

AI-based Retinal Image Analysis for the Risk of Autism Spectrum Disorder (ASD) and Global Developmental Delay (GDD) in Pre-schoolers

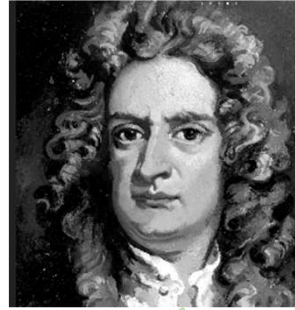
We aim to transform “Special Needs” into “Special Talents”

Prof Benny Chung-Ying ZEE, Dr Jack Lee, Ms Maria Lai

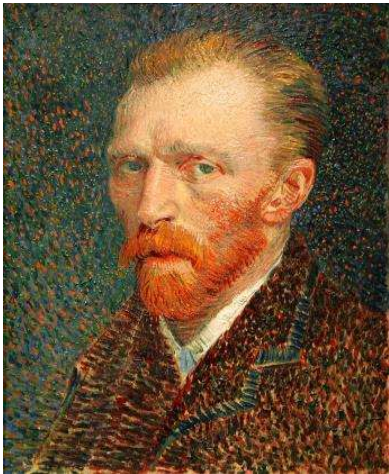
Centre for Clinical Research and Biostatistics (CCRB), The Chinese University of Hong Kong

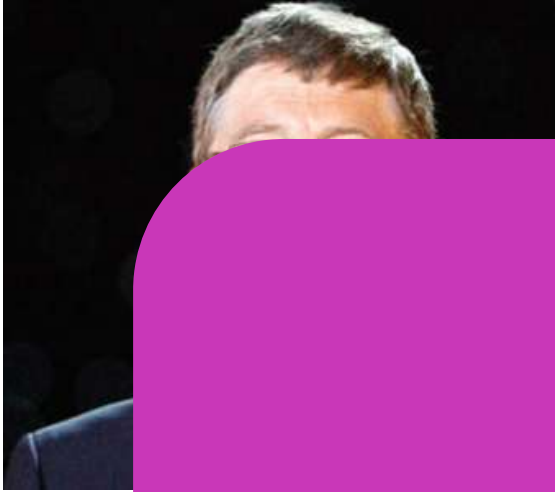
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 satoshi tajiri bobby fischer temple grandin
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 john chambers emily dickinson susan boyle
 albert einstein dan aykroyd carl jung
 diane swonk james durbin jane austen
 trevon noah bruce jenner jay leno
 orlando bloom charles darwin





They are celebrities who are believed to be autistic or diagnosed with autism.



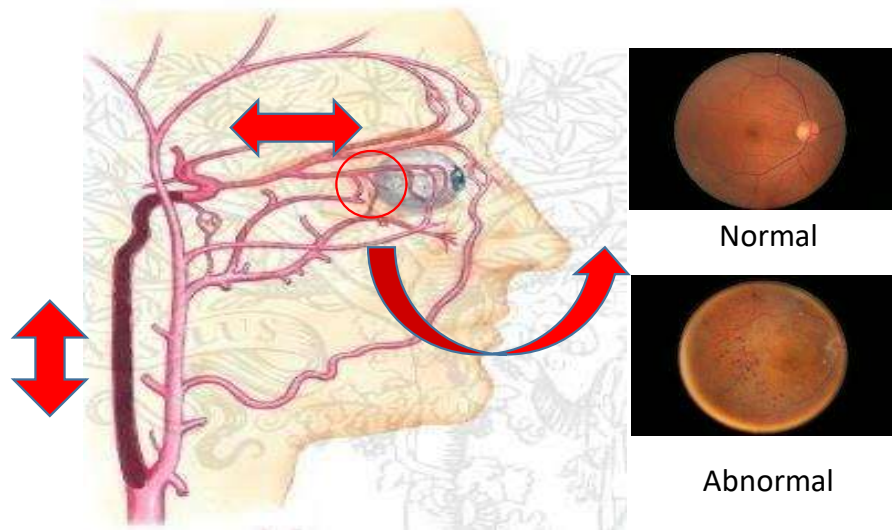
john chambers
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 james durbin
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 trevon noah
 orlando bloom
 charles darwin

Background (ASD & GDD)



- There are about 75,000,000 people who have ASD (about 1% of the world's population).
- About 1 in 100 children will be diagnosed with ASD. About 1 in 36 children in the US.
- ASD prevalence has increased by 178% since 2000.
- Typical assessment of ASD requires hours and multiple visits

Machine learning and AI-based methods were used in the retinal image analysis for estimating risks of multiple chronic diseases



Retina reflects:

1. Eye diseases, e.g. diabetic retinopathy, AMD, glaucoma
2. Cerebrovascular and Cardiovascular health, e.g. risk of stroke, risk of coronary heart disease (CHD)
3. Brain health, e.g. risks of vascular dementia and Alzheimer's disease, white matter hyperintensities (WMH)

Automatic Retinal Image Analysis (ARIA) – Health Risk Assessment

Characteristics	Advantages
Cloud-base	Accessible anywhere and easily scalable
Fully Automatic	No human intervention needed
Fast	Analysis takes only minutes
Research Evidence-based	Sensitivity and Specificity > 90%
Non-invasive	Fundus camera widely available and can be repeated
Environmental Friendly	No body specimen or blood sample involved

Patents and Publications of ARIA Technology

Publications Related to ARIA

Patents

- US Non-provisional (US8787638 B2) "Method and device for retinal image analysis"
- Taiwan Region Patent No. I578977
- China Patent No. CN103458772B "视网膜图像分析方法和装置"

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Biostatistics CUHK



SCIENTIFIC REPORTS

OPEN Retinal Information is Independently Associated with Cardiovascular Disease in Patients with Type 2 diabetes

Received: 14 April 2015
Accepted: 04 December 2015
Published: 12 January 2016

Vivian Yawei Guo^{1,2}, Juliana Chung Ngor Chan^{3,4,5}, Harriet Chung⁶, Risa Ozaki⁷, Wingyee So⁷, Andrea Luk⁷, Augustine Lam⁸, Jack Lee¹ & Benny Chung-Ying Zee^{1,7}

Images analysis as an objective spectrum disorder

Yee So⁶, Fung Ping Yuen⁶, Chloe Kwok⁶

Primary Care, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong, China

98-307
© 2013 <http://www.nature.com/scientificreports/>

Machine-learning method for localization of cerebral white matter hyperintensities in healthy adults based on retinal images

Benny Zee^{1,2,7}, Yanyan Wang^{3,4,7}, Jack Lee^{1,2}, Yuhua Fan^{3,4}, Jinhong Zeng^{3,4}, Bonnie Lam^{3,4}, Adrian Wong^{3,4}, Lin Shi^{7,8}, Allen Lee⁹, Chloe Kwok⁶, Maria Lai⁶, Vincent Mok^{3,4} and Alexander Lau^{3,4}

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Automatic Retinal Image Analysis Using Fundus Photograph

Prospective Association of Cardiovascular Disease—A Systematic Review and Meta-analysis of Cohort Studies

Research Article | Open Access

Volume 2020 | Article ID 6051831 | 8 pages | <https://doi.org/10.1155/2020/6051831>

Diabetic Eye Screening Wales (DESW)



Peking Union Medical College

Infectious Disease CUHK



RESEARCH ARTICLE

Retinal image analytics detects hyperintensities in healthy adults

Alexander Y. Lau^{1,2}, Vincent Mok^{1,2}, Jack Lee^{3,4}, Bonnie Lam^{3,4}, Adrian Wong^{3,4}, Chloe Kwok⁵, Maria Lai⁵

¹Division of Neurology, Kong

²Theresa Pei Fong Chi

³Clinical Trials and Biostatistics

⁴Department of Neurology

⁵Key Laboratory for

Guangzhou 510080

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Detection of Neovascularization Texture Analysis with Interferometric Retinopathy

Jack Lee, Benny Chung Ying Zee¹, Qing Li

Division of Biostatistics, Jockey Club School of Public Health and Primary Care, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong, China

Segmentation and texture analysis for the automatic detection of diabetic retinopathy

Jack Lee, Benny Zee¹, Qing Li

Division of Biostatistics, Jockey Club School of Public Health and Primary Care, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong, China



Journal of Stroke and Cerebrovascular Diseases

Volume 26, Issue 4, April 2017, Pages 679-695

Review Article

Prediction Factors of Recurrent Stroke among Chinese Adults Using Retinal Vasculature Characteristics

