Autism research is evolving to provide better ways to diagnose and treat the disorder.

Science claims that autism is mainly due to genetic and environmental factors, and involves everything neurological (the brain, heart, stomach, throat you name it!). Naturally, the best approach to properly diagnose and treat the disorder would be to examine the individual’s neurological activities (asking questions like: How does the different body parts interact? How does the heart function? How is the digestive system?). However, autism is most often diagnosed and treated using the naked eye of a clinician observing how the person behaves (asking question like: Is he looking at me? Is he fidgeting?). Clearly, there is a gap between what science suggests, and how this is clinically diagnosed and treated.

With the current state of technology, we can close this gap and improve the way autism is diagnosed and treated! The Sensory-Motor Integration Lab (SMIL) at Rutgers University and the New Jersey Autism Center of Excellence both led by Dr. Elizabeth Torres is steering this movement to transform the way autism is diagnosed and treated! We would like you to be a part of this movement, to help us pioneer the next change, to ultimately improve the life of people with ASD.
How is ASD diagnosed?

ASD is commonly diagnosed by a trained clinician, who observes and assesses the individual’s behavior. For example, this can be done based on the rubrics of ADOS (Autism Diagnostic Observation Schedule), a Psychological instrument, which focuses on the individual’s social behavior and communication; or it could be done based on the Diagnostics and Statistical Manual of Mental Disorders (DSM), a manual that Psychiatrists have to guide them on how to diagnose and prescribe medicine. However, because these assessments rely on the observation of how the individual interacts with the clinician, they are inevitably subjective. In fact, there are many cases where children are misdiagnosed with ASD, and severity of the disorder inaccurately assessed.

Of course, this may be the best way to diagnose, if we did not have the technology. Today, with countless high-resolution sensors such as smart-watches, smartphones, and other research grade devices (e.g., EEG, motion capture system), it is now possible to do this more objectively, and even at the convenience of one’s home. Moreover, this would be much cheaper to do, as most of us already have smartphones!

How can ASD be diagnosed with devices like smartphones and smartwatch?

At the Sensory-Motor Integration Lab (SMIL), we have done research for over a decade on how an individual’s movement variability is informative about the neurological state. We have tested this on well over 1000 individuals of different age groups, gender, education, and neurological disorder (e.g., ASD, Schizophrenia, Parkinson’s disease). As people move around, the variations in their motions fluctuate. As it turns out, they fluctuate differently in each disorder; and within each disorder, they have certain characteristic patterns. The way these fluctuations change over time is unique to each person, just like a fingerprint. The common characteristic pattern among autistic individuals is the high noise level (lacking order or structure), and this noise increases with the disorder’s severity [1].

Most commercially available smart-watches and smartphones have the capacity to record your motion. What our lab invented is an algorithm to use this recorded motion and compute the noise level from its fluctuation pattern. This would not only make the diagnosis more objective and accurate, but it would also allow the patient to do this remotely from the convenience of one’s home. Moreover, it can also be used to continuously track the severity of the patient’s disorder.
**How would this change the way ASD is treated?**

Using the fluctuation pattern of the ASD individual, we are promoting treatments that would reduce the level of noise in these people. This cannot be done by merely “making” the individual act or behave in a certain way (for instance, by encouraging the child to imitate another person). We need to think more deeply! The “healthy” fluctuation pattern can only be observed, if the person possesses agency.

**What do we mean by agency?** All of us certainly do not have full agency, since we cannot fully control the fate of our lives. What we mean is the capacity to physically act *at will*, and control our surroundings. Healthy adults can certainly recognize thirst, and willfully hold a cup to get water. But neurologically impaired patients have difficulty in recognizing thirst, and/or reaching out the arm to hold a cup to pour water. That’s what we mean by agency. We want to treat the autistic person, by helping them self-discover their wants and needs, and learn how to attain their goals. Just like how a newborn infant explores the environment, and eventually learns to control his actions over the years.

**How can you increase agency in an autistic person?**

In an earlier study [2, 3], we asked ASD children to sit in front of a screen and did not provide any further instructions. The screen that we provided was a part of a system, where we would display a video clip (such as a Disney clip) only when the child’s hand was positioned in a specific space (just like the sensor-based faucet at public bathrooms). We did not ask them to look for anything or to move in a certain way. Nevertheless, the child eventually found out a way to display the video clip and did so spontaneously. Surprisingly, over the short time period, from the moment of not knowing what to do, until the moment when the child understood how to turn the video ON, we noticed a dramatic fall in the noise level of his fluctuation pattern. There, we discovered a target for treatment - to reduce the noise in the child’s movement fluctuation (that is invisible to the naked eye!).
This is the type of intervention that we are aiming for. We are developing ways to help the autistic person learn how to discover their needs and wants, and how to pursue their desires in their own unique and effective manner. We want to encourage the autistic person to freely discover how to control the things around him(her)self – whether that is video, the body, or the interactions with others - just like how healthy adults discover their own way to navigate this world. Eventually, we want to have a treatment that would allow autistic children and adults to become more independent and integrated into the community.

