Ohmuro, Kurihara, & Kataoka, 2006). With this knowledge in tow, we can outsource the algorithmic decoding of the speech to leased supercomputer processing space that can be activated in real time and on demand (Foster & Tuecke, 1996) to effectively process the speech and return the findings in mere seconds, much in the way that Apple's Siri is able to remotely process in near-instantaneous fashion (Aron, 2011). This has far-reaching implications because the price of smartphones and mid/broadband Internet access can be reached in areas across the United States through new initiatives such as net neutrality (Lee & Wu, 2009).

Because Scandinavia and Denmark have long been leaders in telecommunications technologies, it should come as no surprise that the implementation of this diagnostic technology should be a natural fit for this context. In fact, a late 1980s era technology, Integrated Services for Digital Network (ISDN), deployed more in Denmark than in any other country globally

 (Sorensen, 1987), can support the voice channels needed to maintain the quality of service (QoS) necessary to support this sort of diagnosis (Wang & Crowcroft, 1996). Furthermore, this would be ideal to spread further still: beyond the contexts of the research focus—Denmark and North America—and toward less developed nations and regions of the world such as Sub-Saharan Africa, where mobile data networks would allow the sounds to be recorded as a stored mp3 file or voice note on a mobile phone and uplinked for remote processing and response by text, even if the phone was not a true smartphone (Aker & Mbiti, 2010).

The next key breakthrough in the field of diagnosis has been facial recognition technology. This is particularly remarkable because it permits the diagnosis not just of autism as a whole but also of specific subtypes of the condition that can help tailor early interventions that will be invaluable in the process of beginning therapy and not losing those valuable early days when the signs of autism can be reversed and the hope for a higher-functioning future for these individuals successfully preserved (Rogers, 1996). This study, too, is being conducted at the University of Missouri's Thompson Center for Autism Treatment, where 3D facial scanning technology is able to effectively construct a digital model of the subject and run detailed analysis on the individual's facial construction to execute a general diagnosis with 97% accuracy and a subtype analysis at 83% (Virnes, Kärnä, & Vellonen, 2015). It is imperative to start early treatment because even if the specific subtype analysis is not accurate, it is still possible to execute and tailor therapy that will be continually refined through traditional means (Brandler & Sebat, 2015).

It will be possible to implement facial recognition modeling in the contexts we are examining and through myriad available technologies. For the highest degree of accuracy in scanning, it will be necessary to acquire and appropriately employ a top-resolution camera. One example of this would be the hardware used currently for personal clothes fitting by Virginia Tech start-up company VirtualU, which offers access to sub-$10,000 USD scanning equipment suitable for this task (Sinha, 2015).

At the consumer level, it would also be possible to execute this scanning (albeit with a lower degree of reliability) using commercially available products common in both North America and Denmark that have a practical dual usage over the life cycle of the product for families with children with or without autism. One example of this is the Nintendo 3DS: This device is a portable gaming console with three-dimensional display capability and, more importantly in this context, three-dimensional image capture capability using its dual onboard camera system (Yasumoto & Teraoka, 2015). In this particular instance, the three-dimensional images could be captured by families and sent in for diagnosis at regular intervals (the development of facial features varies greatly depending on the individual), which would contribute to the detection and effective diagnosis of autism. Whereas, for an individual with Down syndrome, it is often possible to visually detect the condition with the naked eye from an early age, those same visual cues in the bone and facial structure are present in children with ASD but it is necessary to employ the use of computer technology to detect the special geometries that are too intricate and seemingly benign to be effectively diagnosed by the naked eye (Adams & Clark, 2015).

A potential implementation of this research is the creation of therapy techniques that can take the lessons learned and mobilize them for availability in rural communities and regions not traditionally served by specialists trained in these interventions. One particularly promising example of this is Missouri’s TeleHealth Network (Kwong, Calouro, Nasseri, & Gutierrez, 2015). This is an exciting prospect because it brings together several key members of the treatment (and even diagnosis) process and makes them available to families over commercially available platforms such as Skype, which will become increasingly accessible using the abovementioned initiatives such as net neutrality. The individuals who would be brought together under such a program include a child psychologist, a dietitian, and the parent of an individual with autism.

The logical progression of this, after the consultations with the individual’s family, would be to involve an ABA therapist remotely to execute the therapy. It does not make sense to stop here, however, because the next step would be to implement some sort of autonomous algorithm that would introduce a virtual avatar that could execute the therapy in a dynamic fashion and tailor the intervention to the individual using feedback loops to maximize effective methods of therapy—and increase their incidence such that they can be effectively employed without subsidizing an individual to execute the therapy (Buzhardt, Rusinko, Heitzman-Powell, Trevino- Maack, & McGrath, 2015).

This is not only limited to avatars but could also potentially include robots that could execute the therapy in person to have a higher degree of reality, with a facial-realistic device that could train the individuals with autism. Hanson Robotics of Korea’s latest research describes the potential for interaction with a robot that can predictably re-create proper social cues time and again at a superior level to therapists, who may grow impatient or misinterpret feedback (Sandry, 2015). As the algorithm improves, the therapy will grow more reliable and scalable. With these new methods in tow, the future holds great promise for empowering families of autistic individuals with ever more accurate diagnosis and therapy to make life better day by day for those on the spectrum.

References

Adams, D. J., & Clark, D. A. (2015). Common genetic and epigenetic syndromes. *Pediatric Clinics of North America*.

Aker, J. C., & Mbiti, I. M. (2010). *Mobile phones and economic development in Africa* (Working Paper No. 211). Location: Center for Global Development.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders, text revision (DSM-IV)*. Location: American Psychiatric Association.