Yuanyuan Zhao, PhD¹, Haihe Yu, PhD¹, Zhuxian Yang, PhD¹, Benny Zee, PhD^{1,2}, Jack Lee, PhD^{1,2}, Lei Kuang, PhD student¹

Endocrinology Swansea, UK





A machine learning approach for retinal images analysis as an objective screening method for children with autism spectrum disorder

Maria Lai ^a, Jack Lee ^a, Sally Chiu ^c, Jessie Charm ^d, Wing Yee So ^a, Fung Ping Yuen ^f, Chloe Kwok ^a, Jasmine Tsoi ^a, Yuqi Lin ^a, Benny Zee ^{a, b}  

After the univariate analysis, we used a generalised linear model based on the penalised maximum likelihood to model additional information for classification. The results of this multivariate model are our primary analysis. Our primary analysis was based on the 23 ASD cases and matched control pairs. Among the 23 matched pairs, 17 (73.9%) pairs were male participants, with an average age of 13.17 years. The sensitivity and specificity for this multivariate classification model were 95.7% (95% CI 76.0%, 99.8%) and 91.3% (95% CI 70.5%, 98.5%) respectively. The area under the ROC curve was 0.974 (95% CI 0.934, 1.000). The probability of ASD was calculated and shown graphically for the cases and controls (Fig. 2). The mean probability of ASD for the controls was 0.205 (95% CI 0.096, 0.314) and the mean probability of ASD for cases was 0.761 (95% CI 0.638, 0.885). We also performed the analysis for all the 70 participants without matching and found that the resulting classification model had a sensitivity of 95.7% (95% CI 84.0%, 99.2%) and specificity of 91.7% (95% CI 71.5%, 98.5%). The area under the ROC curve was 0.983 (95% CI 0.958, 1.000). Overall, the results were highly consistent.



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Retina as a portal to the brain? New findings suggest #retinal images could be used for early identification of #autism and other #neurologicaldisorders to allow for early diagnosis and intervention.

#retina "is an extension of the central nervous system, and consists of glial cells and retinal ganglion cells and axons... Recent research has used the retinal #nerves fibre layer to evaluate associations with #brain structural abnormalities. Prospective studies using fundus camera and optical coherence tomography have correlated retinal changes to several CNS disorders such as #stroke, #multiplesclerosis, #parkinsonsdisease and #alzheimers disease.


"By employing machine learning and complex analysis methods, we could detect ASD with much higher accuracy"

The sensitivity and specificity for the classification model were 95.7% and 91.3% respectively.

Maria Lai, Benny Chung-Ying Zee and colleagues, Shenzhen Research Institute, The Chinese University of Hong Kong

<https://lnkd.in/eYirUWF>

#neuroscience #research #science #ophthalmology #optometry #neurological #machinelearning



A machine learning approach for retinal images analysis as an objective screening method for children with autism spectrum disorder

thelancet.com • 2 min read

Results of the ASD paper for aged between 7 and 20 years

Table 1
Univariate analysis of retinal characteristics (gender and age-matched).

	Normal (N = 23)	ASD (N = 23)	P-value
Left arterio-venule ratio	.748 (0.722–0.774)	.782 (0.753–0.812)	.062
Left average asymmetry index	.842 (0.818–0.865)	.808 (0.780–0.836)	.090
Left nipping (probability)	.326 (0.300–0.353)	.393 (0.362–0.424)	.002
Left hemorrhage (probability)	.320 (0.297–0.342)	.356 (0.330–0.381)	.009
Left occlusion (probability)	.068 (0.055–0.081)	.080 (0.069–0.092)	.030*
Left exudates (probability)	.258 (0.233–0.283)	.308 (0.281–0.336)	.005
Right hemorrhage (probability)	.291 (0.275–0.308)	.320 (0.295–0.344)	.051
Right exudates (probability)	.225 (0.205–0.246)	.263 (0.232–0.294)	.051
Average cup-to-disc ratio	.414 (0.389–0.438)	.445 (0.413–0.478)	.100
Average disc diameter (μm)	262.0 (250.2–273.9)	279.5 (268.0–290.9)	.013
Average cup diameter (μm)	109.4 (98.9–119.9)	125.5 (112.7–138.4)	.028

Note: The *p*-value with a.

* represents nonparametric test of matched pair data (Wilcoxon Signed-Rank Test), others use paired *t*-test.

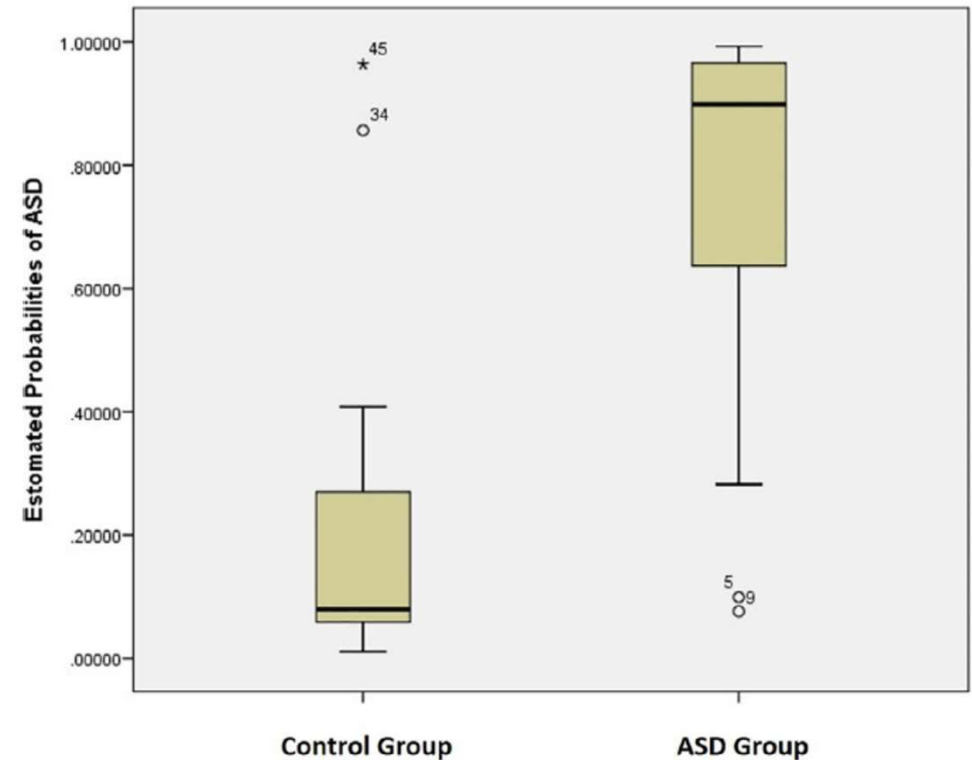


Fig. 2. Box plot for the probability of ASD based on the matched case–control data.

References: Lai M, Lee J, Chiu S, Charm J, So WY, Yuen FP, Kwok C, Tsoi J, Lin Y, Zee B, “A machine learning approach for retinal images analysis as an objective screening method for children with autism spectrum disorder”, *EclinicalMedicine* 2020, 100588

Global Attentions for the ASD Retinal Image Analysis Technology – A Worldwide Market

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TECHNOLOGY NEWS MARCH 15, 2021 / 9:13 AM / UPDATED A YEAR AGO

HK scientist develops retinal scan technology to identify early childhood autism

By Aleksander Solum 2 MIN READ

HONG KONG (Reuters) - A Hong Kong scientist has developed a method to use machine learning and artificial intelligence to scan retinas of children as young as six to detect early autism or the risk of autism and hopes to develop a commercial product this year.

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HK Scientist Develops Retinal Scan Technology to Identify Early Childhood Autism

South China Morning Post

Hong Kong researchers claim breakthrough method can detect autism risk by scanning back of eye

- Chinese University team studied retinal images taken with specialised camera found in eyes of children with the disorder
- The approach method promises a quick diagnostic tool that is up to 96 per cent more test subjects to fully develop the technique

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Healthcare

Hong Kong scientist develops retinal scan technology to identify early childhood autism

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中大研“眼底相” 计算自闭症风险

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Scientist develops retinal scan technology to identify early childhood autism



HK scientist develops retinal scan technology to identify early childhood autism

Tuesday, March 16, 2021, 10:21 GMT+7

Dhaka Tribune

TODAY'S PAPER NEWS BUSINESS SPORTS OPINION D2 SHO

Home / World / East Asia

HK scientist develops retinal scan technology to identify early childhood autism

Reuters Published at 03:21 pm March 15th, 2021



CCRB won two Gold Medals and a Special Award in the 49th International Exhibition of Inventions Geneva, 16–20 April 2024

The International Exhibition of Inventions Geneva (IEIG) is the world's largest annual event devoted exclusively to inventions and the licensing market. This year, more than 1000 exhibitors from 45 countries presented their exclusive inventions, research, and new products.