![Image](image.png)

**What is the next step in this research movement?**

The SMIL is pioneering this movement, and this cannot be done without the help from the autism community. We have the framework laid out, and we have evidence to show that this method works. However, in order to make these methods robust and ultimately widespread, we need the participation of autistic children and adults at all levels of severity, so that we can refine our methods for diagnosis and treatments. **We invite you to be a part of this exciting movement!** We are currently conducting studies to gather data at the Sensory-Motor Integration Lab (SMIL) at Rutgers University (New Brunswick campus). We invite all individuals with ASD, their family members, and typically developing healthy individuals as well.

**What is expected in the study?**

In this study, the participant will wear wireless motion sensors (similar to smart-watch) that would be attached across different parts of the body (for demonstration, see xsens.com [Link](xsens.com)). These sensors will record the movement of the participant while performing a set of tasks. The participant would also wear an adhesive wearable ECG near the collarbone to record the heart activity (see mc10inc.com [Link](mc10inc.com)).

In general, the participant would 1) walk freely around the room, 2) perform pointing motions and/or throw magnetic darts, and 3) lie down for about 5 minutes. Depending on the participant’s age and preference, we would have the participant perform additional tasks (e.g., play shape sorter, peg...
puzzle, draw on a sketchbook). The study would take about 1 - 1.5hr, and our lab (SMIL) is located at Rutgers University, located at 152 Frelinghuysen Road, Piscataway, NJ 08854.

Within a few months to a year after the study, we would provide a profile of the participant’s statistical pattern, with a comparison of what a similarly aged neuro-typical person would show (left) for each set of tasks that the participant performed. We caveat that this method is still a work in progress, and the results that we would share is not FDA approved.

How can you sign up to participate in this study?

If you are interested in having your family member or yourself participate in this study, or have any questions, please contact:

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Members of the Sensory-Motor Integration Lab (SMIL)
The Science Behind It All

How is the fluctuation pattern measured? The Sensory-Motor Integration Lab (SMIL) has been researching people’s movement for over a decade. What we discovered from our work is that the fluctuations of one’s motion is informative about the person’s motor control. Let’s take an example of a pointing action (see Figure 1A). When a person points at the green dot (the visual target), he makes two types of actions. One is the forward reaching action (red arrow) and another is the backward retracting action (blue arrow). During these actions, motion sensors record the kinematics (such as speed, velocity, acceleration) as shown in Figure 1B. What we found is that the peak values of these kinematics (denoted in red dots during reaching actions; and blue dots during retracting actions) are informative about the control that is exerted. Here, we assume that a reaching action (in red) involves more control since it has a specific intended goal to reach the target, and a retracting action (in blue) involves less control, since this is an automatic action without a specifically instructed ‘goal’. If we compile all the red dot values and plot a histogram and compile all the blue dots and plot a histogram (as shown in Figure 1C), we notice the difference in the shapes of these histograms. In mathematical terms, such histogram shapes can inform us about the noise level, which essentially indicates how unpredictable the motion is.
How does the fluctuation pattern of ASD person differ from a healthy person?

People with ASD have shown high noise levels compared to their healthy counterparts. One of the studies that reveal such finding is from an earlier work conducted at the SMIL (shown in Figure 2). Here, typically developing children and ASD children performed pointing motions repeatedly for 100 times. For the neurotypical child (left), the speed was periodically consistent throughout their repeated motions; however, for the ASD child (right), the speed was randomly different across each pointing motion. This can be seen in Figure 2A, where each line represents the speed profile during a single pointing motion; and in Figure 2B, where the color denotes the speed across trials of repeated pointing motion (y-axis); and in Figure 2C, where the yellow dots indicate the moment peak is exhibited in their speed graphs. All figures 2A-C is represented across time frames (x-axis).

What does this noise mean? The high noise level we see in people with ASD can be interpreted in two ways. It can be that the brain activities have lots of noise, and this noisy pattern is simply sent to the body, and the bodily motion is reflecting that noise coming from the brain. But we can think of this the other way as well. There may be a lot of noise that the ASD person is sensing from his/her self-generated motions, and this excessively noisy sensory information from the body is continuously sent to the brain, and the brain is thus inundated with noise.

