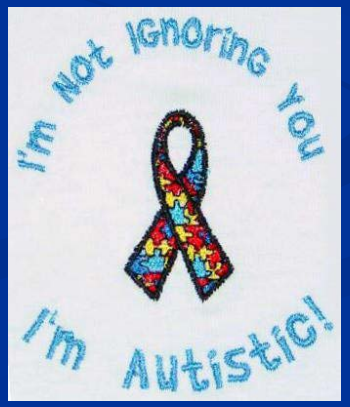
# Autism

# Autism

- Affects 1 in 166 children
- More common in boys than girls
- Usually diagnosed by age 5
- Delays in language
- First identified in 1943 by Leo Kanner
- Asperger's syndrome (Hans Asperger, 1944; 1994)

- Spectrum of disorders
  - Kanner's autism
  - Asperger's syndrome (no language delay!)
  - PDD-NOS

- Triad of impairments (DSM-IV)
  - Deficits of social interaction
    - eye-gaze; failure to develop peer relationships
  - Impairments of language and communication
    - total lack of speech; pragmatic impairments
  - Restricted or stereotyped behaviors
    - routines, rituals; motor mannerisms (flapping)


Diagnostic and Statistical Manual of Mental Disorders: DSM IV]

(I) A total of six (or more) items from (A), (B), and (C), with at least two from (A), and one each from (B) and (C)

(A) qualitative impairment in social interaction, as manifested by at least two of the following:

1. marked impairments in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body posture, and gestures to regulate social interaction
2. failure to develop peer relationships appropriate to developmental level
3. a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people, (e.g., by a lack of showing, bringing, or pointing out objects of interest to other people)
4. lack of social or emotional reciprocity ( note: in the description, it gives the following as examples: not actively participating in simple social play or games, preferring solitary activities, or involving others in activities only as tools or "mechanical" aids )

(B) qualitative impairments in communication as manifested by at least one of the following:

1. delay in, or total lack of, the development of spoken language (not accompanied by an attempt to compensate through alternative modes of communication such as gesture or mime)
2. in individuals with adequate speech, marked impairment in the ability to initiate or sustain a conversation with others
3. stereotyped and repetitive use of language or idiosyncratic language
4. lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level

(C) restricted repetitive and stereotyped patterns of behavior, interests and activities, as manifested by at least two of the following:

1. encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus
2. apparently inflexible adherence to specific, nonfunctional routines or rituals
3. stereotyped and repetitive motor mannerisms (e.g hand or finger flapping or twisting, or complex whole-body movements)
4. persistent preoccupation with parts of objects

(II) Delays or abnormal functioning in at least one of the following areas, with onset prior to age 3 years:

(A) social interaction
(B) language as used in social communication
(C) symbolic or imaginative play

(III) The disturbance is not better accounted for by Rett's Disorder or Childhood Disintegrative Disorder

# Pragmatics

The practical knowledge necessary to use and interpret language appropriately in social and real-world contexts.

Why are social contexts important?

How do you answer the telephone?

Why are real-world contexts important?

e.g., *deictic* terms, “here” vs. “there”

# Pragmatics in autism

Nonverbal gesture

Proto-declarative gestures (used to share interest in an object, or direct attention to an event) virtually absent (proto-imperatives normal)

Speech acts impaired

Declarative statements, showing off, acknowledging a listener, requesting information virtually absent

Conversational discourse

Deficits in conversational ability

Prosody

Deficits in pragmatic uses of prosody (e.g., non-grammatical stress, pauses)

All share an emphasis on social use of language!

# Formulaic speech

What is a formula? A prefabricated sequence that is stored and retrieved whole from memory ("How are you?"; "You're welcome").

Formulas are important for social use of language; may also reflect a short-cut to avoid grammatical processing

Types of formulaic speech in autism:

- Idiosyncratic sound-meaning associations ("I want to go blue" = go outside)
- Excessively literal language ("No, it's raining water")
- Trouble with pronouns and other deictic terms (you, me, here, this, etc.)
- Immediate / delayed echolalia (lexically, prosodically, syntactically faithful)
- Abnormalities in intonation, voice quality (pitch), prosody

On average, compared with other children, children with autism have:

Higher rates of formulaic speech

Lower rates of spontaneous (non-formulaic) utterances

# Syntax in Autism

- Spontaneous speech shows reduced syntactic complexity (relative to typically-developing children and developmentally delayed children)
- Closed class items omitted (e.g., the)
- Lower rates of novel, non-imitative utterances – higher rates of reliance on formulaic speech
- Impaired on tests of immediate sentence repetition

  - Impairments not found for all children!

# Morphology in Autism

- Omission of inflectional morphemes in spontaneous speech in children with ASD
  - Produce *play* for *playing*; *played*; *plays*
- Irregular inflections relatively spared

- For elicited forms –
  - High rates of omissions and incorrect inflections in language impaired children with ASD (compared to children with ASD who had apparently normal language)
    - *wash* or *washing* for *washes*; *catch* or *catching* for *caught*
  - A different study found normal accuracy for children with ASD (relative to typically-developing children), but faster-than-normal response times for regular past tenses (walked, plagged, digged), but normal response times for irregular past tenses (dug, splim → splam).