The Centre for Clinical Research and Biostatistics (CCRB) has won a **Special Award**: “Prize of Korean Invention Promotion Association (KIPA),” and a **“Gold Medal with Congratulation of the Jury”** for the Project: “AI Retinal Image Analysis for the Risk of Autism (ASD) and Global Developmental Delay (GDD) in Preschoolers.”

Another **Gold Medal** for the Project: “AI-based Automatic Retinal Image Analysis (ARIA) for Detecting Depression Risk in Adults.”



Reference:
https://www2.ccrb.cuhk.edu.hk/web/?page_id=3185

AI Retinal Image Analysis for the Risk of Autism (ASD) and GDD in Preschoolers
 Analyse de l'image rétinienne par l'IA pour le risque d'autisme (ASD) et de retard global de développement (GDD) chez les enfants d'âge préscolaire

There are around 317 million young people with developmental disabilities worldwide. Among them, 168 million are with Autism Spectrum Disorder (ASD). Our team has developed an AI-based Automatic Retinal Image Analysis (ARIA) to detect the risks of ASD and Global Developmental Delay (GDD) for preschoolers with more than 90% accuracy. We planned to apply ARIA to the general population as a screening tool for ASD and GDD. Once we identify children with a high risk of ASD and GDD using ARIA, we can contribute to evidence-based interventions, including PIER, JASPER, ESDM, SCERTS, etc. and use ARIA to monitor their progress.

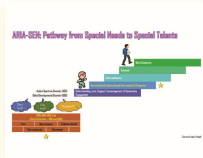
We aim to turn:
 Children with Special Needs to Children with Special Talents

To achieve this aim, ARIA is used as a monitoring tool to evaluate the effectiveness of the interventions for ASD and GDD and try to find the most effective personalized interventions that generate confidence and continue to nurture their talents.

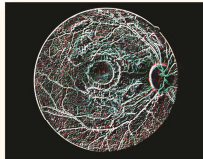
- Fully automatic
- Can be done by a layperson in the community
- Non-invasive
- No radiation
- No side effects
- Fast
- Convenient
- Accurate



A child is taking a retinal image



ARIA-SEN: Pathway from special needs to special talents



Prof. Benny ZEE, Dr. Jack LEE, Ms. Sally CHIU, Ms. Maria LAI
 The Jockey Club School of Public Health and Primary Care
 Faculty of Medicine



Previous research shows that retinal images reflect Brain MRI characteristics

BRAIN COMMUNICATIONS

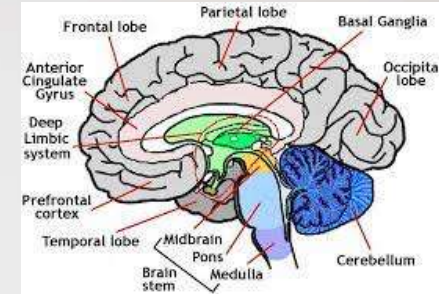
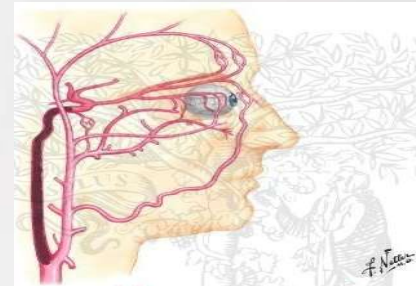
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Machine-learning method for localization of cerebral white matter hyperintensities in healthy adults based on retinal images

Benny Zee, Yanny Wong, Jack Lee, Yuhua Fan, Jinsheng Zeng, Bonnie Lam, Adrian Wong, Lin Shi, Allen Lee, Chloe Kwok ... Show more

Author Notes

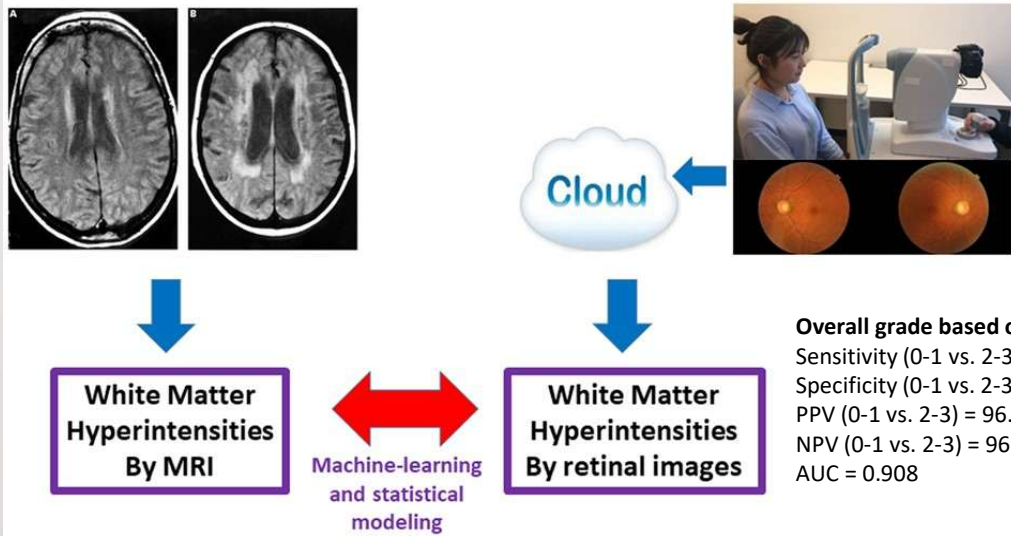
Brain Communications, Volume 3, Issue 3, 2021, fcab124,



Retinal vessels are the only directly visible vessels

Retinal vessels have the same

- embryo origin
- histological structure
- pathological change



Summary

- We can identify specific brain regions with WMH using AI-based retinal image analysis (ARIA)
- Our analysis showed that retinal images can be used to estimate various parameters inside the brain, including microbleeds and cerebral infarcts.
- We postulate that we would be able to separately classified ASD from GDD.

Proposed Biological Measurements

MRI Measurements are Useful Biological Markers

Table I. Biological Classification Results in Autism Spectrum Disorders

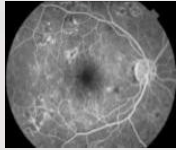
Biological characteristics	Measurement type	Brain regions	ASD/AUT ^a	TD control ^a	Sensitivity (%)	Specificity (%)	Reference
GM and WM	Volume and area	Cerebrum, cerebellum	30 LFA, 12 HFA	32	94.7	92.3	Akshoomoff et al. [2004]
GM, WM	Volume	L fusiform gyrus, R temporal stem, and R inferior temporal gyrus	33 HFA	24	85.0	83.0	Neeley et al. [2007]
GM	Cortical thickness	40,000 region-specific locations	16 HFA	11	89.0 Accuracy		Singh et al. [2008]
WM	Size distribution	Gyral window	14 (HFA&LFA)	28	67.0	89.0	Casanova et al. [2009]
Papillary light reflex	Infra-red pupillography	–	24 ASD	43	91.7	93.0	Fan et al. [2009]
GM	Cortical thickness	33 regions by hemisphere	22 ASD	16	95.0	75.0	Jiao et al. [2009]
GM	Volume	33 regions by hemisphere	22 ASD	16	77.0	69.0	Jiao et al. [2009]
WM fibers	Shape		41 HFA	32	72.0	72.0	Adluru et al. [2009]
GM	MRI network pattern classification	Frontal, temporal, parietal, and cerebellar systems	22 ASD	22	77.0	86.0	Ecker et al. [2010]
WM	MRI network pattern classification	Frontal, temporal, parietal, and cerebellar systems	22 ASD	22	73.0	64.0	Ecker et al. [2010]
GM & WM	MRI network pattern classification	Frontal, temporal, parietal, and cerebellar systems	22 ASD	22	77.0	77.0	Ecker et al. [2010]
Auditory cortex	MEG latency delay	Superior temporal gyrus	25 ASD ^b	17	75.0	81.0	Roberts et al. [2010]
Speech acts	Vocalization analysis	–	AUT non-AUT delay vs TD		Accuracy 77.0–90.0		Xu et al. [2009]

^aAll male, except for Jiao [2009], 22 ASD (19M and 3F) and 16 TD (13M and 3F).