Aron, J. (2011). How innovative is Apple's new voice assistant, Siri? *New Scientist, 212*(2836), 24.

Baer, D. M., Wolf, M. M., & Risley, T. R. (1968). Some current dimensions of applied behavior analysis. *Journal of Applied Behavior Analysis, 1*(1), 91–97.

Bal, E., Harden, E., Lamb, D., Van Hecke, A. V., Denver, J. W., & Porges, S. W. (2010). Emotion recognition in children with autism spectrum disorders: Relations to eye gaze and autonomic state. *Journal of Autism and Developmental Disorders, 40*(3), 358–370.

Baron-Cohen, S., Golan, O., & Ashwin, E. (2009). Can emotion recognition be taught to children with autism spectrum conditions? *Philosophical Transactions of the Royal Society B: Biological Sciences, 364*(1535), 3567–3574.

Brandler, W. M., & Sebat, J. (2015). From de novo mutations to personalized therapeutic interventions in autism. *Annual Review of Medicine, 66*, 487–507.

Buzhardt, J., Rusinko, L., Heitzman-Powell, L., Trevino-Maack, S., & McGrath, A. (2015). Exploratory evaluation and initial adaptation of a parent training program for Hispanic families of children with autism. *Family Process*.

Cooper, J. O. (1982). Applied behavior analysis in education. *Theory into Practice, 21*(2), 114–118.

Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). Applied behavior analysis.

Foster, I., & Tuecke, S. (1996). Enabling technologies for web–based ubiquitous supercomputing. In *high performance distributed computing, 1996, proceedings of 5th IEEE International Symposium on* (pp. 112–119). IEEE.

Golan, O., Ashwin, E., Granader, Y., McClintock, S., Day, K., Leggett, V., & Baron-Cohen, S. (2010). Enhancing emotion recognition in children with autism spectrum conditions: An intervention using animated vehicles with real emotional faces. *Journal of Autism and Developmental Disorders, 40*(3), 269–279.

Gutstein, S. E. (2009). Empowering families through relationship development intervention: An important part of the biopsychosocial management of autism spectrum disorders. *Ann Clin Psychiatry, 21*(3), 174–82.

Gutstein, S. E., Burgess, A. F., & Montfort, K. (2007). Evaluation of the relationship development intervention program. *Autism, 11*(5), 397–411.

Hiwasaki, Y., Ohmuro, H., Kurihara, S., & Kataoka, A. (2006). A G.711 embedded wideband speech coding for VoIP conferences. *IEICE Transactions on Information and Systems, 89*(9), 2542–2552.

Karst, J. S., & Van Hecke, A. V. (2012). Parent and family impact of autism spectrum disorders: A review and proposed model for intervention evaluation. *Clinical Child and Family Psychology Review, 15*(3), 247–277.

Kwong, M. W., Calouro, C., Nasseri, L., & Gutierrez, M. (2015). The federally funded telehealth resource centers. *SIG 18 Perspectives on Telepractice, 5*(1), 14–23.

Lee, R. S., & Wu, T. (2009). Subsidizing creativity through network design: Zero-pricing and net neutrality. *Journal of Economic Perspectives*, 61–76.

Pierce, W. D., Epling, W. F., Dews, P. B., Estes, W. K., Morse, W. H., Van Orman, W., & Herrnstein, R. J. (1994). Activity anorexia: An interplay between basic and applied behavior analysis. *The Behavior Analyst, 17*(1), 7.

Rogers, S. J. (1996). Brief report: Early intervention in autism. *Journal of Autism and Developmental Disorders, 26*(2), 243–246.

Rourke, B. P. (1982). Central processing deficiencies in children: Toward a developmental neuropsychological model. *Journal of Clinical and Experimental Neuropsychology, 4*(1), 1–18.

Rutter, M. (1983). Cognitive deficits in the pathogenesis of autism*. *Journal of Child Psychology and Psychiatry, 24*(4), 513–531.

Sandry, E. (2015). Re-evaluating the form and communication of social robots. *International Journal of Social Robotics*, 1–12.

Sinha, V. (2015, January 30). How Caroline Pugh at VirtualU Inc. intends to measure your exact body size. *Washington Business Journal*. Retrieved from

Sorensen, K. V. (1987). Research project into the introduction of ISDN in Europe (Denmark, the Netherlands, Federal Republic of Germany, France, United Kingdom).

Virnes, M., Kärnä, E., & Vellonen, V. (2015). Review of research on children with autism spectrum disorder and the use of technology. *Journal of Special Education Technology, 30*(1).

Walker, D. R., Thompson, A., Zwaigenbaum, L., Goldberg, J., Bryson, S. E., Mahoney, W. J., . . . Szatmari, P. (2004). Specifying PDD-NOS: A comparison of PDD-NOS, Asperger syndrome, and autism. *Journal of the American Academy of Child & Adolescent Psychiatry, 43*(2), 172–180.

Wang, Z., & Crowcroft, J. (1996). Quality-of-service routing for supporting multimedia applications. *Selected Areas in Communications, IEEE Journal, 14*(7), 1228–1234.

Wing, L., Gould, J., & Gillberg, C. (2011). Autism spectrum disorders in the DSM-V: Better or worse than the DSM-IV? *Research in Developmental Disabilities, 32*(2), 768–773.

World Health Organization. (2012). International classification of diseases (ICD).

Yasumoto, M., & Teraoka, T. (2015). VISTouch: Dynamic three-dimensional connection between multiple mobile devices. In *Proceedings of the 6th Augmented Human International Conference* (pp. 89–92). ACM.

Zwaigenbaum, L., Bryson, S., & Garon, N. (2013). Early identification of autism spectrum disorders. *Behavioural Brain Research*, *251*, 133–146.