# Phonology in Autism

- Many studies report normal performance for individual speech sounds (for both expressive, receptive language)
- Some impairments found for combinations of sounds into syllables and words
  - Deficits in repetition of auditorily presented nonsense words (barrazon)
  - Non-word reading is less clearly impaired

# Lexical Abilities in Autism

Relatively intact word learning

- Forming a sound-meaning association

Normal receptive vocabulary processing

- Word-picture correspondence (“Is this a …?”)
- Word-picture matching (choose the correct picture)
- Picture selection (show me all the …)
- Word definition (“What is a …?”)

Spared single word production

- Picture naming
- Synonym/antonym generation
- Reading single words out loud

Occasional impairments on verbal fluency tasks

- Rapid automatic naming (name pictures as rapidly as possible)
- Name as many words as you can that start with the letter ‘f’
- Name as many animals as you can

# Conceptual Knowledge in Autism

- Seems to be largely spared
  - For individual word meanings
  - For conceptual organization of meanings
    - Children with ASD show normal pattern of prototypicality ratings for members of categories at both basic and superordinate levels
    - Semantic priming appears normal (based on one study)
- Processing of words related to mental or emotional states seem to be impaired

- Category Labels
  - Super-ordinate
    - mammal, animal
  - Basic-Level
    - dog
  - Sub-ordinate
    - beagle, terrier, rottweiler, alsatian

# Theories of Cognition in Autism

Language and non-language domains

# Theory of Mind in autism

Theory of Mind hypothesis: Autism involves difficulty interpreting behavior as causally linked to mental states (Baron-Cohen, Leslie and Frith, 1985)

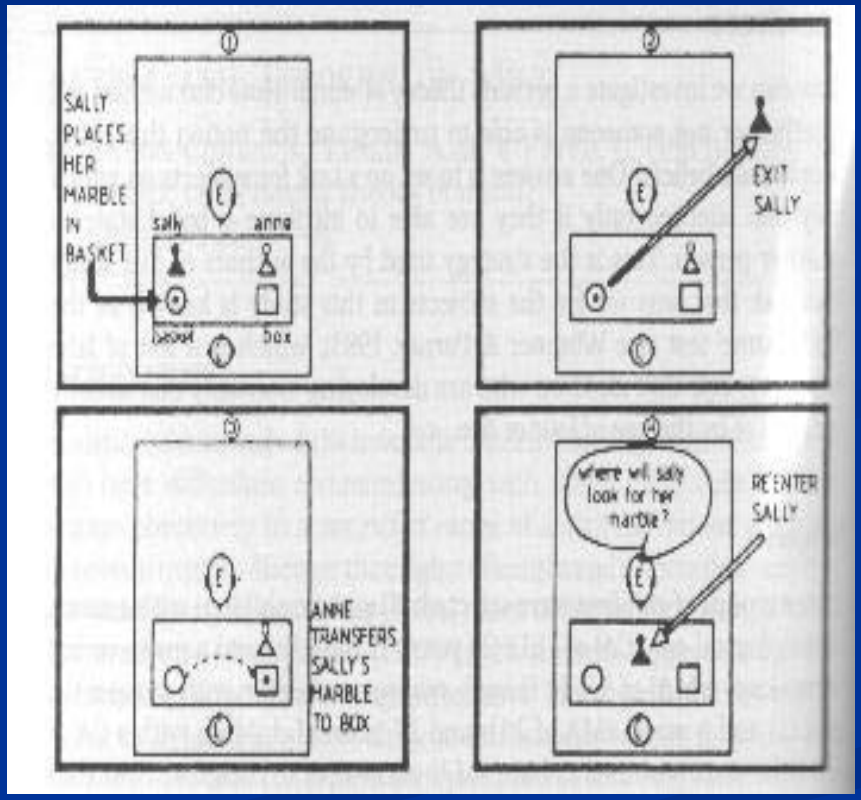
- Speech that does not entail viewing people as mental beings not necessarily impaired
- Speech that does entail viewing people as mental beings or requires shared attention (e.g., deictics) is impaired

Hypothesized to underlie both social and pragmatic impairments

# Theory of Mind

Sally-Anne Test

Does the child rely on her own knowledge, or can she answer based on what she knows about Sally's knowledge?



# Procedural Deficit Hypothesis

- Brain structures subserving procedural memory are dysfunctional
  - Frontal/basal-ganglia circuits
  - Frontal/cerebellar circuits
  - Predicts variability across individuals
  - Predicts range of grammatical abilities
    - Hypo (like Parkinson's)
    - Hyper (like Huntington's)
  - Compensation in declarative memory is expected
    - Strong lexical abilities
    - Over-reliance on formulaic speech