^bNineteen without language impairment and six with language impairment.

Reference: Lange N, Dubray MB, Lee JE, Froimowitz MP, Froehlich A, Adluru N, Wright B, Ravichandran C, Fletcher PT, Bigler ED, Alexander AL, Lainhart JE. Atypical diffusion tensor hemispheric asymmetry in autism. *Autism Res.* 2010 Dec;3(6):350-8.

Related Developments of Automatic Retinal Image Analysis (ARIA) Technology



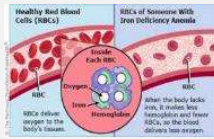
Diabetic Retinopathy,
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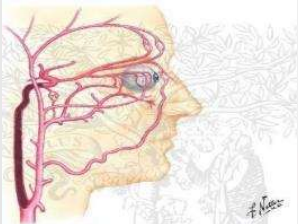
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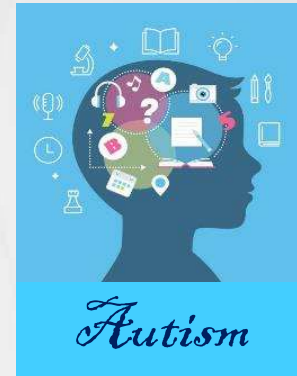
WMH for Dementia
Risk 認知障礙風險



Risk of Diabetes
糖尿病風險



Long COVID
新冠後遺症



Autism Spectrum Disorder
自閉症

Health Promotion and Risk Assessment

Elderly and Adults Population

Children Population

New Study for Preschoolers (aged 2-6)

1. To determine the ARIA estimated retinal characteristics for global developmental delay (GDD), autism spectrum disorder (ASD) and control group. Compare the retinal characteristics among the three groups.
2. To determine classification models using retinal images for GDD versus the control group
3. To determine classification models using retinal images for ASD versus the control group

Eligibility Criteria

Inclusion criteria

1. Children aged between 2 and 6
2. Written consents by subjects' legal guardian/next-of-kin

Exclusion criteria

1. Poor retinal image quality that cannot be used in the analysis
2. Other eye diseases that are not suitable for retinal imaging include congenital cataracts and retinopathy of prematurity
3. Children are distressed with a flashlight or have experience with photosensitive seizures
4. Written consents not given by subjects' legal guardian/next-of-kin

It is feasible to take retinal images in young children



References:

1. Patel CK, Fung TH, Muqit MM, Mordant DJ, Geh V. Non-contact ultra-widefield retinal imaging and fundus fluorescein angiography of an infant with incontinentia pigmenti without sedation in an ophthalmic office setting. J AAPOS. 2013 Jun;17(3):309-11.
2. <http://buddhaeyecare.com/pediatric-ophthalmology.php>
3. <https://www.prlog.org/12636760-eye-introduces-imageselect-application-to-enhance-pediatric-retinal-examination-results-for-new-born-infants-and-young-children.html>

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匡扶智障 FOR people with intellectual disabilities

Retinal Imaging Process using Digital Non-Mydriatic Retinal Cameras with additional training materials



* No dilation is required.

Results for ASD and GDD study aged 2-6

	Number of subjects
Case	414 (ASD 115, GDD 151, Both 148)
Control	1798
Total	2212

Age and Gender Distribution for Cases

	Total cases N=414	ASD N=115	GDD N=151	ASD+GDD N=148
Age				
2	9	2	4	3
3	34	6	19	9
4	114	39	34	41
5	175	45	67	63
6	82	23	27	32
Gender				
Male	301	87	94	120
Female	113	28	57	28

Age and Gender Distribution for Cases

			Age(Year)					
Gender			2	3	4	5	6	Total
Female		ASD	0	2	6	15	5	28
		GDD	1	7	17	20	12	57
		ASD and GDD	0	0	7	13	8	28
	Total		1	9	30	48	25	113
Male		ASD	2	4	33	30	18	87
		GDD	3	12	17	47	15	94
		ASD and GDD	3	9	34	50	24	120
	Total		8	25	84	127	57	301
Total		ASD	2	6	39	45	23	115
		GDD	4	19	34	67	27	151
		ASD and GDD	3	9	41	63	32	148
	Total		9	34	114	175	82	414

Number of Definite and Suspected Cases

Cases Classification		N=414
ASD	ASD (94)	115 (26.6%)
	Suspected ASD (21)	
GDD	GDD (134)	151 (36.5%)
	Suspected GDD (17)	
ASD and GDD	ASD and GDD (122)	148 (35.7%)
	Suspected ASD and GDD (24)	
	Suspected ASD and Suspected GDD (2)	

Age and Gender Distribution for Controls

	Age(Year)					
Gender	2	3	4	5	6	Total
Female	0	118	249	330	90	787
Male	1	144	305	439	122	1011
Total	1	262	554	769	212	1798

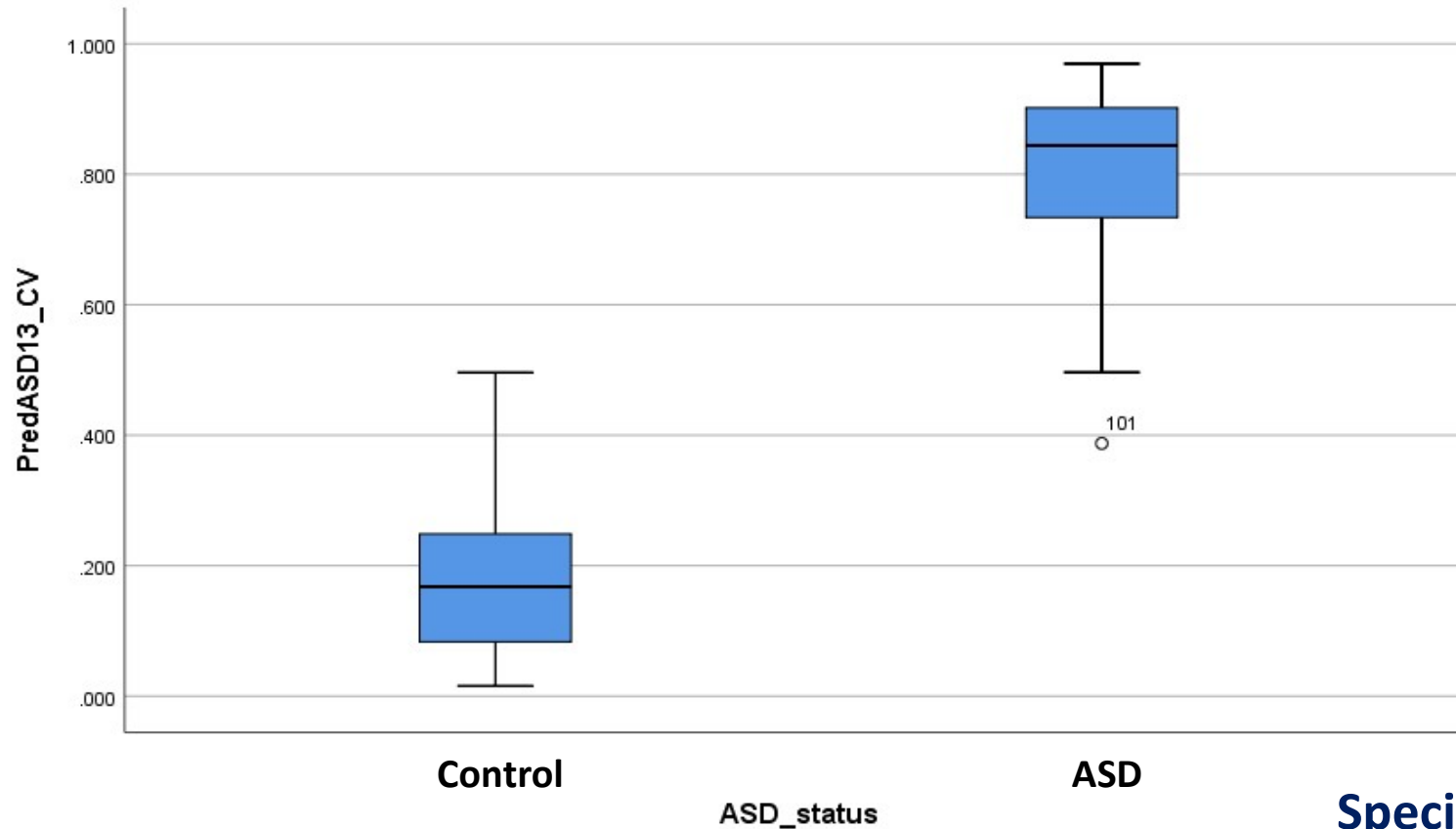
Age and Gender Distribution for Matched Case-Control

		Age(Year)						
Gender		2	3	4	5	6		Total
Female	Case	1	9	30	48	25		113
	Control	0	10	30	48	25		113
Male	Case	8	25	84	127	57		301
	Control	1	32	84	127	57		301
Total	Case	9	34	114	175	82		414
	Control	1	42	114	175	82		414

Note: In our matched dataset, except for three cases involving 2-year-olds, where the age differences exceed 6 months (specifically 8 months, 8 months, and 9 months), all other cases have age differences within 6 months.

