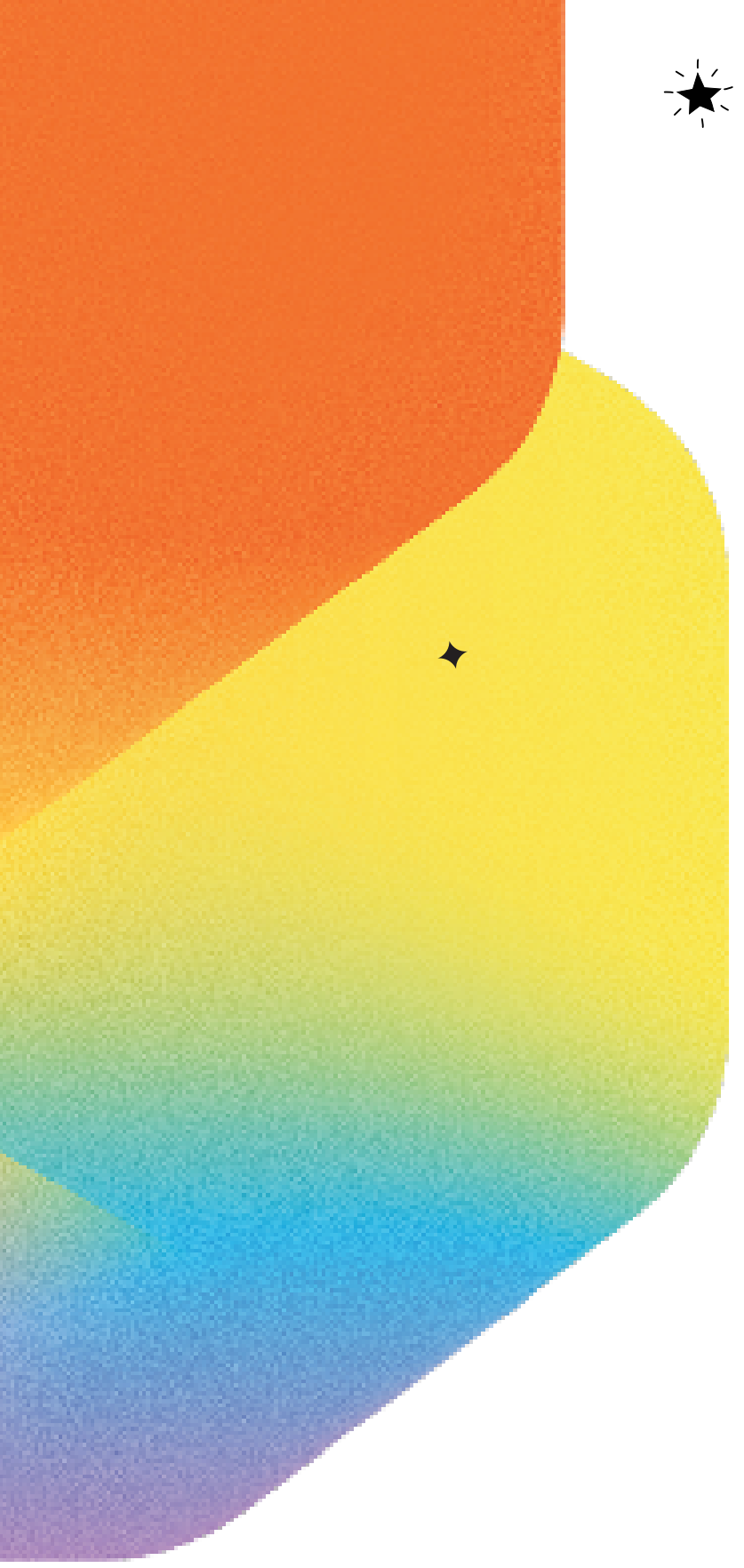

10 YEARS of SPARK

10 YEAR REPORT

STEP BY STEP
WE SPARK
AUTISM RESEARCH

SPARK

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The SPARK Community

400,000+	TOTAL STUDY PARTICIPANTS
170,000+	INDIVIDUALS WITH AUTISM
30+	ACADEMIC AND MEDICAL INSTITUTIONS
300+	RESEARCHERS USING SPARK DATA