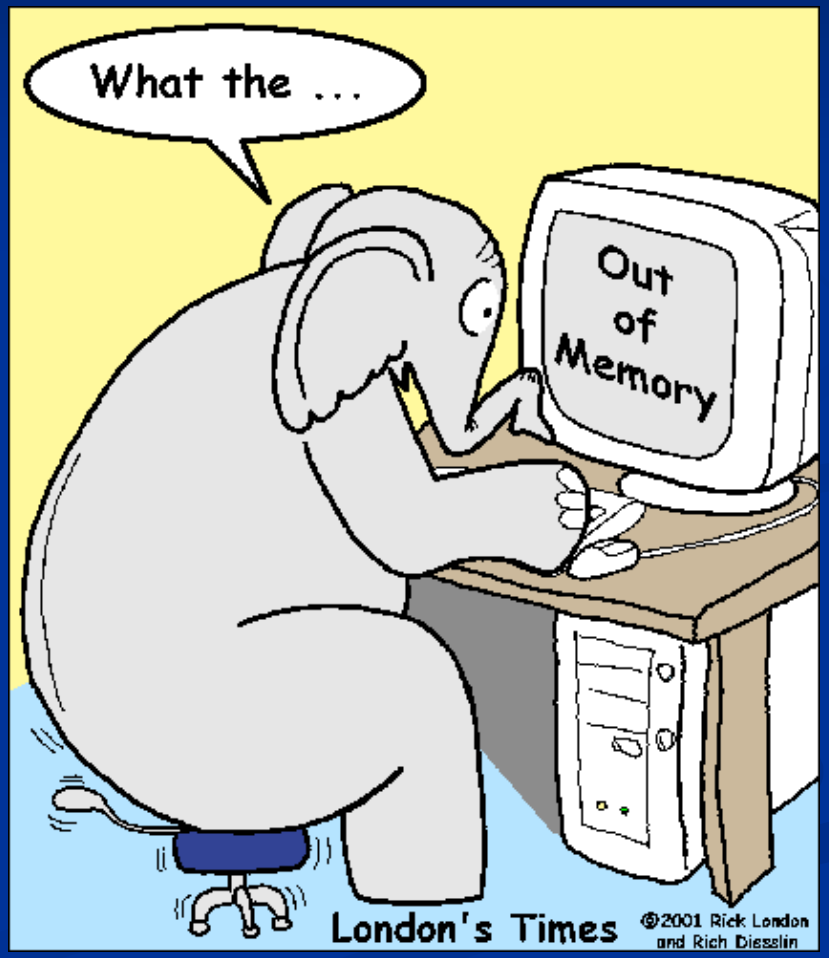
# Procedural memory in autism

- Procedural Memory Functions
  - Impaired procedural learning
    - Rotary pursuit

  - Motor impairments
    - Impaired pantomime and imitation
    - Impaired complex skill learning (dancing)
    - Hypokinetic movements (bradykinesia)
    - Hyperkinetic movements (chorea)

# Declarative memory in autism

- Declarative memory functions
  - Spared semantic memory
    - Normal representation and organization of word meanings
    - Strong ‘rote’ memory
    - Normal paired associate learning
  - Impaired episodic memory

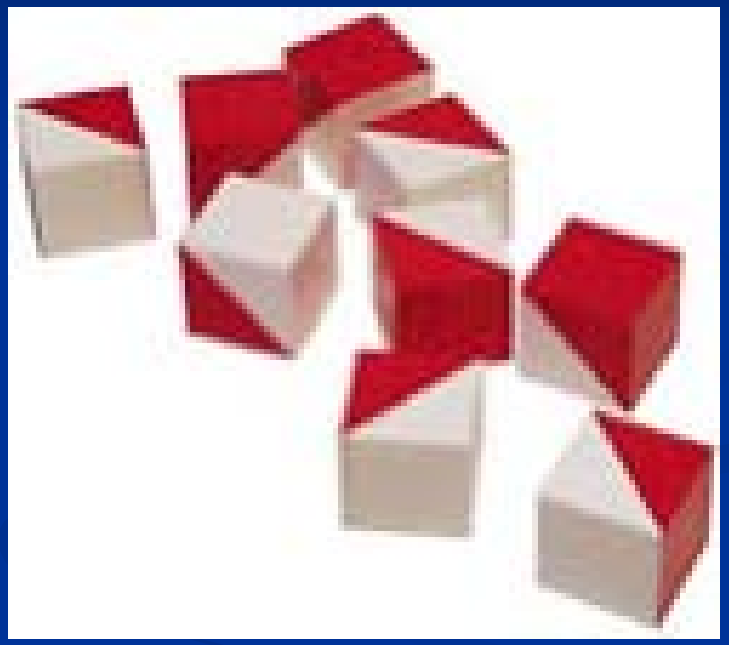


# Complex Information Processing Deficit

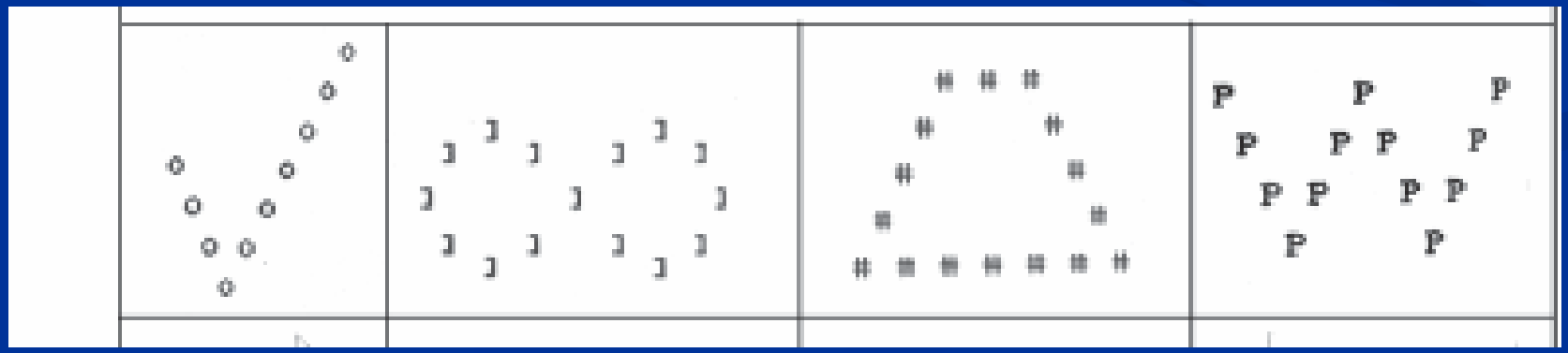
- Across domains, complex functions impaired, simple functions spared
  - Language
    - Spared lexical processing (simple)
    - Impaired grammar/pragmatics (complex)
  - Non-language (e.g.)
    - Spared simple motor (finger tapping)
    - Impaired complex motor (grooved pegboard)
  - (complexity not well defined…)

