No Object Permanence:

- Infant will look intently at the spot where an object disappeared but, according to Piaget, they still have no concept of object permanence

Sensorimotor Substages:

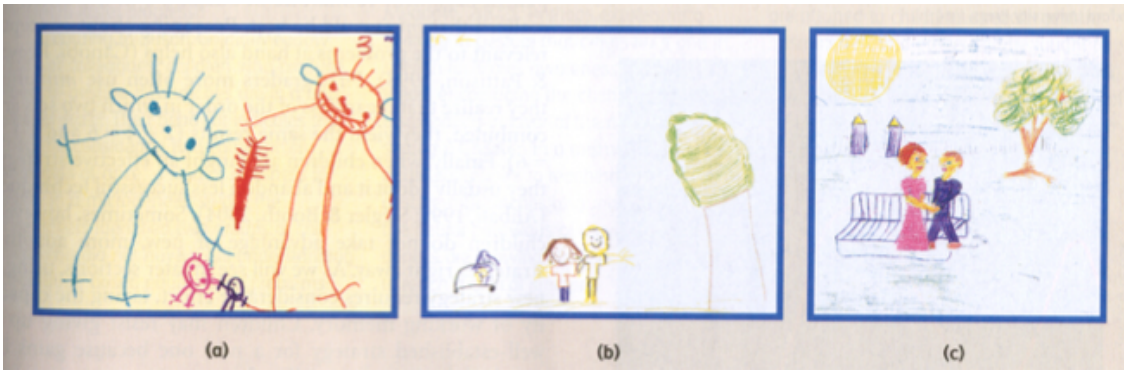
Sub	Age	Description
3	4 – 8 months	Infants becoming increasingly interested in the world around them. By the end of this substage, **object permanence**, the knowledge that objects continue to exist even when they are out of view, typically emerges.
4	8 – 12 months	During this substage, children make the **A-Not-B error**, the tendency to reach to where objects have been found before, rather than to where they were last hidden.

Sub	Age	Description
5	12 – 18 months	Toddlers begin to actively and avidly explore the potential uses to which objects can be put.
6	18 – 24 months	Infants become able to form enduring mental representations. The first sign of this capacity is **deferred imitation**, the repetition of other people's behavior a substantial time after it occurred.

Object permanence:

- Objects are tied to infant's awareness of them.
  - "out of sight, out of mind"
- Hidden toy experiment:
  - 4 months: no attempt to search for hidden object.
  - 4-9 months: visual search for object .
  - 9 months: search for and retrieve hidden object.
- A-not-B task (Diamond, 1985)
  - 9 months: A/B error after 1/2 second delay.
  - 12 months: 10 second delay needed to produce error.
  - See also studies by Rene Baillargeon in Slater, A & Lewis, M. (2007). Introduction to infant development (Second Edition).

Case & Okamoto (1996):
- E.g. Horizontal decalage



Conservation (an illustration of Case's theory):
- E.g. 5-year-old that cannot conserve liquid but has some isolated schemes.
- Schemes become automatic.
- Central conceptual structure.

Robert Siegler's (1996)Model of strategy choice (overlapping waves theory):
- Chen & Siegler (2000): 2 year-olds solving simple problems (how to use a tool to obtain an out-of-reach toy).
- Variable strategy use (Miller & Coyle, 1999; Schauble, 1996; Siegler, 1995).
- Conservation: 5-year-olds will use the strategy suggested by Piaget on one trial but other strategies on other trials (Siegler, 1995).

Strategic Variability:
- Rehearsal (McGilly & Siegler, 1990).
- Adjustment to growing competence (Perry, Church, & Goldin-Meadow, 1988).

Core Knowledge Theories

The core knowledge perspective:
- Begin with innate knowledge systems:
  - Pre-wired with core domains of thought.
- Infants could not make sense of the multifaceted stimulation without genetic "set-up" (Carey & Markman, 1999; Pinker, 1997; Spelke & Newport, 1998)
- Four key systems (Spelke, 2004)`;
  - Representing inanimate objects.
  - Actions.
  - Number.
  - Space.
- Two widely studied concepts in infancy:
  - Physical knowledge.
  - Numerical knowledge.

Studying domains of thought:
Violation of expectation paradigm:
- Expected event and unexpected event.
- Measure looking times.
- Looking time is longer for the unexpected event = violated their expectations, showing they knew what should have happened.

