The Scientific Method

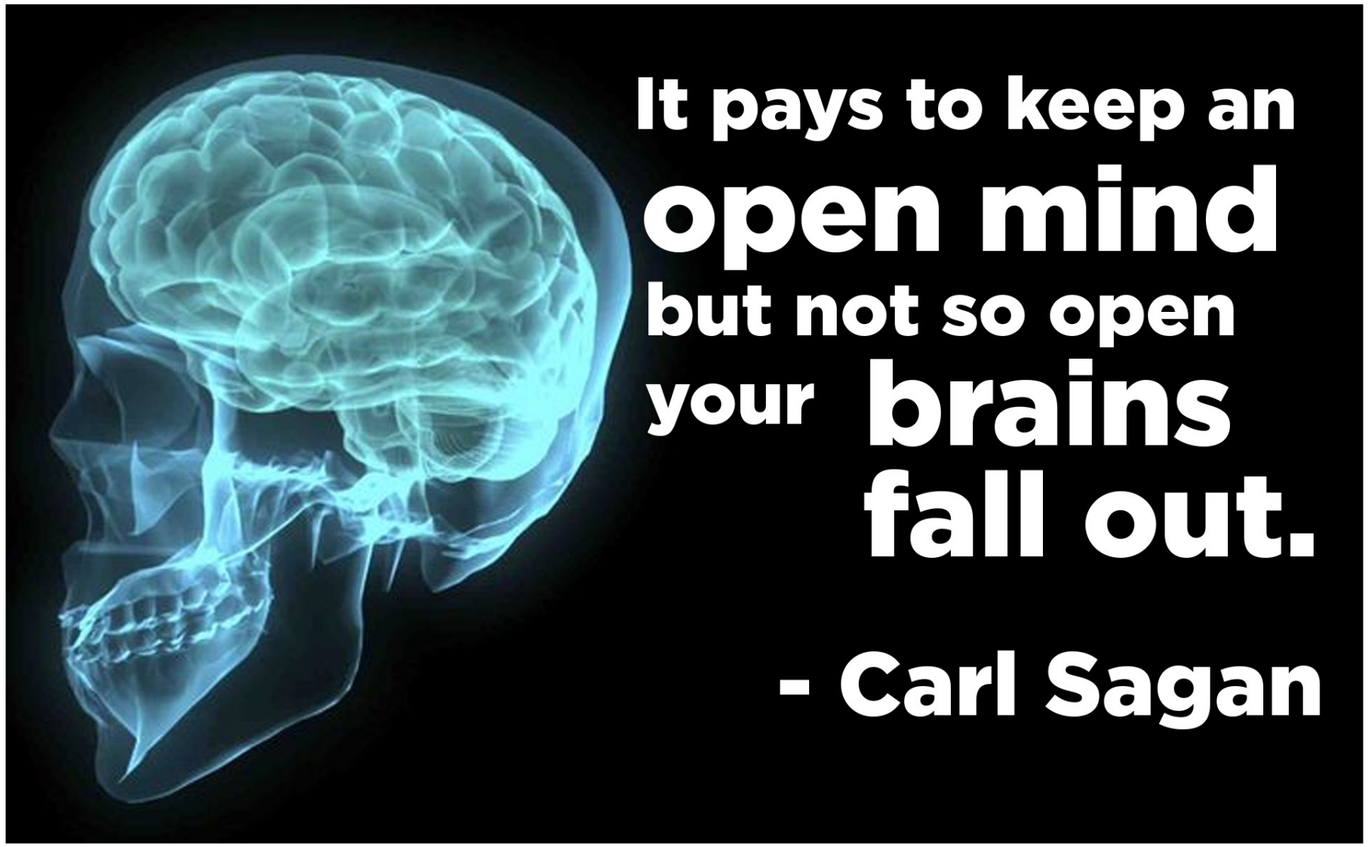
"Science is a way of trying not to fool yourself"
(Richard Feynman)

steven j. barnes

Learning Goals

- Identify the key features of scientific skepticism.
- Identify and explain the six principles of scientific thinking.
- Explain what a theory is in the scientific method.
- Explain what an operational definition is.