SPARK Genetic Data

200+	AUTISM-RELATED GENES DISCOVERED ‘
4,000+	AUTISTIC PEOPLE RECEIVED A GENETIC FINDING
78,000	AUTISTIC PARTICIPANT’S DNA SEQUENCED
119,000	FAMILY MEMBERS’ DNA SEQUENCED

SPARK Research Match

300+	RESEARCH MATCH STUDIES LAUNCHED ‘
142,000+	FAMILIES INVITED TO PARTICIPATE
66,500+	RESPONSES TO STUDY INVITATIONS

About SPARK

Ten years ago, SPARK set out with a bold mission: to advance autism research and make discoveries to improve lives.

Today, SPARK has become the largest autism research study ever! Together, we’ve broken new ground, unlocked insights, and built a foundation for discoveries still to come. This 10th anniversary report celebrates what we’ve accomplished together—and honors the people who made it possible.

10 Areas Where SPARK Increased Our Understanding

The SPARK community has made incredible progress to advance autism research.

- ACCELERATED DISCOVERY OF THE GENETIC CAUSES OF AUTISM
- GAINED INSIGHTS INTO DIFFERENCES BETWEEN BOYS AND GIRLS
- DEEPENED OUR UNDERSTANDING ABOUT AUTISTIC WOMEN
- DISCOVERED BRAIN-LANGUAGE LINKS ARE MORE COMPLEX THAN PREVIOUSLY THOUGHT BY STUDYING BABY SIBLINGS
- HELPED UNDERSTAND AUTISTIC ADULT HEALTH OUTCOMES AS THEY AGE
- ENHANCED ABILITY TO PREDICT BEHAVIORAL OUTCOMES IN CHILDREN
- EXPLORED HOW DATA CAN BE USED TO DEFINE AUTISM SUBTYPES
- RETURNED 1,000'S OF GENETIC RESULTS
- INCREASED AWARENESS OF SENSORY ISSUES
- GAINED A MORE IN-DEPTH VIEW OF PROFOUND AUTISM

About Genetics

Studies using SPARK's sequencing data have led to the discovery of hundreds of genes that are strongly linked to autism.

These discoveries reflect the wide spectrum of autism and help us to better understand the complex genetic factors.

SPARK Genetic Milestones

2023	EXPANDED OUR RETURN OF RESULTS EFFORTS TO INCLUDE SECONDARY FINDINGS FOR CANCER AND HEART-RISK GENES
2024	THE STUDY MOVED FROM WHOLE EXOME TO WHOLE GENOME SEQUENCING

New Layers to the Genetics of Autism

SPARK provides researchers with unprecedented numbers of genetic sequences from people with autism. Using SPARK data, alone and with other large datasets, researchers have been able to dig deeper into the genetics of autism than ever before.

Before SPARK data, autism studies focused on rare and spontaneous genetic changes that have large effects and often lead to intellectual disability. With many more sequences, researchers are now identifying genetic variants that lead to moderate effects, often with no intellectual disability, and are more likely to be inherited. These variants are beginning to explain how autism is passed down in families.[1,2]

Autism genetics studies are now big enough to uncover new sets of autism genes, which will help researchers understand the biology of autism.[3] They are helping to untangle autism from conditions with overlapping genetics, such as developmental delay and intellectual disability.[4-6] They are also helping us understand why autism is more common, and sometimes looks different, in boys and men than in women and girls.[5,7]

Guide to Autism Genetics Variants

Each person with autism has a unique set of environmental and genetic factors that contribute to their condition.

Genetic variants are like ice cubes of varying sizes in a cup of water. The line represents the threshold for an autism diagnosis. There are different ways for the water to reach the line, which may lead to an autism diagnosis. Different types of variants can work together, along with environmental factors.