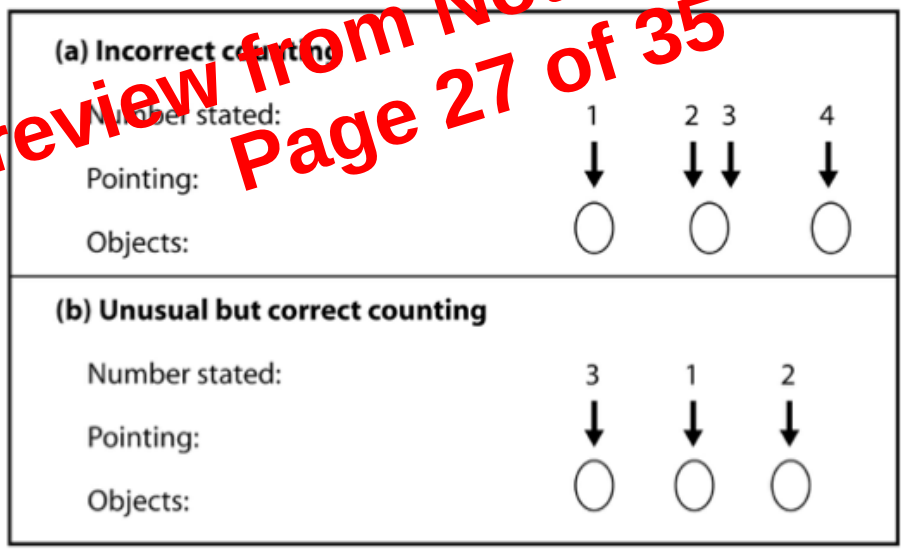
Developmental Psychology 7 - Development of Number Cognition

Learning outcomes:
- Understand the necessary requirements for a mathematical system.
- Discuss whether infants represent an abstract number system.
- Discuss infants ability to perform basic operations on number.
- Evaluate different theories about number.

Mathematical Systems.
Requirements:
- Represent numbers in terms of a set of mathematical entities.
- Operate on these representations:
    - Mathematical functions:
        - Addition .
        - Subtraction.
        - Multiplication.
        - Division.

Counting principles (Gelman & Gallistel, 1978):
- Rochel Gelman has suggested that counting is guided by 5 principles:
    1. One to one: Assign each item to be counted with only one and only one number tag.
    2. Stable order: assign number tags in the same order.
    3. Cardinality: the last number tag assigned indicates the numerosity of the set.
    4: Abstraction: counting principles apply to any set of objects.
    5: Order irrelevance: the order in which objects receive number tags is irrelevant. The 'doesn't matter' principle.

Counting Procedures:



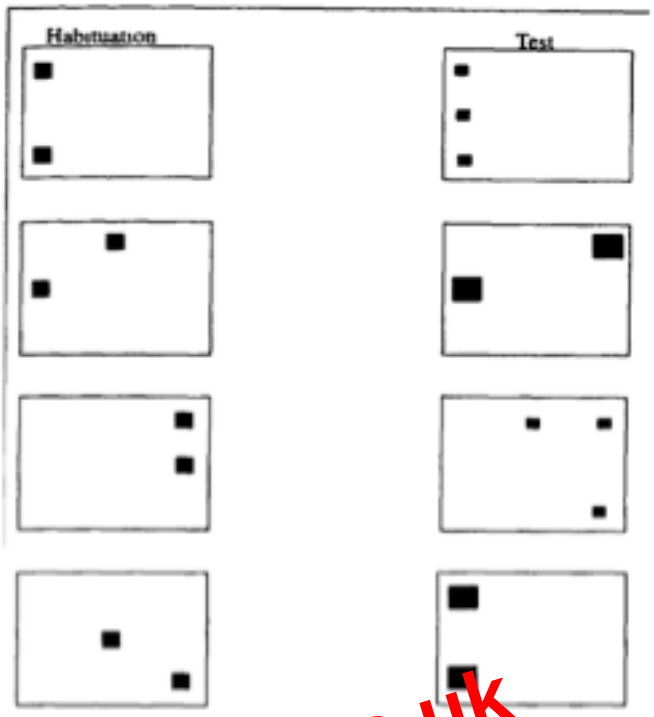
Do children use these principles?
- Gelman & Gallistel (1986) describe a study where 3, 4, and 5-year-old children were asked to count coloured chips of various set sizes. Children were videotaped and the tapes were analyzed to determine how children count. This study focussed on the first three counting principles.

i) One-one principle: children were scored correct if they assigned each item a distinct number word. Results showed that with set sizes under 5, children of all ages succeed. As set size increases, younger children start to have problems. 3-year-olds have trouble with 7 items, only 50% of 5-year-olds succeed with set sizes of 9, 11, 19.

- See Antell & Keating (1983) for similar pattern with 1 week old infants. Habituated to 3-dot displays, dishabituate to 2-dot displays. (see also Starkey et al., 1990; van Loosbroek & Smitsman, 1990).

Are these experiments about number?

- Clearfield & Mix (1999) designed a similar experiment to Starkey & Cooper, except that they varied the size of the objects that each child saw in the two phases.
- Babies were divided into two groups:
  - One group saw the same number of objects but the total amount of contour of the squares varied, so it equalled the amount of contour length there would have been if a square was added or subtracted.
  - In the other group the total number of squares changed but the contour length remained the same as the habituation phase.



Results:

- When the amount of contour stayed the same across the two phases and the number varied babies showed no sign of reviewed interest in the second phase.
- When the number of items stayed the same, and the total amount of contour changed across the two phases the babies showed signs of increased interest in the second phase.
- Evidence that babies were responding to the overall quantity of stuff, not the number of items.

Comment from Kelly Mix (Mix, Huttenlocher & Levine, 2002)

"The conservative interpretation is that infants prefer to use contour length over number. The more radical interpretation is that in all the other habituation studies, the infants were really attending to contour length rather than number".