# Weak Central Coherence

- Superior performance in autism
- Strong performance on block design



  - Inferior central coherence
  - Superior local coherence



# Summary of Theories

Impaired theory of mind
- Explains pragmatic deficits
- Says nothing about grammar or lexicon or motor or memory

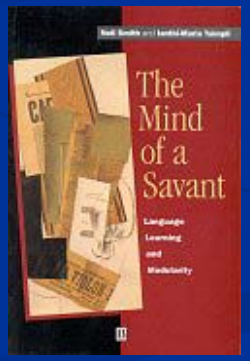
Procedural Deficit Hypothesis
- Variation in grammar; spared lexicon
- Links language to motor, memory performance
- Says nothing about pragmatics

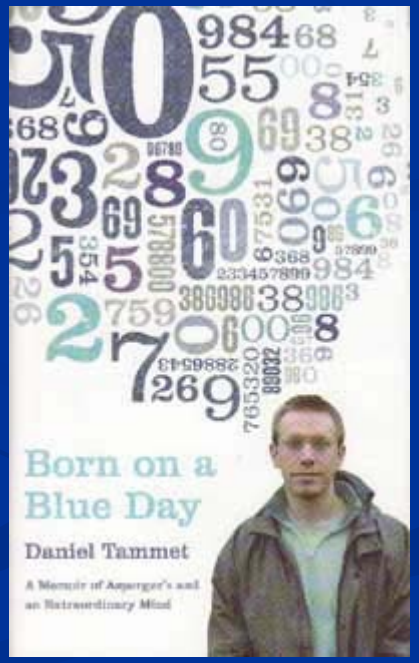
Complex information processing deficit
- Spared at simple functions (words, tapping)
- Impaired at complex functions (grammar, pragmatics, motor)
- Complexity not well defined

Weak central coherence
- Focus on smaller language units (words)
- At expense of larger units (sentences, discourse)
- Says nothing about motor, memory performance

# Savant Syndrome

- Exceptional skills in context of impaired cognition
  - Prodigious – skills are exceptional compared to anyone
    - less than 100 individuals
    - Kim Peek; Daniel Tammet
  - Talented – remarkable for age and cognitive level
- Close association between autism and savantism
  - Nearly every savant is on autistic spectrum
  - Nearly 10% of individuals with autism have savant abilities

# Domains of Savant Talent

- Music
  - Perfect pitch
  - Hear a piece once, play it perfectly
- Art
  - Drawing / Sculpture
- Mechanical ability
- Memory
  - Personally experienced events; dates
  - Perfect memory for books (Kim Peek)
- Calendar calculation
- Arithmetic
- Language
  - Hyperlexia
  - Poetry
  - Language learning
    - Christopher
    - Daniel Tammet

- All savants have exceptional memory
- All have obsessive-compulsive tendencies
- Some savants have talents in multiple areas

