Can We Predict Behavior Problems in Children with Autism?

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Abstract

Kids with autism often “see” the world differently than other kids do. They can have unique experiences of vision, hearing, taste, smell, or touch sensations. These sensory changes are often linked to behavior problems such as isolation, lack of interest, aggression, anxiety, depression, or lack of attention. We thought it would helpful if we could detect behavior problems that might not be obvious yet but are possible in the future. In our study, we used computer programs, based on a type of artificial intelligence called machine learning, to predict possible behavior problems based on how autistic kids receive sensations in their everyday lifes. Our programs analyze the answers to test questions about the way kids perceive the world through their senses, and these programs can then make reliable predictions of behavior problems before they arise. These early predictions allow families and doctors to be aware of and treat those problems early.

Keywords: machine learning, autism, sensory perception, behavior problems, prediction.

WHAT IS AUTISM?

Autism is a brain disorder with a big impact on how people perceive the world around them, how they behave, and how they socialize (for more information on autism, see this Frontiers for Young Minds article). Autistic kids may struggle with social interactions like making friends, for example. They can also have unusual interests, like trains, dinosaurs, traffic lights... The behavior of autistic kids can cause problems in their development, growth and social relationships.

Kids with autism often perceive visual, auditory (hearing), taste, smell, or touch sensations differently than kids without autism do. For example, overreaction to certain daily life sounds as the fridge, a fan... These differences in perception are believed to be related to the behavioral problems that these kids often experience. What if we could predict behavior changes before they are obvious and cause problems, just by understanding the way that kids are perceiving sensations? This knowledge could give doctors an early sign of behavior changes so they could treat them, and could also give families time to learn how to manage behavior changes.

To know how kids perceive their environments (i.e., how they see, hear, taste, touch, or smell) is not simple, but parents of autistic kids can take some tests that provide valuable information for doctors and researchers. We used two tests for kids and teenagers: a sensory test, which asks about kids' perceptions, and a test about behavior problems such as anxiety, rule breaking, or attention problems 1, 3]. In our research, we asked parents to complete the sensory test, and then we used the scores from that test to predict the scores on the behavior test.

OUR WORK

During the study, we asked the parents of 72 autistic kids (21 girls and 51 boys) to take the sensory and behavior tests. Kids' ages ranged from 6–14 years old. The sensory test, called Sensory Profile 2 (SP-2), has 86 questions [1], and the answers are scores with possible values of 0 (not applicable), 1 (almost never), 2 (occasionally), 3 (half of the time), 4 (frequently), or 5 (almost always).

The questions in the SP-2 test are divided into groups: *seeking*, *avoiding*, *sensitivity*, and *registration*. The scores in these groups define how the child "sees" the world. For example, high scores in questions from the *seeking* group mean that the child wants to feel everything from the environment, like touching everything, watching bright lights very closely, or taking risks climbing on a tree. High *avoiding* scores mean that the child does *not* want to feel sensations around themself and prefers to avoid them. High *sensitivity* scores mean that the child feels sensations stronger than other people do. High scores in the *registration* category mean that the child barely feels sensations that others easily feel. Extremely high or low values on any of the questions indicate sensory experiences that are different from non-autistic kids. **Figure 1A** shows the number of questions for each group, with example questions. We thought that sensations of touch (*touch processing*) could also be interesting to predict changes in behavior.

(A) Sensory Profile 2		
Group	**No. of questions**	**Example questions**
Seeking	19	Does the child try to smell things that are not food?
Avoiding	20	Does the child cover their ears to protect from sounds?
Sensitivity	19	Does the child eat only certain flavours?
Registration	22	Does the child seem not to notice temperature changes?

Touch processing	11	Does the child scratch their skin when something touches it?
Total	86	All test questions
(B) Child Behavior Checklist		
Behavior problem	**No. of questions**	**Example questions**
Anxious/depressed	13	The child cries a lot.
Withdrawn/depressed	8	The child is usually in a bad mood.
Physical complaints	11	The child has headaches without medical cause.
Social problems	11	The child is more dependent than other kids.
Thought problems	15	The child sees things that are not real.
Attention problems	10	The child has problems finishing tasks.
Rule-breaking behavior	17	The child normally lies or cheats.
Aggressive behavior	18	The child destroys other's things.
Internal problems (other people cannot see)	32	Anxious/depressed, withdrawn/depressed, physical complaints.
External problems (other people can see)	35	Rule-breaking behavior and aggressive behavior.
Total problems	113	Includes all the test scores.

Figure 1: (A) The SP-2 test is designed to understand how an autistic child "sees" the world. The questions are divided into 5 groups based on the type of sensory perception being looked at. Scores for each question range from 0 (not applicable) to 5 (almost always). **(B)** The CBCL test looks at behavior problems. Scores for each question range from 0 (sometimes true) to 2 (very true).