What is interesting is that this pattern we found among ASD people is similar to a deafferented person (a person who cannot sense his body motions, and instead relies on vision to know whether he is sitting down or walking). So, based on these types of patients, we conjecture that the type of sensory signal that ASD people’s brain are receiving is like those who cannot sense their bodily motion.

Figure 2. ASD children (right) show highly random noise in their repeated pointing motions compared to healthy children (left) of similar age.

Figure 3. Deafferented person who cannot feel his body
Is noise bad? It is not that simple. While having noise sounds like a bad thing, healthy people have a good balance of noise. Some actions that involve voluntary control (e.g. when you point at an object, or reach out to get something) involve a certain level of noise; and some actions that involve spontaneous control (e.g. when you make natural hand gestures while talking to a friend) involve a different level of noise. So, a healthy person possesses a wide range of noise, each corresponding to a certain type of control. But if you have an imbalanced and excessive noise across the body, and across the different levels of neuromotor control (ranging from autonomic to involuntary to voluntary levels), you will not have the proper sensory feedback that is needed to structure your thoughts and guide your (moment-by-moment) actions. In this case, the brain will have too much cognitive load to even think of a simple direction of movement (e.g. right vs. left); while the healthy person will not have this problem, thanks to the proper sensory feedback from the bodily biorhythms.

How does this noise vary across age? We have measured this noise level among healthy people and ASD people, across different ages ranging from 3 to 61, as shown in Figure 5 [2, 3]. In general, we found the noise level to be high when the healthy person is at preschool age (denoted in green), and to reduce over the years until they reach adulthood (denoted in red). If we compare this to ASD children with ages 3-25 for both verbal (denoted in black) and non-verbal (denoted in pink) capacity, we found their noise level to range in the area of a typically-developing preschool aged child.
This finding alludes to the stunted development among ASD children in attaining full agency of their body. But further, this also provides a direction of target for treatment (shown in blue circle). This is a great improvement over how ASD is treated today. Currently, treatment goals are rather subjective, as they are based on the clinician’s subjective assumptions and expectations (asking questions like, does he make eye contact? does he make fewer repetitive motions?). Furthermore, the treatments never address the deeper questions: why is he not making eye contact? why is he, a 10-year-old boy (for example), making repetitive motions as an infant would? These questions can certainly be addressed if we consider the person’s physiological aspects of their nervous systems.

For that reason, we are suggesting a more objective approach, that is not confined to dictating how a person should socially behave. Instead, we suggest that treatments should help direct a person to have better control over their brain and body, in a more physiologically sensible manner. This can be done by defining the treatment goals to be based on the physiological measures (e.g., motor fluctuation patterns).

**Is the problem confined to the noise in motion sensing?** No, there are other problems, but they cannot be measured with the current state of technology. (Maybe we can do that 10 years from now). But at this stage, we can certainly measure the person’s motion non-invasively in the comfort of their homes and infer the quality of the sensory feedback that the brain receives from the bodily motion (with high precision!). These motions include some obvious ones such as the kinematics (e.g. speed, velocity) of one’s body movements.

But we can also include some non-obvious ones, such as facial muscles that spontaneously express emotions, throat muscles needed for swallowing and talking, and heart muscles to autonomously sustain our heart beating and our lungs breathing.

The rationale behind this approach is that a person’s level of control ranges on a spectrum from autonomic to involuntary to voluntary (see arrow on the left) and we have three types of muscles that accomplish those levels of control: cardiac, smooth and skeletal. Our SMIL research has found evidence that these levels of muscle control can be used to stratify the broad spectrum of autism.

The fluctuation patterns generated by these motions in ASD are different depending on the level of control. This is not surprising, but we now know that these different patterns
automatically create classes of a certain kind, whereby people with similar patterns group together. Since the body is interconnected within multiple layers of the nervous system (across central, peripheral, and autonomic nervous systems), this outcome makes sense. Naturally, the disorder should be found across the different nervous systems, and consequently, across different levels of control.

When we talk about agency – that is, to physically act according to one’s will to modify one’s environment– we believe that it can only be experienced by having the proper balance of neuromotor control across all these levels, so the systems work together holistically and effectively. That being said, we are not confined to examining how the right arm is moving, or how a person is making eye contact. We are thinking bigger and deeper and are looking at all aspects of the body – from the heart to the body to the brain.

If you would like to learn more about the work that is done at SMIL, please go to our website: https://sensorymotorintegrationlab.com/

References