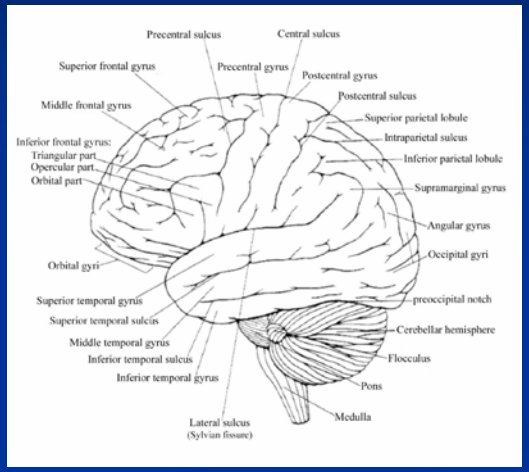
# Theories of savant talent

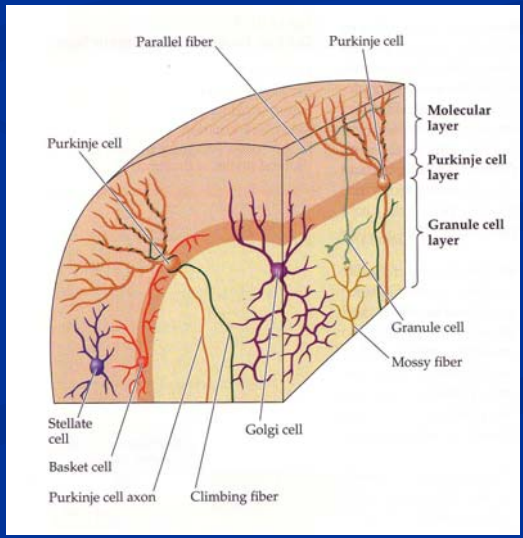
- Excessive practice
  - Attentional deficits lead to excessive focus
  - BUT, some talents appear spontaneously…
- Exceptional rote memorization
  - Drawing, ability to play music not just memorization
- Creation of a rich knowledge base through implicit learning
  - Vague on details of how implicit learning happens
- Compensation
  - Right hemisphere compensates for damaged left hemisphere
  - Procedural memory compensates for dysfunctional declarative memory
  - Declarative memory compensates for dysfunctional procedural memory
- Stronger than normal episodic memory
  - Extensive reliance on hippocampus for savant talent
  - Possibly due to damage to the amygdala
- Weak central coherence
  - Focus on details leads to excessive practice, creation of rich knowledge base

# Studies of the Brain in Autism

# Brain in autism

- Few consistent findings
  - Abnormalities of Broca's area
    - Reduced volume
    - Reduced functional activation
    - Abnormal asymmetry (increased rightward)
  - Abnormalities of temporal lobe areas
    - Increased volume
    - Increased functional activation
    - Abnormal asymmetry (increased leftward)
  - Reduced numbers of Purkinje cells in cerebellum
- Findings from other structures not consistent
  - Hippocampus
  - Basal-ganglia



# A Structural imaging study of language in Autism (De Fossé et al., 2004)

Assessed language abilities of boys with autism, using CELF (Clinical Evaluation of Language Fundamentals) and non-word repetition

Examined cortical (grey matter) asymmetry in Broca's area (pars opercularis + pars triangularis) and planum temporale

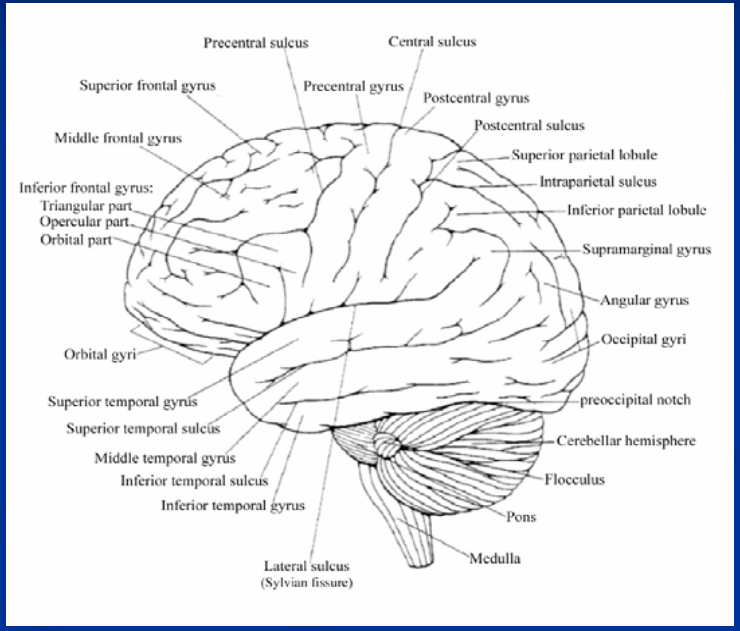



*Table 1. Characteristics of the Subject Groups (mean ± SD)*

| Characteristic | NC (n = 11) | ALN (n = 6) | ALI (n = 16) | SLI (n = 9) |
|---|---|---|---|---|
| Age (yr) | 10.4 ± 2.7 | 8.3 ± 0.9 | 9.8 ± 2.1 | 9.9 ± 2.3 |
| Full-scale IQ[a] | 114.5 ± 11.3 | 109.3 ± 24.1 | 78.3 ± 14.7 | 93.4 ± 15.5 |
| Verbal IQ | 115.9 ± 12.4 | 97.7 ± 19.3 | 75.1 ± 15.9 | 92.5 ± 15.6 |
| Nonverbal IQ | 110.6 ± 11 | 116.3 ± 24.9 | 87.9 ± 14.3 | 95.7 ± 14.6 |
| *Language testing* | | | | |
| Nonword repetition[b] | — | 8.5 ± 1.9 | 6 ± 2.3 | 8.1 ± 2.9 |
| CELF[c] | — | 101 ± 12.1 | 65.5 ± 9.4 | 85.4 ± 11.2 |

[a]SLI and subjects with autism: Differential Abilities Scale[45]; control subjects: WISC-III.[46]
[b]Repetition on Nonsense Words subtest of NEPSY.[50]
[c]Clinical Evaluation of Language Fundamentals.[49]

SD = standard deviation; NC = normal control; ALN = autism with normal language; ALI = autism with language impairment; SLI = specific language impairment.

$$\text{symmetry index} = 100 \times \frac{\text{Left}_{volume} - \text{Right}_{volume}}{\frac{1}{2}(\text{Left}_{volume} + \text{Right}_{volume})}$$

where left PU volume and right PU volume are identically labeled PUs in the left and right hemisphere. Positive values indicate that the PU is larger in the left hemisphere. Thus, if the symmetry index is 20, the volume in the left hemisphere is larger than the right hemisphere by 20% of the average volume of the left and right hemispheres. The symmetry index is a ratio of volumes, and thus, a valueless quanitity. We