ONE DE NOVO VARIANT

De novo variants are not inherited from parents and can have a large effect on the water line. One de novo variant may be enough to lead to autism in a single family member who has no family history of the condition.

RARE/MODERATE EFFECT VARIANTS

A few genetic variants of moderate effect may also lead to autism. These may be inherited from a family member.

COMMON/MILD EFFECT VARIANTS

Common/ mild effect variants are found in many people, with and without autism. A certain combination of these, passed down from one or both parents, can help push the water above the line.

Links Between Autism Genetics

SPARK participants have the opportunity to fill out multiple surveys. This gives researchers rich data on autism features and co-occurring conditions that they can link with genetic data from the same participants.

One large study used SPARK data to look for factors that predict childhood milestones, such as when parents say their child first walked, or ate without help.[8] Children diagnosed under the age of 5 and those with strong autism risk variants showed greater delays than children without these features. Two other studies combined SPARK survey data with SPARK genetic data, which they used to calculate polygenic scores of autism or other conditions. Polygenic scores are tallies of genetic variants that tend to be present in people with certain traits.

"When we got our genetic results, it gave us more of a road map."

– **DAKIN STOVALL**
AUTISM MOM
SPARK PARTICIPANT

One study with SPARK participants suggests that the link between having mental health challenges and being gender-diverse might be due to the stress of gender diversity, rather than a single genetic cause.[9]

Another study used SPARK data to create a polygenic score for attention-deficit/hyperactivity disorder (ADHD) and autism that would improve upon traditional scores' ability to tell the two conditions apart.[10]

The Value of Genetic Analysis

SPARK is one of the largest research studies to tell participants about genetic variants that are the likely cause of their autism. Several studies have looked at these data to understand the best ways to approach genetic testing for autism.

A study on SPARK data shows that about 9 percent of autistic people in SPARK have a genetic cause that is well-understood and can be shared with families.[11] Finding these types of genetic variants is more likely in females with autism than in males, and in people with complex medical features, such as intellectual disability, motor challenges, or seizures. Having more of these features increases the chance that a SPARK participant will have a reportable genetic finding, but even people with none of these predictors may have a clear genetic contribution that SPARK can report back to them.

Another study sent surveys to families both before and after they received genetic results from SPARK. It found that receiving a result reduced parents' feelings of self-blame and did not change their sense of optimism, self-esteem, and views of genetic stigma.[12]

Surveys of SPARK participants can help researchers understand how people think about genetic testing and participation in research studies. According to one study, both SPARK and non-SPARK participants have come to understand more genetic concepts over

the past 8 years. And families that enroll in SPARK tend to know more about genetics than the general public does.[13]

SPARK participants are more likely to expect a result if their child has more autism symptoms, and they are less likely to expect one if they feel that their stress, behavior, attitudes, worries, and emotions caused their child's autism.[14]

Asian and Black families are traditionally under-represented in genetics studies. A focus group of Asian and Black families interested in participating in SPARK describes barriers to participation, but also a desire to contribute to help future generations.[15] SPARK is working on several projects to recruit people who are traditionally underrepresented in genetics studies.

Finding Groups within the Autism Diagnosis

By combining SPARK participants' genetic and questionnaire data, scientists can start to look for different types of autism. One study used machine learning, a form of artificial intelligence, to identify four types of autism from 239 developmental and behavioral features from SPARK surveys. The researchers mapped these features to different types of genetic changes.[16]

Another study looked at six core factors of autism, such as social challenges or insistence on sameness, and found that these classic autism features are more linked to mild genetic changes than to strong ones.[17]

Another study suggests that early development, language changes, and genetic profiles can help predict which children might later have intellectual disabilities, though these predictions aren't perfect yet.[18]

About Diagnosis and Services

Many researchers have focused on making sure that autism diagnoses happen in a timely manner.

Children are getting autism diagnoses earlier than ever before. Still, things like sex at birth, symptoms, and access to care and services have a significant impact on diagnosis age.