The test about behavior problems, called the Child Behavior Checklist (CBCL), has 113 questions with scores of: 0 (not true), 1 (sometimes true), and 2 (very true) [2]. The higher the score in a CBCL question, the greater the likelihood of the behavioral problem reflected by that question. For each behavior problem, we use the scores of the related questions, along with the child's age and sex, to calculate the CBCL score, which has a value are between 0 and 100. **Figure 1B** lists the 11 behavioral problems that we looked at in our study, with examples of questions.

MACHINE LEARNING

We wanted to predict whether kids with autism are likely to have problematic behavior changes based on how they "see" their environments. To predict behavior problems that are not happening yet might sound complex, but thanks to computer programs based on **machine learning** it has become much easier. Machine learning programs are used, for example, in sports, streaming platforms, or social media, to make content suggestions based on what we have watched or liked. These programs make predictions about future situations (for example, a picture we might like) by learning from information about the past (other pictures we liked, accounts we follow, etc.). In our case, we wanted to see if we could use machine learning to predict a child's scores on the CBCL test based only on the scores from their SP-2 test.

Let us imagine the scenario in **Figure 2**. There is a 5-year-old girl who kicks a ball, and it goes 5 m. Another girl, who is 10 years old, kicks the ball 10 m. Can you try to guess how far a 7-year-old girl might be able to kick the ball? Maybe it is not easy to know for sure, but common sense tells you that the ball will most likely travel a distance between 5-10 m, because the 7-year-old girl is expected to be stronger than the 5-year-old girl but weaker than the 10-year-old girl.

In this example, the age of the girl is used to predict the distance the ball travels. In our autism study, the machine learning program uses the scores from the SP-2 test to predict future changes in behavior, which would be reflected in a future CBCL test. For example, in **Figure 3** we used information on how a child avoids sensory experiences (*avoiding* in Figure 1A) to predict the existence of problems in social environments (*social problems* in Figure 1B), as we will see in the next section.

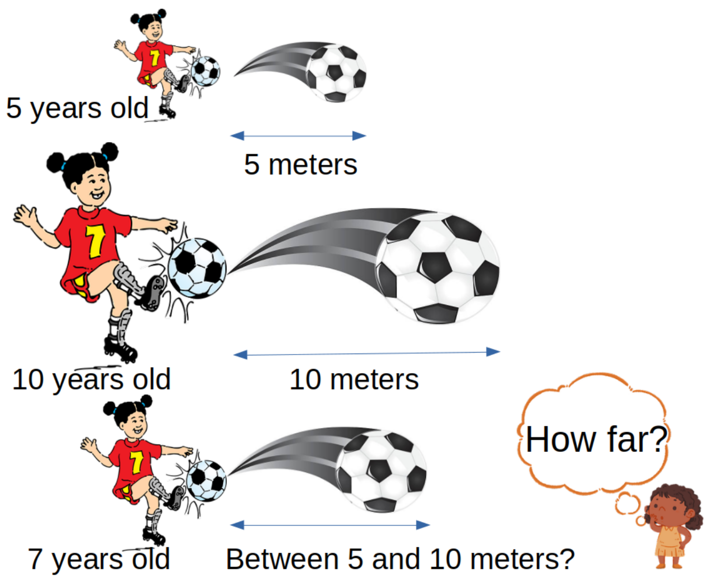

Figure 2. Predictions can be made from existing information. For example, if you know that a 5-year-old girl can kick a ball 5 m, and a 10-year-old girl can kick a ball 10 m, you can make a prediction of how far a 7-year-old girl might be able to kick a ball.

CREATING THE PROGRAM

There were three steps to create our machine learning program: training, testing, and reliability assessment.

Training

To train the program, we gave it examples from kids' scores on SP-2 and CBCL tests. For example, we gave the program a child's 20 scores from the SP-2 group *avoiding* (question scores 1, 4, 1, 5, 4, 1, 4, 0, 1, 2, 2, 1, 2, 1, 4, 2, 0, 1, 1, 1) and the child's *social problems* score (57) in the CBCL test; a second child has different *avoiding* scores (2, 1, 5, 5, 4, 5, 0, 1, 5, 0, 1, 4, 0, 5, 5, 0, 1, 0, 1, 2) and a *social problems* score of 78; etc. We gave the computer this kind of data for 71 out of 72 kids, thus leaving one kid out. These data compose the **training set**, as it is meant to teach the computer program the relationship between SP-2 and CBCL scores—similar to how you could see a relationship between age and how far the ball was kicked in **Figure 2**.

Testing

Once the computer program was trained, we gave it SP-2 scores from the child who was not included in the training stage. Using the relationships learned from the training data, the program calculates the CBCL score using just the child's SP-2 scores. The training and testing were repeated 72 times, each one leaving a different child out of the training set and using it for testing.