(contour length = the sum of the perceptual contours of the items in the display)

However see studies by Xu & Spelke (2000)..this lecture & Leslie, Glanville & Lerner, 2003)

Wynn, Bloom, & Chiang (2002): {see also Wynn, 1995; Xu & Spelke, 2000}

N= 24 infants (mean age 5 months 3 days)

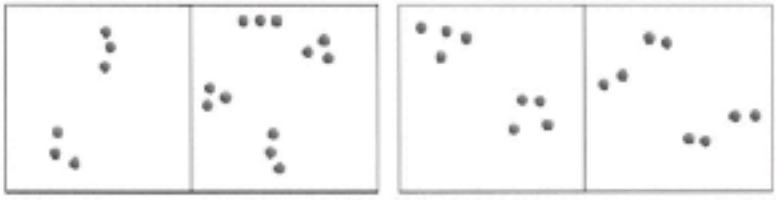


Fig. 1. Sample frames from each of the habituation and test movies.

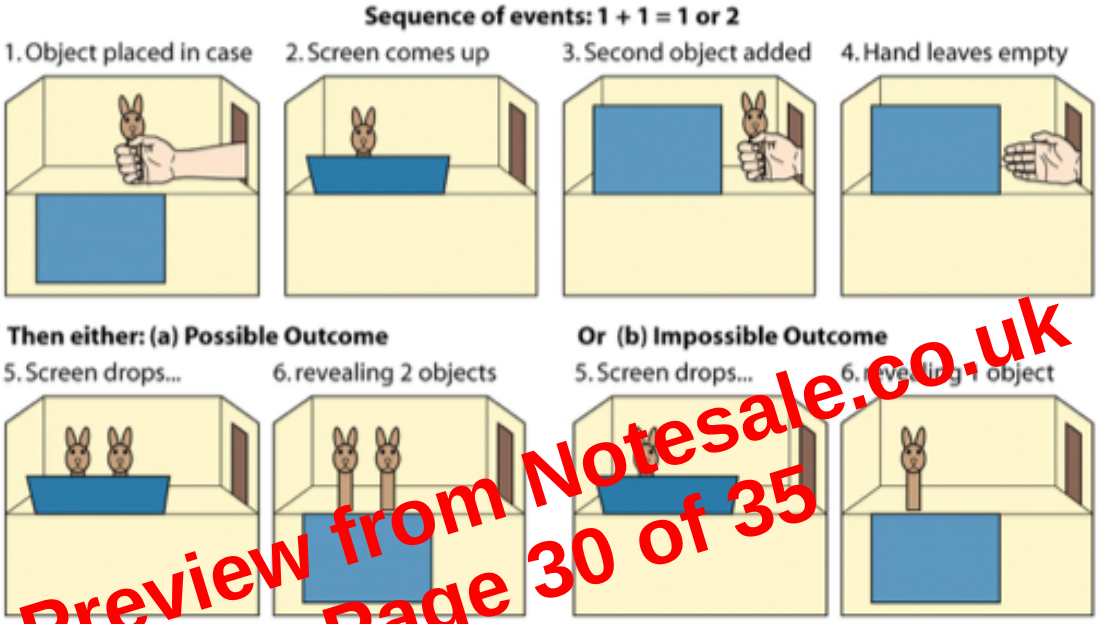
Summary of the evidence:

- A number of researchers suggest abstract representations of small numbers (e.g. Wynn):
    - Independent of modality of input (e.g. Starkey, Spelke, & Gelman, 1990).
    - Independent of perceptual properties of specific array (e.g. Wynn)
    - **This is highly debated**
    - Alternatives:
    - Number needs to be teased apart from its continuous dimensions (e.g. surface area; Xu & Spelke, 2000).
    - Changes in this ability may underlie number development itself.

Operating on number: Wynn (1992):

- Wynn showed infants to be capable of performing simple addition and subtraction.

Infants' Arithmetic Skills; Wynn's Doll Task:



Wakeley, Rivera, & Langer (2000):

- Same methodology, but introduced the:
    - 3 – 1 = 1 and the 3 -1 = 2 events.
    - Results: found no differences in looking times between correct trials and incorrect trials.
    - In addition, failed to replicate Wynn's findings.
    - Conclusion: Need for extreme caution.
    - (see talk by guest speaker: Prof. Alan Slater).

Summary:

- Evidence for some 'understanding of number'.
- How numerical knowledge is represented in highly debated.
- If infants understand addition, why can they only apply this knowledge to small number sets? (see Hauser & Carey, 2002).
- Non-verbal representation of numerical magnitudes
- Very young infants discriminate small numbers of tones (vanMarle & Wynn, 2003), moving objects and collections of objects (van Loosbroek & Smitsman, 1990; Wynn et al., 2002), simple dots (Antell & Keating, 1983; Starkey & Cooper, 1980), causal relationship between dropping objects and noises (Kobayashi et al. 2002).
- 5-month-olds conduct arithmetical operations (e.g. Wynn, 1992).