Early Diagnosis

Recent research on SPARK participants shows that the age of autism diagnosis is influenced by many factors.[19-26] Although autism awareness and early diagnosis have improved, parents and adults find that navigating the diagnostic process is a challenge.[27]

Children who are diagnosed early in life, typically before age 5, tend to have developmental delays, intellectual disabilities, a sudden loss of skills, or autism-specific first signs, such as non-typical eye contact.[19,20] By contrast, women, and people who have received other mental health diagnoses, tend to be diagnosed later, often after age 21. Adults in this group report behaviors to hide or mask their autism features, also called camouflaging.[21-24] Families of Black and multiracial children often face multiple evaluations, misdiagnoses, and longer wait times.[25,26]

Barriers and Access to Care

SPARK research has looked at the treatments and services for autistic children and adults. It has also helped to document the challenges that people face in getting access to help.[26,28-37]

Many autistic children receive at least one type of therapy, but what they receive varies. Rural families often rely on school-based services, whereas urban families are more likely to get therapy at home. Common barriers to treatment include long waitlists, limited insurance coverage, and, during the COVID-19 pandemic, disruptions to care that made challenges worse. Service disruptions during the pandemic had a negative impact on family mental health overall.[28-30] Families with lower income, children with more severe autism, or children with repetitive behaviors were the most likely to face these challenges and the least likely to access online services.[31-37]

Because Every Autism Journey Is Different,

Every Autism Journey Matters for Research

About Behavior

SPARK researchers understand that the ways in which autistic people experience the world can create both high-highs and low-lows.

Through their research, they are working to better understand behaviors like sensory sensitivities, emotion regulation, and special interests.

Sensory Sensitivities

Researchers used SPARK data as part of a large study to explore how autistic people experience the world through their senses. The main question was whether sensory behavior should be thought of as a single thing, or studied individually for each sense. They found that people who have high sensory sensitivity or find sensory inputs uncomfortable tend to feel the same across sensory inputs, such as sounds, smells, or textures. However, the opposite kind of reaction – liking, or not minding, sensory inputs – can depend on individual preference. The researchers suggested that surveys and treatments should focus on each of the five senses separately to get a better understanding of a person's sensitivities and discomforts.[38]