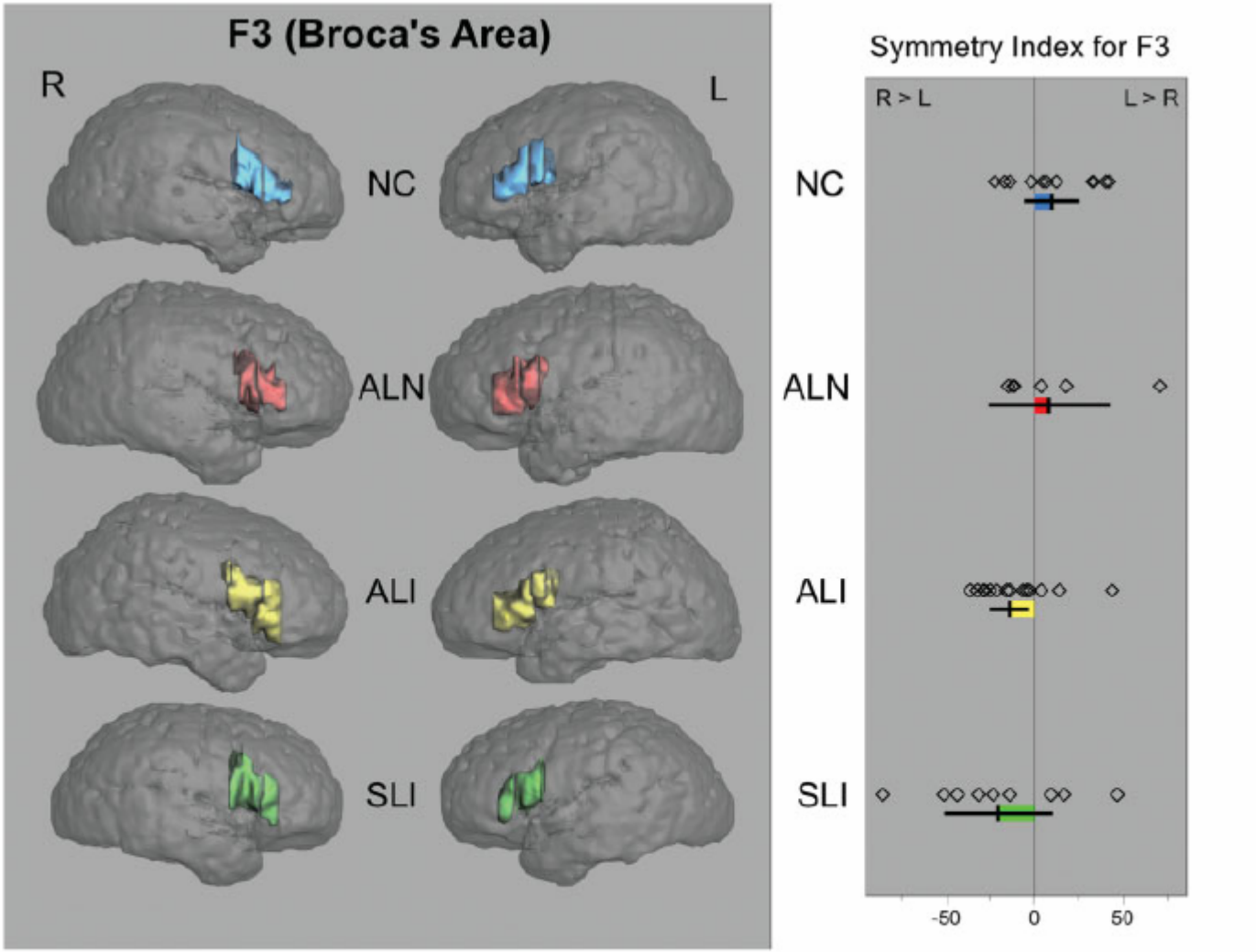



*Fig 2. Surface renderings of four brain scans from subjects representative of each of the four study groups. Inferior frontal gyrus pars opercularis plus pars triangularis (Broca's area, "F3") is highlighted in each hemisphere. A scatterplot is shown by group of each subject's F3 asymmetry value. Group means, with color on bars indicating difference from zero, and error bars indicating 95% confidence intervals are shown below each group's data points. Positive symmetry index values indicate larger left-sided volumes. Subjects in the figure were chosen based on being closest to their respective group mean value of F3 asymmetry. The actual symmetry index for the cases shown (with group mean in parentheses) are NC, 11.2% (9.7%); ALN, 3.2 (8.2); ALI, −14.7 (−14.2); and SLI, −24.3 (−20.3). R = right; L = left; NC = normal control; ALN = autism with normal language; ALI = autism with language impairment; SLI = specific language impairment.*

- Abnormal asymmetry in Broca's (R > L)
  - Combination of decreased LH volume / increased RH volume
- Abnormal planum temporale asymmetry (L > R)
  - Combination of increased LH volume / decreased RH volume