- Skills to evaluate claims with an open mind and carefully
- Overcoming our biases
- Six principles…



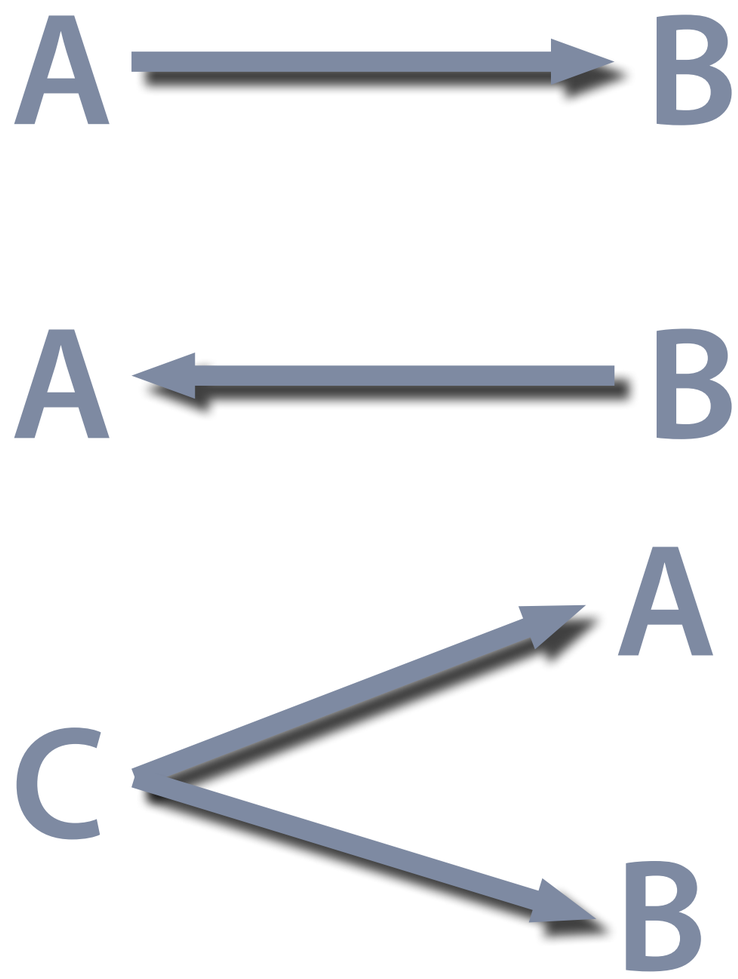
Critical Thinking Skills

Ruling out Rival Hypotheses

Important alternate explanations should be considered.

Correlation vs Causation

Can we be sure variable A causes variable B?



Critical Thinking Skills

Falsifiability

Can the claim be disproven?

Possible to duplicate scientific findings?

Lab Mice Are Stressed Out By Male Scientists, Which May Skew Results

The animals seem calmer around women.

By Douglas Main Posted 01.29.2014 at 1:00 pm

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Critical Thinking Skills

Replicability

Early report

Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children

A J Wakefield, S H Murch, A Anthony, J Linnell, D M Casson, M Malik, M Berelowitz, A P Dhillon, M A Thomson, P Harvey, A Valentine, S E Davies, J A Walker-Smith

Summary

Background We investigated a consecutive series of children with chronic enterocolitis and regressive developmental disorder.

Methods 12 children (mean age 6 years [range 3–10], 11 boys) were referred to a paediatric gastroenterology unit with a history of normal development followed by loss of acquired skills, including language, together with diarrhoea and abdominal pain. Children underwent gastroenterological, neurological, and developmental assessment and review of developmental records. Ileocolonoscopy and biopsy sampling, magnetic-resonance imaging (MRI), electroencephalography (EEG), and lumbar puncture were done under sedation. Barium follow-through radiography was done where possible. Biochemical, haematological, and immunological profiles were examined.

Findings Onset of behavioural symptoms was associ[ated] by the parents, with measles, mumps, and rub[ella] vaccination in eight of the 12 children, with measl[es] infection in one child, and otitis media in an[other]. All 12 children had intestinal abnormalities ranging from lymphoid nodular hyperplasia to aphthoid ulceration. Histology showed patchy chronic inflammation in 11 children and reactive ileal lymphoid hyperplasia in seven, but no granulomas. Behavioural disorders included autism (nine), disintegrative psychosis (one), and possible postviral or vaccinal encephalitis (two). There were no focal neurological abnormalities and MRI and EEG tests were normal. Abnormal laboratory results were significantly raised urinary methylmalonic acid compared with age-matched controls ($p=0.03$), low haemoglobin in four children, and low serum IgA in four children.