Emotion Regulation

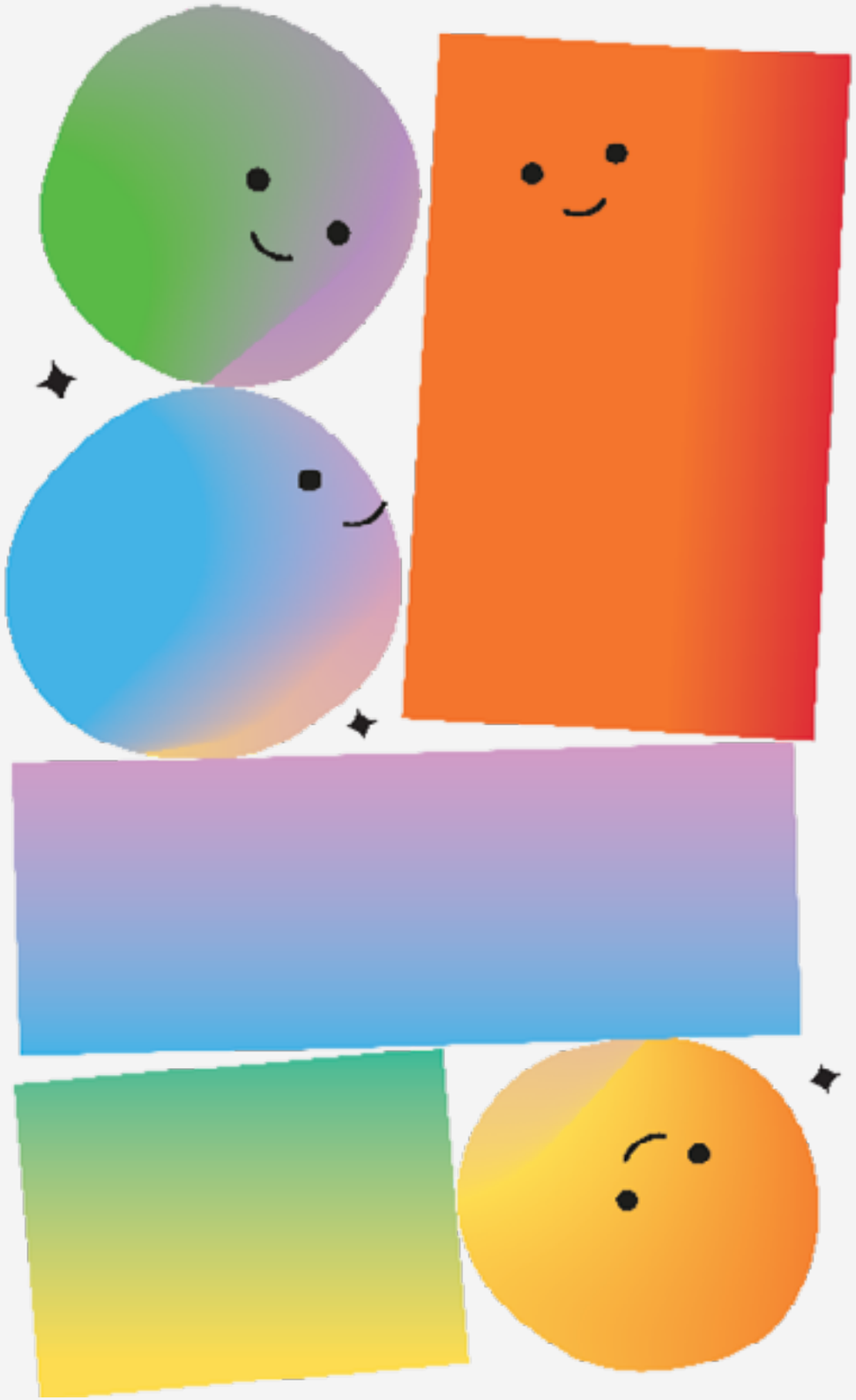
A team of researchers recently recruited SPARK participants to create a new measure of emotion dysregulation for use in younger children, ages 2 to 5 years. Doctors can use the Emotion Dysregulation Inventory – Young Child (EDI-YC) to assess all toddlers, including those with developmental concerns or diagnoses and those without. This makes it a particularly useful tool in the early screening of young children.[39]

Another recent study used SPARK data to learn about the link between emotions and types of restricted and repetitive behaviors (RRBs) in non-speaking autistic children. They found that children with intellectual disability who are non-speaking have more anxiety and more difficulty regulating their emotions, and are more likely to engage in certain RRBs, including self-injury behaviors, than those who communicate with single words.[40]

Special Interests

SPARK data has also provided new insights into the special interests of autistic youth. The study identified eight ways that children engage with special interests, such as creating, collecting, and information-seeking. Caregivers tend to view certain types of engagement, such as creating and information-seeking, as positive and adaptive. By contrast they view others, like perseverating (fixating on a thought or task) and object attachment, more negatively. Thinking about special interests as types, or modalities, can help parents and caregivers support their children's interests in a way that promotes positive development and well-being.[41]