*Table 3. Volumes (mean ± SD) of Brain Regions of Interest (ml)*

| | NC | | ALN | | ALI | | SLI | |
|---|---|---|---|---|---|---|---|---|
| Brain Region | Right | Left | Right | Left | Right | Left | Right | Left |
| Whole cerebrum | 609.9 ± 27.6 | 611.1 ± 30.3 | 622.4 ± 35.2 | 621.6 ± 35.5 | 636.3 ± 62.1 | 636.9 ± 61.4 | 584.9 ± 35.6 | 582.0 ± 31.7 |
| Whole cerebral cortex | 367.1 ± 16.9 | 368.2 ± 20.1 | 375.1 ± 25.9 | 375.8 ± 32.2 | 383.7 ± 37.0 | 383.7 ± 37.3 | 349.1 ± 20.0 | 349.9 ± 18.9 |
| *Primary parcellation units of interest* | | | | | | | | |
| Broca's Area (F3) | 8.6 ± 1.5 | 9.6 ± 2.2 | 9.0 ± 2.1 | 9.7 ± 1.7 | 10.2 ± 3.0 | 8.7 ± 1.9 | 9.8 ± 2.5 | 7.9 ± 1.7 |
| Planum temporale | 3.3 ± 0.8 | 3.9 ± 0.9 | 3.2 ± 0.8 | 3.6 ± 0.5 | 3.1 ± 0.7 | 4.1 ± 1.0 | 2.9 ± 0.4 | 3.9 ± 0.8 |
| *Bordering parcellation units of interest* | | | | | | | | |
| Frontal operculum | 2.8 ± 0.7 | 2.6 ± 0.7 | 2.7 ± 0.7 | 2.4 ± 0.7 | 2.6 ± 0.7 | 2.7 ± 0.7 | 2.9 ± 0.7 | 2.3 ± 0.9 |
| Superior temporal gyrus | 6.8 ± 1.5 | 6.7 ± 1.0 | 7.3 ± 1.1 | 6.7 ± 1.3 | 7.4 ± 1.3 | 6.9 ± 1.4 | 6.2 ± 1.0 | 6.3 ± 0.9 |
| Supramarginal/angular | 18.4 ± 3.8 | 17.5 ± 4.2 | 18.5 ± 5.4 | 18.1 ± 4.4 | 21.3 ± 2.9 | 18.1 ± 4.0 | 15.4 ± 2.8 | 14.9 ± 3.5 |
| Parietal operculum | 3.1 ± 0.9 | 3.7 ± 0.9 | 3.4 ± 0.9 | 3.3 ± 0.9 | 3.1 ± 0.6 | 4.2 ± 1.3 | 3.2 ± 0.5 | 3.4 ± 0.9 |

Volumetric data for the parcellation units are provided as a reference for their symmetry indices, which are shown in Table 4.

NC = normal control; ALN = autism with normal language; ALI = autism with language impairment; SLI = specific language impairment.

# fMRI Study of Language (Just et al 2004)

- Visual sentence comprehension:

The comprehension task was to read an active or passive sentence and respond to a probe (displayed on a separate line) identifying either the agent or the recipient of the action by pressing the left or right hand response button that was on the same side as the correct response, such as:

The cook thanked the father.

Who was thanked? cook – father

(An example of a passive sentence and probe is The editor was saved by the secretary. Who was saving?)

| | | FSIQ | PIQ | VIQ | Age |
|---|---|---|---|---|---|
| Autistic | Mean | 109.1 | 104.3 | 111.0 | 27.4 |
| n=17 | Min | 87 | 84 | 91 | 15 |
| | Max | 146 | 132 | 148 | 53 |
| Control | Mean | 106.9 | 106.9 | 106.1 | 28.1 |
| n=17 | Min | 86 | 86 | 88 | 15 |
| | Max | 130 | 136 | 121 | 47 |

# Results

- In ASD participants:
  - Normal accuracy
  - Faster than normal response times
  - Greater activation (than controls) in posterior superior temporal sulcus relative to controls
  - Reduced activation (compared to controls) in left inferior frontal gyrus; supplementary motor area
- What does increased / decreased activation mean?