Interpretation We identified associated gastrointestinal disease and developmental regression in a group of previously normal children, which was generally associated in time with possible environmental triggers.

Lancet 1998; **351:** 637–41
See Commentary page

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Introduction

We saw several children who, after a period of apparent normality, lost acquired skills, including communication. They all had gastrointestinal symptoms, including abdominal pain, diarrhoea, and bloating and, in some cases, food intolerance. We describe the clinical findings, and gastrointestinal features of these children.

Patients and methods

12 children, consecutively referred to the department of paediatric gastroenterology with a history of a pervasive developmental disorder with loss of acquired skills and intestinal symptoms (diarrhoea, abdominal pain, bloating and food intolerance), were investigated. All children were admitted to the ward for 1 week, accompanied by their parents.

Clinical investigations

We took histories, including details of immunisations and exposure to infectious diseases, and assessed the children. In 11 cases the history was obtained by the senior clinician (JW-S). Neurological and psychiatric assessments were done by consultant staff (PH, MB) with HMS-4 criteria.[1] Developmental assessment included a review of prospective developmental records from parents, health visitors, and general practitioners. Four children did not undergo psychiatric assessment in hospital; all had been assessed professionally elsewhere, so these assessments were used as the basis for their behavioural diagnosis.

After bowel preparation, ileocolonoscopy was performed by SHM or MAT under sedation with midazolam and pethidine. Paired frozen and formalin-fixed mucosal biopsy samples were taken from the terminal ileum; ascending, transverse, descending, and sigmoid colons, and from the rectum. The procedure was recorded by video or still images, and were compared with images of the previous seven consecutive paediatric colonoscopies (four normal colonoscopies and three on children with ulcerative colitis), in which the physician reported normal appearances in the terminal ileum. Barium follow-through radiography was possible in some cases.

Also under sedation, cerebral magnetic-resonance imaging (MRI), electroencephalography (EEG) including visual, brain stem auditory, and sensory evoked potentials (where compliance made these possible), and lumbar puncture were done.

Laboratory investigations

Thyroid function, serum long-chain fatty acids, and cerebrospinal-fluid lactate were measured to exclude known causes of childhood neurodegenerative disease. Urinary methylmalonic acid was measured in random urine samples from eight of the 12 children and 14 age-matched and sex-matched normal controls, by a modification of a technique described previously.[2] Chromatograms were scanned digitally on computer, to analyse the methylmalonic-acid zones from cases and controls. Urinary methylmalonic-acid concentrations in patients and controls were compared by a two-sample t test. Urinary creatinine was estimated by routine spectrophotometric assay.

Children were screened for antiendomyseal antibodies and boys were screened for fragile-X if this had not been done

Critical Thinking Skills

Extraordinary Claims

Is the evidence as convincing as the claims?

Critical Thinking Skills

Occam's Razor

Does a simpler explanation fit the data equally well?

Critical Thinking Skills

Morgan's Canon

"In no case is an animal activity to be interpreted in terms of higher psychological processes, if it can be fairly interpreted in terms of processes which stand lower in the scale of psychological evolution and development." (Morgan 1903, p. 59)

Critical Thinking Skills

Theories

In everyday language, a ‘theory’ is often synonymous with ‘having a hunch’ about something.

In science, a theory explains events (or behaviors) by offering up ideas that help organize a set of observations; in essence, a theory simplifies a set of observations through explanation.

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An example: Sleep and Memory

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Hypotheses

A good theory produces testable predictions--known as hypotheses.

Back to our example: Our hypothesis might be that if we sleep deprive people prior to listening to this lecture, they will remember less.

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Operational Definitions

Psychologists use operational definitions when they report on their studies.

The operational definition defines what the scientist is going to manipulate or measure.

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Back to our example: Our operational definition of ‘sleep deprived’ might be a reduction of sleep in one night by 3-4 hours.

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