**To identify ASD
in a normal population**

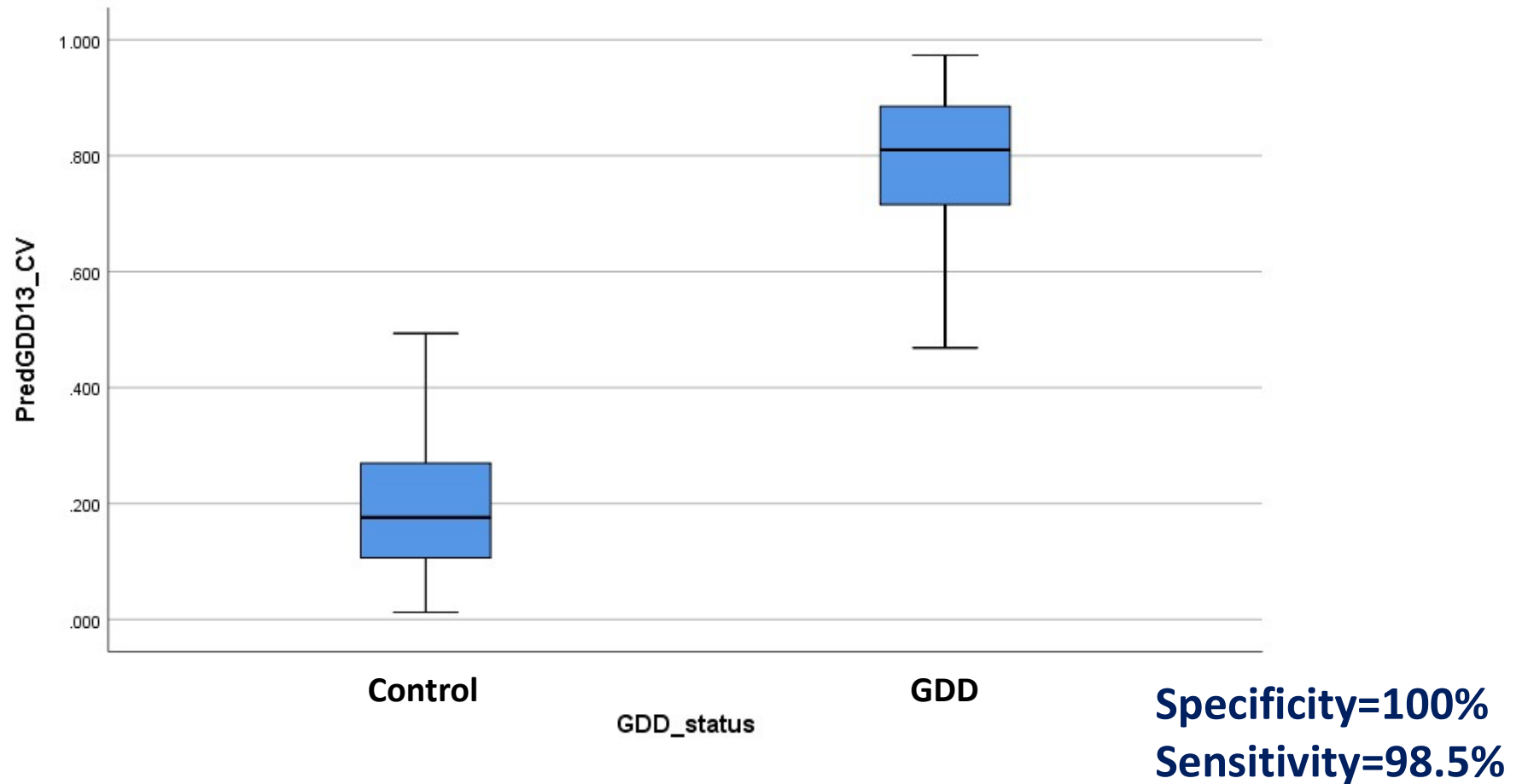
ASD (definite, n=94) vs Control (age-gender matched) With 10-fold cross-validation by SVM (optimization)



Specificity=100%
Sensitivity=97.87%

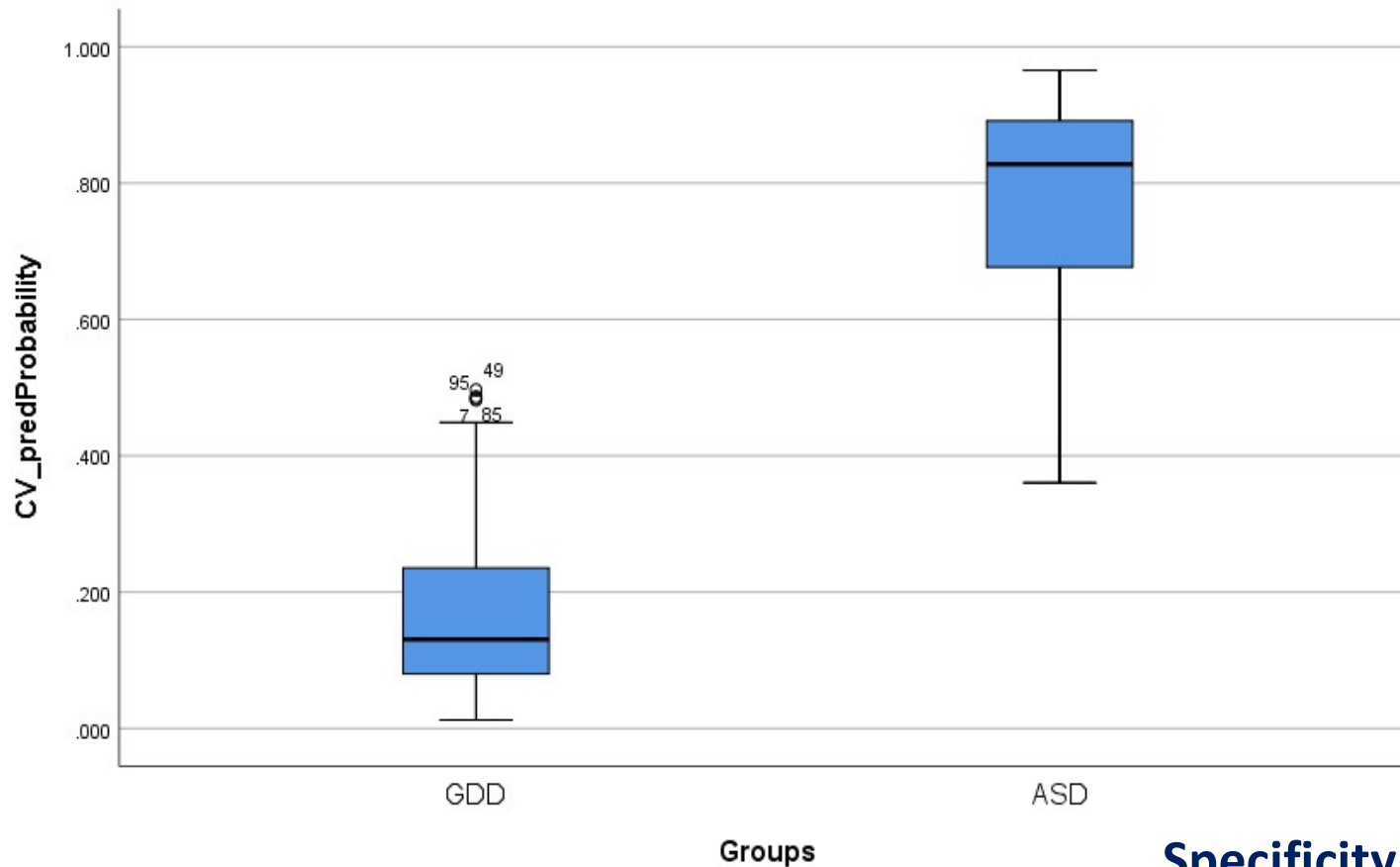
**To identify GDD
in a normal population**