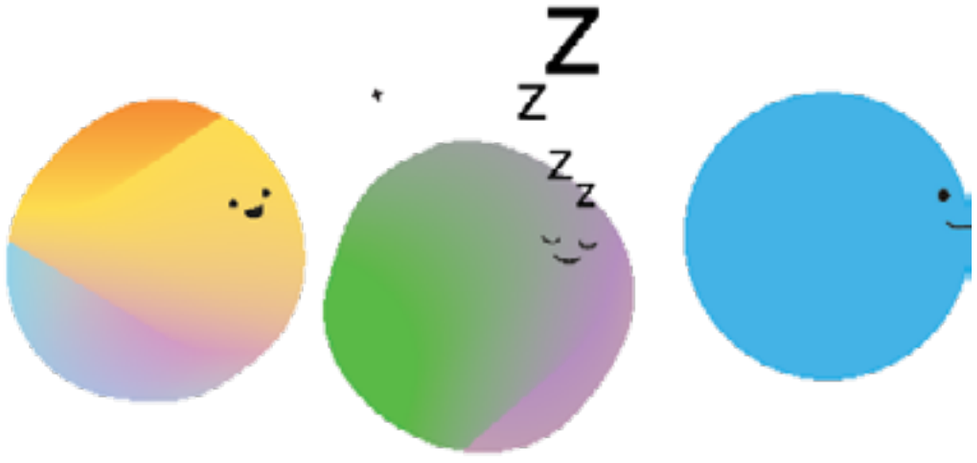
Another related study used self-report to look at gender differences in the special interests of autistic children. The study found that gender did not appear to play a role in the age that children developed their interest nor in the degree to which it interfered with their daily life. There were meaningful differences in the categories of interest, however, which tended to fall along typical gender lines. For example, boys showed more interest in math and construction, and girls reported more special interests about animals or arts and crafts.[42]



About Co-Occuring Conditions

Researchers have used SPARK data and Research Match to better understand both the challenges of co-occurring conditions and the best treatments, services, and supports.

Researchers have also looked into the physical challenges of autism, which are not always addressed.



Child Behavior Conditions

SPARK research shows that co-occurring developmental and behavioral conditions are common.[43,44] A study of over 40,000 children found that ADHD, learning disabilities, and intellectual disabilities are more common in autistic children than in their non-autistic siblings. Other common challenges include depression, anxiety, aggression, and attention difficulties.[43]

The COVID-19 pandemic added extra challenges, affecting the mental health and well-being of both autistic children and adults. Overall, these findings highlight the importance of understanding and supporting mental health alongside autism.[30,37,45]

Motor Coordination and Autism

Other research using SPARK data shows that parent-reported motor delays are very common in autistic children and teens. In one study, almost 90 percent of autistic children, including those without learning or cognitive differences, had motor delays. This rate was about 22 times higher than the rate found in neurotypical peers.[46] These delays can include fine motor skills like writing or holding utensils, and gross motor skills like hand-eye coordination or planning movements. Children with stronger core autism traits were more likely to have motor challenges. Despite the high prevalence of motor delays, few children received therapy.[47-52] To help address this, one research team has developed a "PuzzleWalk" phone app for adults, as well as telehealth social-movement therapies using music and yoga for children in SPARK, to stimulate engagement and motor activity.[53,54]

"Research participation is key to make sure that people understand your conditions and are able to support you."

GABRIELLE BANKS, PH.D.
SPARK SITE PI, UNIVERSITY OF MISSISSIPPI MEDICAL CENTER

Other work looking at developmental delays in autism found that very late onset of milestones, especially motor abilities, such as crawling and walking, could signal the possibility of intellectual disability and potentially a rare genetic disorder.[19,20]

ARFID and Autism

SPARK Research Match helped researchers conduct the first genetic study of Avoidant/Restrictive Food Intake Disorder (ARFID) in autistic people. They found that ARFID symptoms were closely linked to repetitive and sensory behaviors and shared a genetic connection with autism, with nearly 50 percent heritability (due to genetic variation). Even without a formal diagnosis, about 21 percent of autistic children were at high risk for ARFID. Surprisingly, many non-autistic parents also showed ARFID traits, highlighting the importance of monitoring and supporting selective eating across the lifespan.[55]

About Adults

Autism research has undergone a significant shift in the past decade to take into account the experiences of autistic adults.

These experiences include masking, how women and girls are diagnosed, and the neurodiversity perspective. SPARK has also followed this arc, with dozens of studies on the trajectories and unique challenges of autistic adulthood, as well as how to help improve well-being.