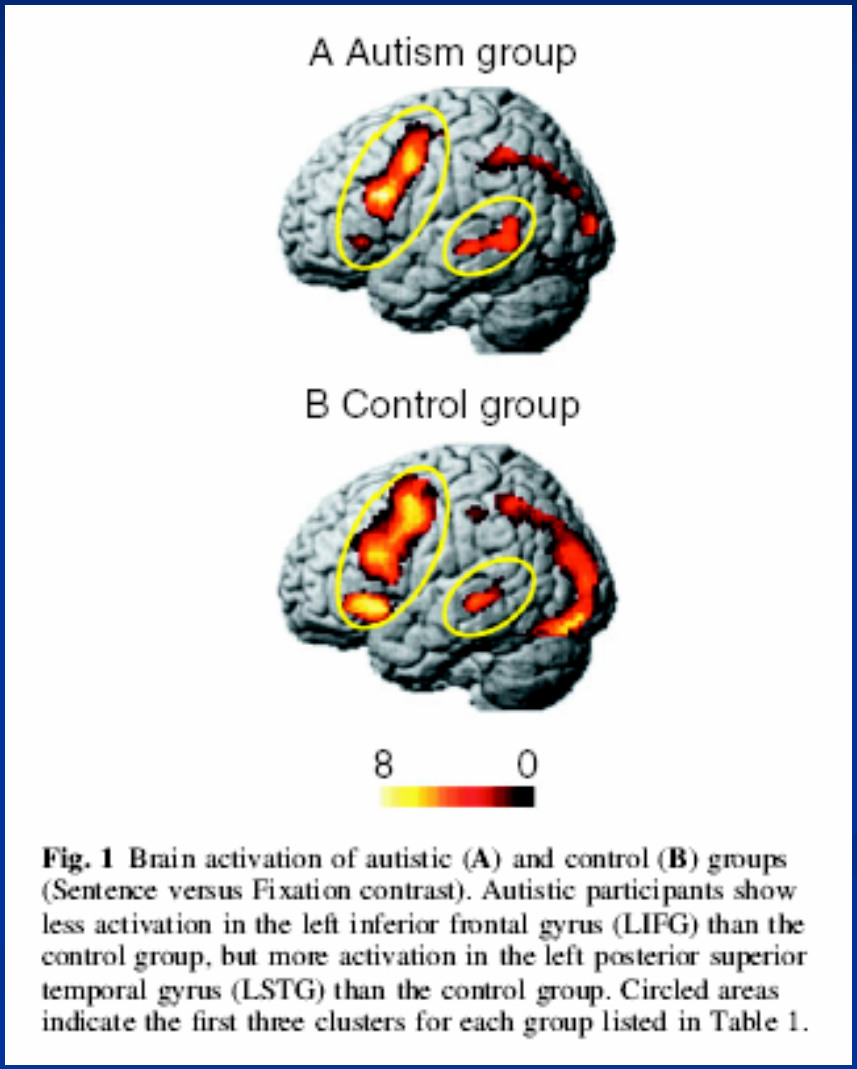



**Fig. 1** Brain activation of autistic (**A**) and control (**B**) groups (Sentence versus Fixation contrast). Autistic participants show less activation in the left inferior frontal gyrus (LIFG) than the control group, but more activation in the left posterior superior temporal gyrus (LSTG) than the control group. Circled areas indicate the first three clusters for each group listed in Table 1.

# Brain Growth in Autism (Redcay and Courchesne, 2005)

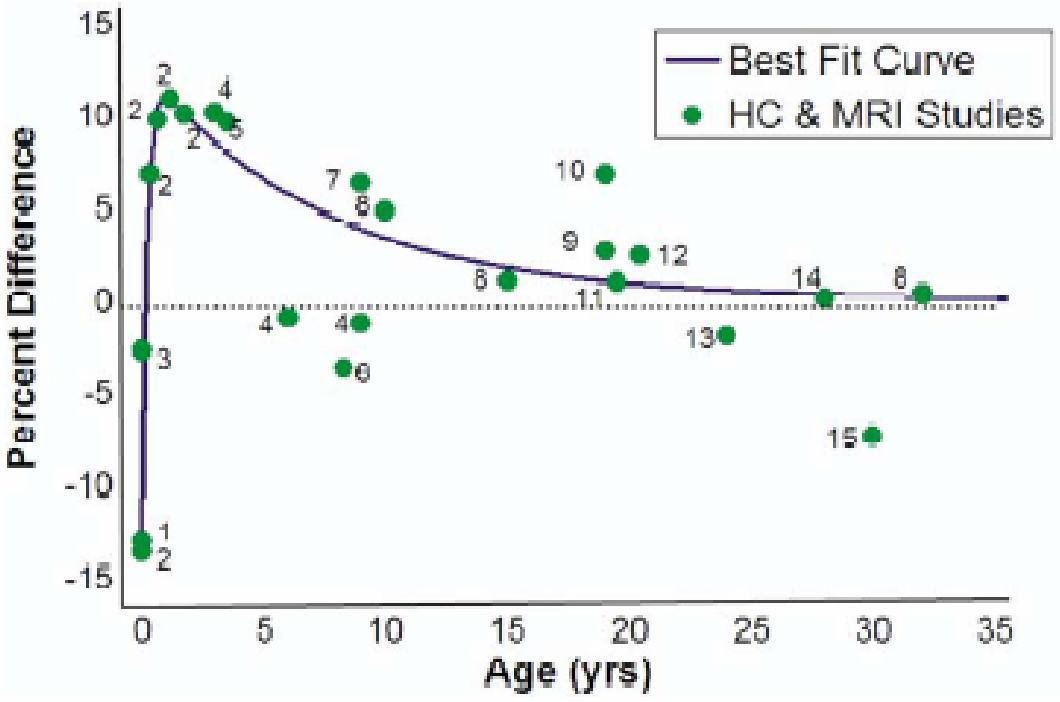



**Figure 1.** HC and MRI percent difference (%Diff) by age. %Diff values from all HC and MRI studies are plotted by the mean age of the study. The best fitted curve shows the most rapid rates of increased deviation from normal brain size in autism within first year of life and the greatest rates of decrease in deviation from normal during middle and late childhood. Study number, as listed in Table 1, is given next to each percent difference value. HC, head circumference; MRI, magnetic resonance imaging.

# Summary

- Autism is complex, difficult to characterize
- A complete theory of autism needs to explain both strengths and weaknesses in the disorder
- Brain basis of the disorder is not well understood