GDD (definite, n=134) vs Control (age-gender matched) With 10-fold cross-validation by SVM (optimization)



**To separate ASD and GDD
populations**

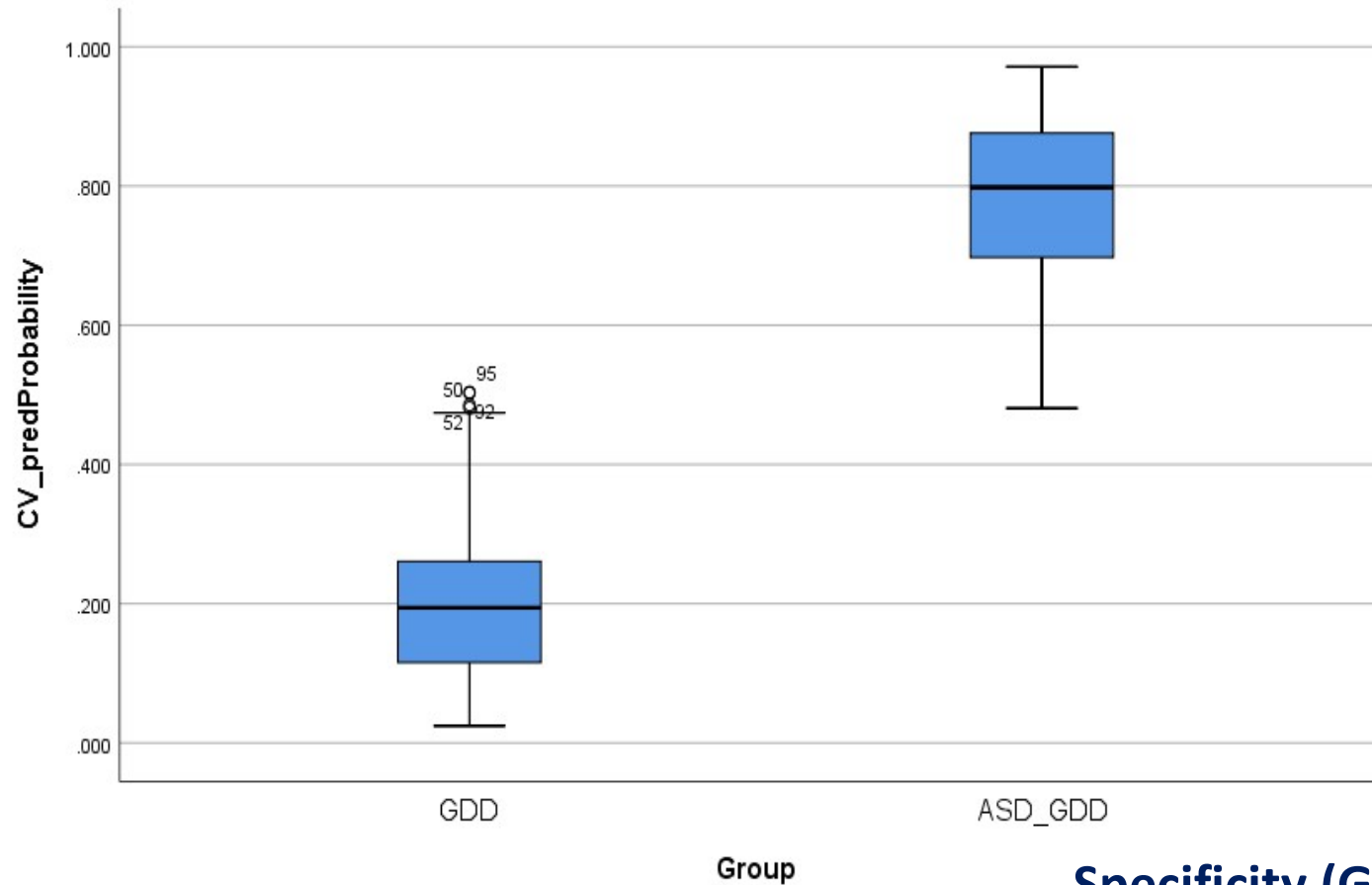
ASD (definite, n=94) vs GDD (definite, 134) With 10-fold cross-validation by SVM (optimization)



Specificity (GDD) = 100%
Sensitivity (ASD) = 96.8%

**To extract ASD from
a mixed population of ASD and GDD**

ASD+GDD (definite, n=122) vs GDD (definite, 134) With 10-fold cross-validation by SVM (optimization)



Specificity (GDD) = 98.51%
Sensitivity (ASD+GDD) = 98.36%

Conclusions

Why is early classification of ASD and GDD important?



AI Retinal Image Analysis for the Risk of Autism (ASD) and GDD in Preschoolers
Analyse de l'image rétinienne par l'IA pour le risque d'autisme (ASD) et de retard global de développement (GDD) chez les enfants d'âge préscolaire

Prof. Benny ZEE, Dr. Jack LEE,
Ms. Sally CHIU, Ms. Maria LAI
The Jockey Club School of Public Health and Primary Care
Faculty of Medicine

There are around 317 million young people with developmental disabilities worldwide. Among them, 168 million are with Autism Spectrum Disorder (ASD). Our team has developed an AI-based Automatic Retinal Image Analysis (ARIA) to detect the risks of ASD and Global Developmental Delay (GDD) for preschoolers with more than 90% accuracy. We planned to apply ARIA to the general population as a screening tool for ASD and GDD. Once we identify children with a high risk of ASD and GDD using ARIA, we can contribute to evidence-based interventions, including PIER, JASPER, ESDM, SCERTS, etc., and use ARIA to monitor their progress.

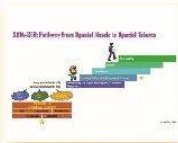
We aim to turn:
Children with Special Needs to Children with Special Talents.

To achieve this aim, ARIA is used as a monitoring tool to evaluate the effectiveness of the interventions for ASD and GDD and try to find the most effective personalized interventions that generate confidence and continue to nurture their talents.

- Fully automatic
- Can be done by a layperson in the community
- Non-invasive
- No radiation
- No side effects
- Fast
- Convenient
- Accurate



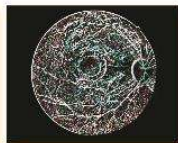
A child is taking a retinal image



ARIA-SEN: Pathway from special needs to special talents



A retinal image taken by a fundus camera



An ARIA-processed retinal image

Supported by:
Health View Bioanalytics
CUHK Faculty of Medicine
The Chinese University of Hong Kong



AI Retinal Image Analysis (ARIA) for the Risk of Autism (ASD) and GDD in Preschoolers

- Classification based on biological markers, such as AI-based retinal image analysis (ARIA), is **objective and accurate** with **sensitivity and specificity > 90%**.
- Retinal imaging is **fast**, and the analysis is **automatic**. This reduces time and cost for the healthcare system and the family.
- ASD and GDD are easily confused, especially at a very young age. It is advantageous to have a **correct early classification**.
- Accurate early assessment of ASD will help start **early intervention** and education, optimising effectiveness.
- Start **talent identification early** for ASD children in music, arts, sports, mathematics, etc.
- Provide **high-quality targeted training and education** for those with identified talents, increasing self-confidence and peer acceptance.