Mental Health Challenges

SPARK research shows that mental health challenges are common in autistic adults, with anxiety, ADHD, and mood disorders, such as depression, as the most frequent co-occurring conditions.[43,44] However, not all are recognized: women and older people have the most diagnoses, while people with language impairments receive fewer psychiatric diagnoses, possibly due to how we assess them.[44]

Adults at the intersection of multiple minority statuses, in particular LGBTQIA+, tend to engage in masking of autistic traits and experience more anxiety and depression.[45,56-65] In general, masking has been found to increase the risk for anxiety or depression in all autistic adults.[57,58]

SPARK research has looked closely at the impact of strengths in autistic adults. Studies highlight how flexibility – both psychological, like continuing to pursue meaningful goals despite difficult feelings, and cognitive, like adapting thinking or behavior – can protect well-being and decrease anxiety.[57,58] Having a stable job, higher education, and steady income can also help protect against depression, and so researchers suggest using behavioral activation strategies and workplace supports to improve outcomes.[45,66] Common strengths seen in autistic adults, such as problem-solving and creativity, can also be used to improve assessments and support.[67]

Studies on depression found that most adults feel they benefit from treatment and support. Positive experiences in treatment were linked to having therapists who were understanding and accepting and who provided practical tools for personal growth, and yet adults reported that talking in therapy could be challenging.[68] Individual differences, such as self-talk or visualization skills and difficulty recognizing and expressing emotions (alexithymia), can also affect experiences with different interventions in therapy.[69] However, cost remains the biggest barrier, and autistic men, and women without a college degree, are more likely to miss out on proper diagnosis or care.[37,70]

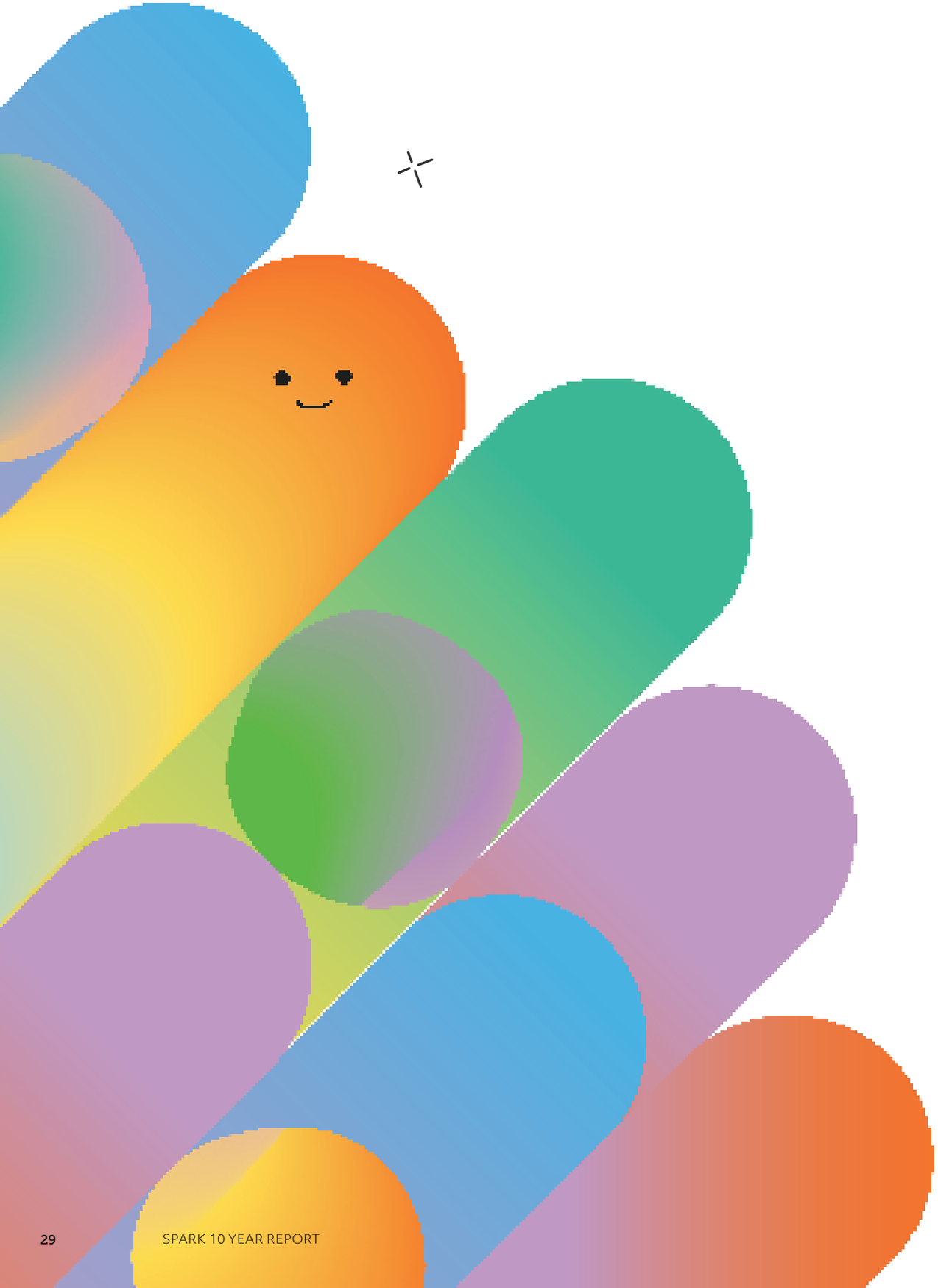
Transitioning to Adulthood and Young Adults