Reliability assessment

To see if the program's predictions were accurate, we needed the true CBCL scores for the kids whose data were used in the testing stage. We analyzed how similar the predicted and true CBCL scores were. The closer the predicted scores were to the real scores, the more reliable the computer's prediction.

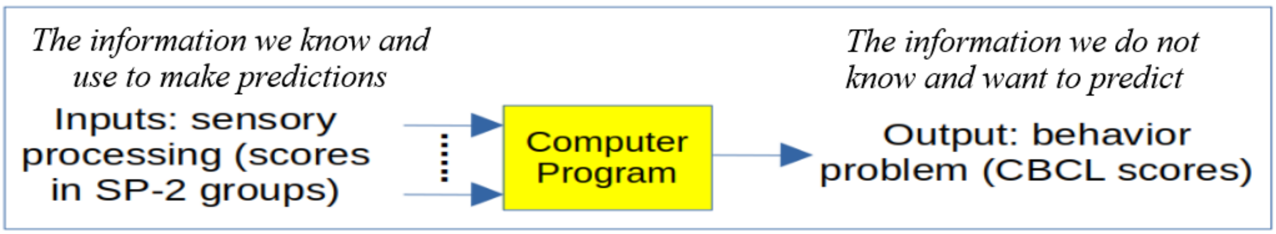

Figure 3. To generate our predictions, we used machine learning programs. After training these programs, we could input (enter) scores from a child's SP-2 test and the program could output (predict) that child's CBCL scores, telling us about possible future behavior problems.

There are several machine learning programs that can be used to get our prediction. Their reliability may change depending on the groups of SP-2 scores and the types of CBCL scores to be predicted. In our research, we tried 26 machine learning programs [3], and we made different programs for each of the groups included in the SP-2 test. The use of 26 machine learning programs with the combination of the 6 SP-2 groups and the 11 CBCL scores means that we tried 26 × 6 × 11 = 1,716 different programs.

RESULTS

We saw that the most reliable program accurately predicts the *external behavior problems* in CBCL considering all the SP-2 scores (*total* group in **Figure 1A**). The scores predicted by our program differ by just 1 unit with respect to the true value. Here is an example to make this clear. We apply the SP-2 test to a child. The *total* group that the child scores on the SP-2 test is the collection of the 86 scores between 0 and 5. We give these numbers to the program, which makes mathematical calculations and predicts a value of 16 for the *external problems* score. Then, we apply the CBCL test to the child, and they get an *external problems* score of 15. Comparing the predicted (16) and true (15) scores, we see that the program was very close to the true score—only one unit off.

Other programs also achieved reliable predictions for the following eight behavior problems: *anxious/depressed*, *withdrawn/depressed*, *social problems*, *thought problems*, *attention problems*, *aggressive behavior*, *internal*, and *total*. The prediction is less reliable for the remaining two problems: *physical complaints* and *rule-breaking behavior*. Specifically, we learned that *avoiding* has a significant influence on *anxious/depressed*. *Seeking* has a strong influence on *attention problems* and *physical complaints*. *Touch processing* plays a role in *rule breaking behavior.* Finally, *registration* influences *social problems*.

Considering the high reliability in the prediction of these 9 types of behavioral problems, it may eventually be unnecessary to use the CBCL test at all—we could possibly just use the SP-2 test and predict the CBCL scores from those results. If the predicted CBCL score indicates that there are behavioral problems, doctors can begin to treat those problems.

CONCLUSION

Autistic kids often receive sensations from their environments in unusual ways, and this may lead to behavior problems. To understand this connection better, we used two tests: one that assess alterations in the senses, and one that looks at behavioral problems. By analyzing scores from the sensory test, we created machine learning programs that could predict scores on the behavior test. We found that prediction of *external* behavior problems (those that all people can see) is highly reliable using the total of all the sensory scores. Our programs can also accurately predict 8 other behavior problems, but they are not as good at predicting the remaining 2. These findings show that it is possible to anticipate problems in behavior by looking at early signs of sensory alterations. Doctors can then use this information to provide early treatments that may help to reduce future behavior problems.

Glossary

Autism: A disorder affecting communication and behavior, often characterized by challenges with social interactions, repetitive behaviors, and unique strengths and differences in how a person perceives and interacts with the world.
Machine learning: A type of artificial intelligence that allows computers to learn from data and improve their performance over time.
Training set: A data set used to teach an algorithm. It has input and output pairs that the algorithm learns from.

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María Tubío Fungueiriño was born in Boiro, Spain, in 1992. She holds a Ph.D. in neuroscience and clinical psychology from the University of Santiago de Compostela. She is currently a researcher at the Instituto de Investigación Sanitaria de Santiago de Compostela (Spain), in the Genomic Medicine Group. Her reseach interests include the psychology of autism.

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