J Autism Dev Disord (2015) 45:1354–1367

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ORIGINAL PAPER

Prevalence of Clinically and Empirically Defined Talents and Strengths in Autism

**Andrée-Anne S. Meilleur · Patricia Jelenic ·
Laurent Mottron**

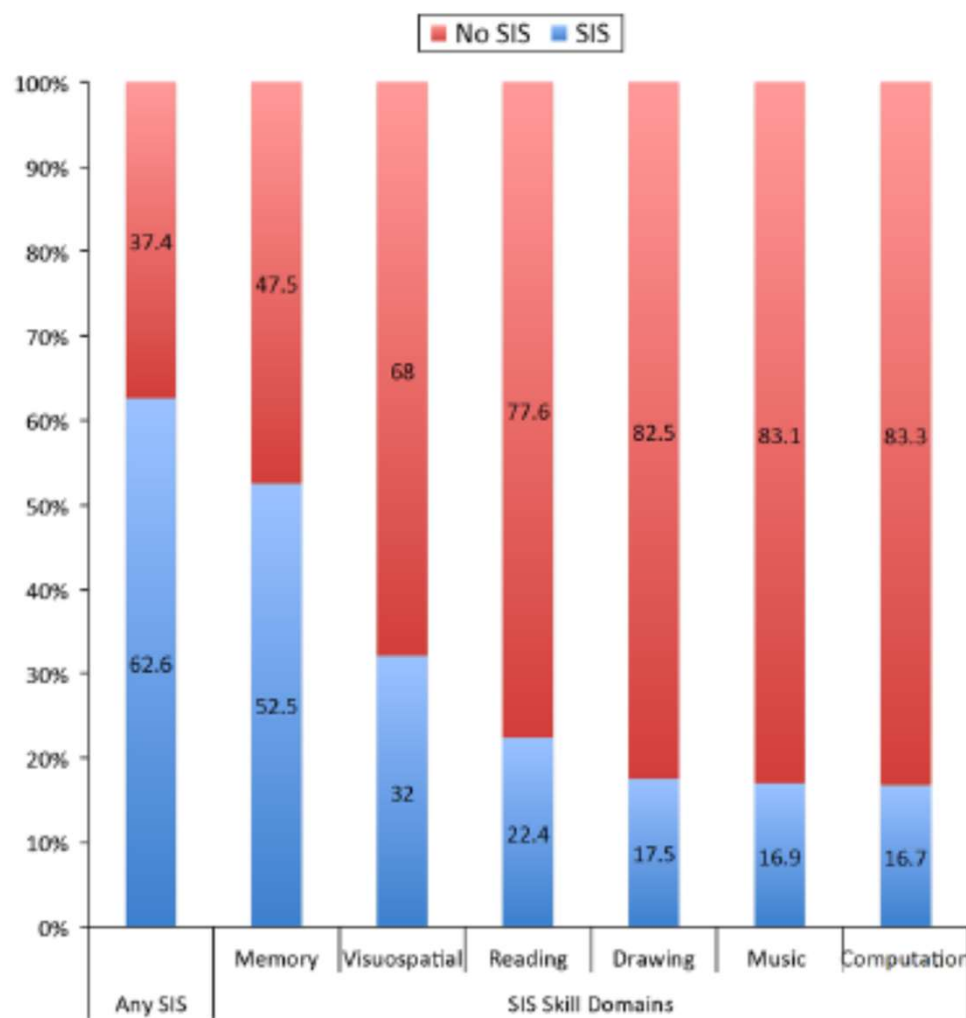


Fig. 2 Graph showing the percentage of the sample from Study 1 with (blue) and without (red) reported talents, or "Special Isolated Skills" (SIS), in any domain and in each of the six ADI-R SIS domains separately

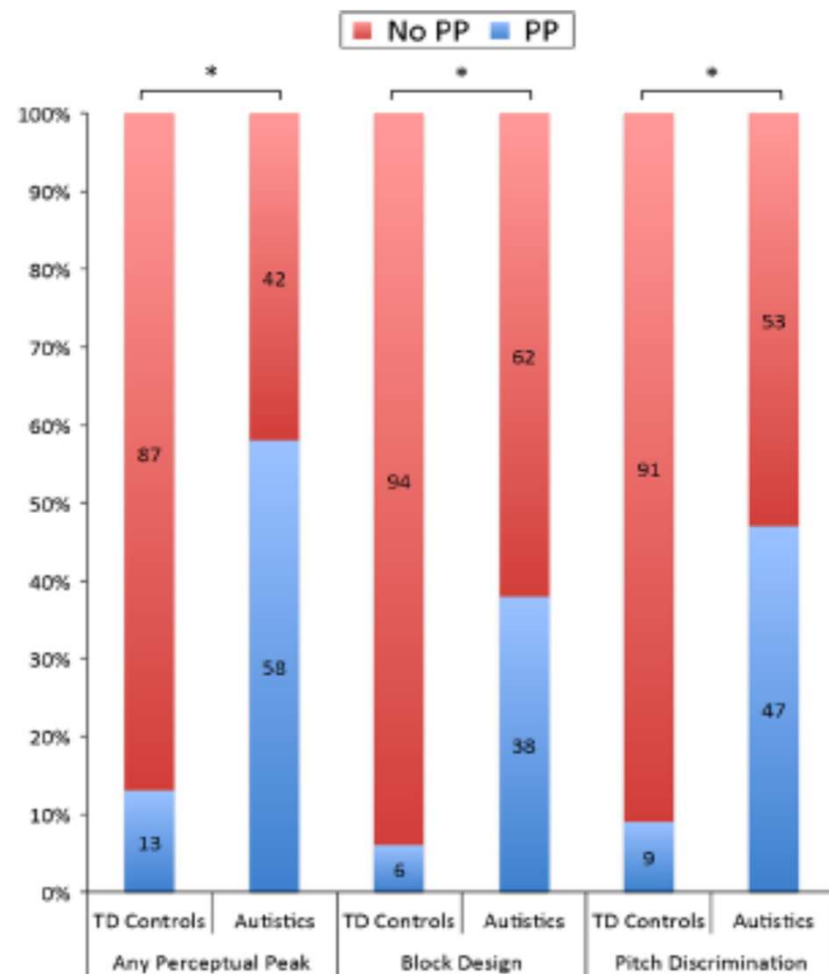


Fig. 4 Graph showing the percentage of the sample from Study 2 with (blue) and without (red) strengths, or "Perceptual Peaks" (PP), in any task and in each task separately. The graph shows the percentages separately for typically developing (TD) controls (left) and autistics (right). The proportion of individuals with and without PP is significantly different between TD controls and autistics. * $p < 0.001$

Table 1 Group studies investigating numerous talents and strengths in ASD, including Kanner and Asperger's seminal descriptions

	N, diagnosis; mean age (range); mean intelligence level (range)	Skill definitions	Skill assessment tools; information sources	Skill types (prevalence in %)
Kanner (1943)	11 autistic individuals; 5.38 (2.33–11); From “severe intellectual defect” to “superior intelligence”	Observations ranging from “At the age of 1 year he could hum and sing many tunes accurately.” to “...and had an excellent rote memory.”	Direct observation; Clinician and parental reports	Any talent (54.5); Memory (54.5); Music (36.3)
Asperger (1944)	4 autistic individuals; 8.25 (6–11); IQ n/a	Observations ranging from “His extraordinary calculating ability had been reported by the parents and verified by us.” to “He was an excellent speller and never made mistakes.”	Direct observation; Clinician and parental report	Any Talent (75); Memory (50); Calculation (25); Spelling (25)
Rimland (1978)	540 autistic individuals; Age and IQ n/a	“...any “special abilities” the child may display.”	Postal survey; Parental report	Any talent (9.8)
Rapin (1996)	51 “High-functioning autistic individuals”; 4.8 (range n/a); NVIQ 102.9 (range n/a)	“...whether they (parents) felt that their child had unusually well developed abilities in memory, mathematics, recognition of letters and numbers, music or motor skills.”	Questionnaire; Parental report	Memory (70.6); Number and Dates (45.1); Puzzle/spatial skills (35.3); Music (27.5); Fine motor (21.6); Letters/numbers (25.5); Other (31.4)
	125 “Low-functioning autistic individuals”; 5.0 (range n/a); NVIQ 45.6 (range n/a)			Memory (44); Dates (13.6); Puzzle/spatial skills (26.4); Music (23.2); Fine motor (14.4); Letters/numbers (9.6); Other (17.6)
Bolte and Poustka (2004)	254 autistic probands; 15.54 (6–49); FSIQ 72.56 (32–129)	ADI-R Score of 3 or 4 coded on “current” behavior: performance level above the participant’s general level of cognitive functioning and above that expected for their age, with (4)	ADI-R special isolated skills items (106–111); Parental report	Any Talent in memory, music, computation, reading, visual-spatial and/or drawing (13)