SPARK data allows researchers to look at autism across the lifespan and the ways that people with autism change as they age. Transitioning to independent life after 18 is known to be challenging. Employment, in particular, is a major developmental milestone that can be difficult for those with learning problems.[71]

One research team reached out to SPARK-enrolled working-age autistic adults without cognitive impairment. They asked these adults to describe their job-specific skills and the employment barriers they had experienced. Autism strengths, such as punctuality and accuracy, and strong daily living skills, such as personal care, helped adults find and keep a job. However, flexibility — the greatest challenge for autistic adults — was the number one predictor of successful employment, even more so than education level and mental health. Helping to improve flexibility, and increasing supports on the job could boost job-related success for autistic adults.[72]

For many, early adulthood is also a critical time for making social connections. Recent research on social participation has shown the importance of considering individual differences. For example, adolescents and young adults differ greatly from one another in the amount of social interaction they need to feel fulfilled.[59]

SPARK Research Match studies have also shown that a surprisingly high number of physical concerns, including fatigue, sleep problems, pain, gastrointestinal issues, and menstrual problems, arise during the teenage years. These concerns are three times higher in women than in men and correlate with depression.[73] A first-of-its-kind self-report study showed that autistic youth start drinking at around the same age and with the same frequency as non-autistic youth, and they are no more likely to use it for social coping and depression. However, autistic youth drink lower amounts of alcohol overall and are less likely to engage in problematic binge drinking.[68]



What's Next?

It's amazing to reflect upon all of SPARK's achievements over the past decade, but our work is never done.

SPARK is committed to supporting autism research for years to come, and we appreciate your time and dedication to understanding the science of autism as well. We hope that as you read through this report, it reminded you that none of this would be possible without YOU!

Together, we are advancing the understanding of autism.

Together, we are making important research possible.

Together, we are making a difference.

For full citations in this report, scan the QR code or visit:

https://bit.ly/10YearCitations

Staff used an artificial intelligence tool, NotebookLM, to help summarize the research. Quotes came from participants and researchers. Staff edited and reviewed the content.

@SPARKforAutism

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SPARK: Simons Foundation Powering Autism Research for Knowledge

“All of our journeys may be different but all of our milestones matter.”

DR. WENDY CHUNG
SPARK PRINCIPAL INVESTIGATOR