Table 1 Group studies investigating numerous talents and strengths in ASD, including Kanner and Asperger's seminal descriptions

	N, diagnosis; mean age (range); mean intelligence level (range)	Skill definitions	Skill assessment tools; information sources	Skill types (prevalence in %)
Howlin et al. (2009)	<i>Assessment 1</i> 87/137 autistic individuals; 24.1 (11–48); FSIQ 77.52 (39–130)	Exceptional cognitive skill in any of the Wechsler subtests (1 SD \geq population norms and 2 SD \geq participant's mean)	Wechsler subtests; Psychometric assessment	Strength in cognitive skill for at least one Wechsler subtest (26.4)
	<i>Assessment 2</i> 93/137 autistic individuals; 34.2 (21–55); PIQ 73.56 (29–135)	Outstanding skill/knowledge definitely above subject's general level of ability and above that of age-matched individuals from the general population	Questionnaire; Parental report	Any Talent in memory, music, computation (including calendrical calculation) and/or visual-spatial (25.8)
	137/137 autistics n/a (11–55) PIQ 69.9 (28–135) VIQ 77.5 (7–134)	See definitions above	Questionnaire and Wechsler subtests	Any Talent and/or cognitive skills (28.5)
Jones et al. (2009)	100 ASD; 15.6 (14.8–16.9) FSIQ 84.3 (50–119)	Test performance highly discrepant from own general intellectual functioning	Wechsler Objective Reading and Numerical Dimensions and test of Word Reading Efficiency; Psychometric assessment	Strength in literacy and/or mathematics (72.7)
Bennett and Heaton (2012)	125 ASD; 10.0 (3–20); IQ n/a but 7.9 % had intellectual disability	One or more skills that were outstanding given their functioning skills based on nine structured and open-ended questions	Questionnaire; Parental report	Any Talent (42); Memory/knowledge (28); Mathematical/numerical (15.2); Artistic (9.6); Music (9.6); Reading/vocabulary (9.6); Spatial (8.8); ICT (8.8); Mechanical (3.2); Other (4.8)

Table 1 continued

	N, diagnosis; mean age (range); mean intelligence level (range)	Skill definitions	Skill assessment tools; information sources	Skill types (prevalence in %)
Current study	<i>Study 1</i> 254 autistic individuals; 11.35 (2–39) FSIQ 87 (40–130) (n = 171)	ADI-R Score of 2 or 7 coded on “current” or “ever” behavior: Performance level above the participant’s general level of cognitive functioning and above that expected for their age, with (7) or without (2) functional or adaptive use of the skill in daily life.	ADI-R special isolated skills items (88–93); Parental report	Any Talent (62.6); Memory (52.5); Visuospatial (32); Reading (22.4); Drawing (17.5); Music (16.9); Computation (16.7)
	<i>Study 2</i> 43/254 autistic individuals; 20.81(14–36); FSIQ 105 (71–125)	Perceptual peak on experimental tasks (1 SD ≥ population mean)	Modified block design and Pitch Discrimination Tasks; Experimental testing	Strength in perceptual performance for at least one experimental task (57.5)
	Same 43 subjects	See definitions above	ADI-R special isolated skills items (88–93) and Experimental Tasks	Any Talent and/or perceptual peak (88.4)

ASD autism spectrum disorders, FSIQ full scale IQ, VIQ verbal IQ, PIQ performance IQ, NVIQ non-verbal IQ, ADI-R autism diagnostic interview-revised

ARIA-ASD and ARIA-GDD aim to Transform Special Needs to Special Talents



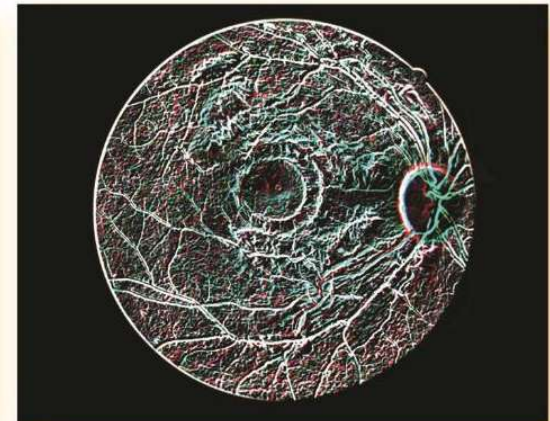
A child is taking a retinal image



ARIA-SEN: Pathway from special needs to special talents



A retinal image taken by a fundus camera



An ARIA-processed retinal image

Special needs schools helping to recruit cases

Acknowledgement

- This project has received much support from the community and the special needs schools. The following are the names of **SEN Preschools and centers** that are helping us recruit the cases. Our team included experienced clinical research personnel and optometrists with exceptional skills in autistic children.
 1. Hong Chi Pinehill Pre-school Centre 匡智松嶺學前及兒童中心
 2. Hong Chi Kwong Fuk Pre-School Centre 匡智廣福學前兒童中心
 3. Heep Hong Society Catherine Lo Centre 協康會慶華中心
 4. Heep Hong Society Fu Cheong Centre 協康會富昌中心
 5. Heep Hong Society Yung Ming Centre 協康會雍明中心
 6. Heep Hong Society Tai Wo Hau Centre 協康會大窩口中心
 7. Heep Hong Society Lei Yue Mun Centre 協康會鯉魚門中心
 8. Heep Hong Society Wan Tsui Centre 協康會環翠中心
 9. Heep Hong Society Yu Ming Centre 協康會裕明中心
 10. Heep Hong Society Wanchai Centre 協康會灣仔中心

Special needs schools helping to recruit cases

Acknowledgement

11. Y Seeds Wellness Service (Team A) 女青悅兒成長服務 (甲隊)
12. Bravo Lutheran Child Development Centre 路德會凝悅兒童發展中心
13. Joyful Kids Lutheran Centre 路德會喜樂寶寶中心
14. Caritas On-site Pre-School Rehabilitation Service 明愛樂成長學前到校支援服務
15. Caritas Lok Miu Early Education and Training Centre 明愛樂苗學前教育及訓練中心
16. Caritas Lok Yau Early Education and Training Centre 明愛樂幼學前教育及訓練中心
17. Caritas Lok Hing Child Care Centre 明愛樂興幼兒中心
18. Hong Kong Christian Service Tuen Mun Early Education & Training Centre 香港基督教服務處屯門早期教育及訓練中心
19. Hong Kong Christian Service Yuen Long Early Education & Training Centre 香港基督教服務處元朗早期教育及訓練中心
20. Hong Kong Christian Service Bridge-Integrated Education Service (Team 1) 香港基督教服務處心橋融合教育服務(第一隊)

Kindergartens helping to recruit controls

Acknowledgement

- We have support from **17 kindergartens**, headmasters and teachers **for the control group**. The following are the names of the Kindergartens. Our team went to these Kindergartens multiple times to recruit controls. Almost all headmasters in these schools expressed interest in using this technology in their schools as soon as it is available.
 1. Tai Po Catholic Kindergarten 天主教大埔幼稚園
 2. St Jerome's Catholic Kindergarten 天主教聖葉理諾幼稚園
 3. St Andrew's Catholic Kindergarten 天主教聖安德肋幼稚園
 4. Raimondi College Kindergarten Section 高主教書院幼稚園部
 5. Cheung Chau Sacred Heart Kindergarten 長洲聖心幼稚園
 6. St Teresa's Kindergarten 聖德蘭幼稚園
 7. Our Lady of Lourdes Catholic Kindergarten 天主教露德聖母幼稚園
 8. St Margaret Mary's Catholic Kindergarten 天主教聖瑪加利大幼稚園
 9. St Stephen's Catholic Kindergarten 聖斯德望天主教幼稚園
 10. Tung Chung Catholic Kindergarten 東涌天主教幼稚園
 11. Kam Lam Catholic Kindergarten 天主教甘霖幼稚園
 12. Star of the Sea Catholic Kindergarten 天主教海星幼稚園
 13. Annunciation Catholic Kindergarten 天主教領報幼稚園
 14. Tsuen Wan Our Lady Kindergarten 荃灣聖母幼稚園
 15. St Thomas' Catholic Kindergarten 天主教聖多默幼稚園
 16. St James Catholic Kindergarten 天主教聖雅各伯幼稚園
 17. St Peter's Catholic Kindergarten 天主教聖伯多祿幼稚園

Thanks

<https://www2.ccrb.cuhk.edu.hk/web/>
<http://healthviewbio.com>