Piaget's Theory of Intelligence

Handbook of Intelligence

Evolutionary Theory, Historical Perspective, and Current Concepts

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Jean Piaget
(1896-1980)

Jean Piaget

- **Jean William Fritz Piaget** (August 9, 1896 – September 16, 1980) was a Swiss psychologist known for his work on child development.

- Piaget's theory of cognitive and epistemological view are together called "genetic epistemology".

https://en.wikipedia.org/wiki/Jean_Piaget

Overview

Piaget's Definition of Intelligence
Framework: Genetic Epistemology
Features:

- Self-organization
- Assimilation and accommodation
- Operative and figurative aspects of intelligence
- Equilibration
- Constructivism
- Semiotic Function and Intelligence
- Affectivity and Intelligence
- Social Interaction and Intelligence

Piaget's Definition of Intelligence

> *We mean nowadays by intelligence, what was formerly called Understanding or Intellect—that is to say, the faculty of knowing.*
> (French historian Taine, 1872, p. vii)

- Piaget used the term *Intelligence* in a broad sense

> *Piaget (1976a, pp. 8–9) identifies a central feature of intelligence as a movement toward increasing* ***spatiotemporal distances*** *in the functional interaction between subject (i.e., person, animal) and world.*

- Guess: The more abstract a concept is, the greater distance it has

Piaget's Definition of Intelligence

Piaget's Definition of Intelligence:

> *Intelligence constitutes the state of **equilibrium** towards which tend all the successive adaptions of a sensori-motor and cognitive nature, as well as all **assimilatory** and **accommodatory** interactions between the organism and the environment.*
> (Piaget 1976a, p. 11)

- *Intelligence constitutes the state of **equilibrium***
- *All the successive adaptions of a sensori-motor and cognitive nature tend towards the equilibrium*
- ***Assimilatory** and **accommodatory** interactions between the organism and the environment tend towards the equilibrium.*

Genetic Epistemology

- Piaget (1950a, b, c) called his theoretical framework ***genetic epistemology***.
- Here, ***genetic*** specifies ***developmental***.
- Epistemology refers to the study of the nature, sources, scope, and validity of knowledge.

> *The **epistemic subject** is able to attain states of knowledge, and the goal of genetic epistemology is to explain* how *the* attainment *of this knowledge is possible.*

- "states of knowledge" means "knowledge/state of knowing"

> *Knowledge, however, "is not to be naively equated with mere belief (or the brute factual existence of a cognitive structure): knowledge has an inescapable normative dimension, one concerning concepts like evidence, objectivity, rationality, validity, truth, etc.* (Kitchener 1993, p. 141).

- The meaning of *knowledge* here is similar to *belief* (in NARS) which is common to multiple agents, with high *truth-value.*

Self-Organization

> *Piaget used the concept of **self-organization** to characterize the relation between biology and psychological development.*

> *At the biological level, **self-organization** is the process by which a system perpetually reconstitutes its processes (e.g., metabolic cycles) and elements (e.g., cells) in order to preserve its continuous functioning.*

> *Piaget considered intelligence a biological adaptation. Self-organizing activity is the biological foundation and origin of intelligence, and cognitive processes are the outcome of and extend the processes of organic self-organization.*

Assimilation, Accommodation, and Scheme

At the biological level

> *The complementary functions of **assimilation** and **accommodation** describe the general characteristics of the exchange between organism and environment.*
> (Piaget 1963, 1970, 1971)

- Assimilation:
  - is the aspect of organism's activity wherein elements of the environment are integrated into the organism's preexisting organizational structures (i.e., the relations between elements)

- Accommodation:
  - is the aspect of the activity wherein an organism's existing ***schemes*** are differentiated and modified in response to the environment.
    - For example, a preexisting metabolic cycle assimilates particular nutrients by breaking them down into the elements that contribute to the continued functioning of the living system. The assimilatory cycle needs to be modified when the organism encounters a new nutrient (accommodation) (Piaget 1963)

Assimilation, Accommodation, and Scheme

At the psychological level

> ***Assimilation*** *and* ***accommodation*** *at the psychological level extend the physiological interactions between the organism and the environment because their functioning no longer depends on the incorporation of material elements but now incorporates* ***informational content****.*
> (Piaget 1963, 1971)

- Scheme (schema)
  - is what is *repeatable* in actions and thought processes. (*Pattern*)

- Assimilation:
  - refers to the incorporation of new information into already existing schemes, a process giving meaning to the content
- Accommodation:
  - Accommodation refers to the modification of existing schemes to account for particular features of the object or situation.

Operative and Figurative Aspects of Intelligence

> *The operative aspect of intelligence refers to the **transforming** and **form-giving**, or **structuring**, aspect of knowledge.*
> (Piaget and Inhelder 1971)

> *It includes **sensorimotor actions**, **internalized actions that are carried out mentally**, and **operations**.* (Mental Operation in NARS)
> (Piaget and Inhelder 1971)

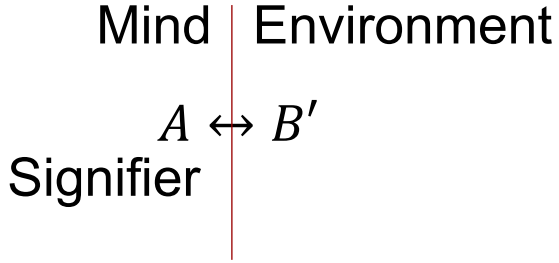
> ***Operations** are internalized actions that have become **reversible** because they are organized in a structure such that each operation is **coordinated** and can be carried out simultaneously with an another operation that cancels it out (e.g., uniting and dissociating elements, adding and subtracting).*
> (Piaget 1976a)

Operative and Figurative Aspects of Intelligence

> *The **figurative aspect** of intelligence includes the functions of **perception, imitation, imagery, and (in part) language** that are supplied by the accommodatory aspect of activity.*
> (Piaget 1969; Piaget and Inhelder 1971)

> *The figurative aspect provides **signifiers**, which, in turn, bear on the "states" of reality and provide data on which the structuring activity of assimilation acts.*

- Signifiers bear on the "states" of reality
- Signifiers provide data; the structuring activity of assimilation acts on the data.
- What is a *signifier*? (similar to a "pointer" in C language)



Operative and Figurative Aspects of Intelligence

> *The figurative aspect provides **signifiers**, which, in turn, bear on the "states" of reality and provide data on which the structuring activity of assimilation acts.*

> *For example, an infant may perceive a rattle and, **assimilating** it to an action **scheme**, she recognizes rattle as something that can be shaken (i.e., the sight of the rattle serves as a **signifier** of what can be done with it).*

Equilibration

What is the so called Equilibration?

> *At each point in development, children are in **a state of equilibrium** with the environment, characterized by **a particular balance of assimilation and accommodation**.*

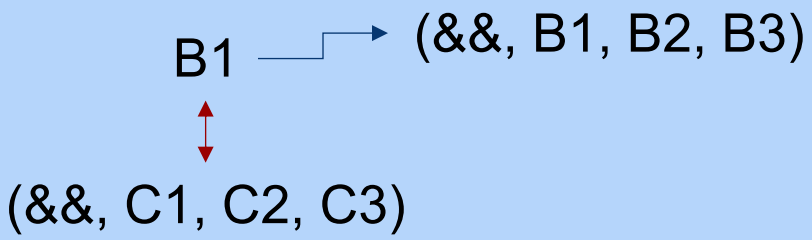
> *Development is a process that leads to increasingly more **stable** (complete and consistent) forms of **equilibrium**.*
> *Piaget (1985) termed this process **equilibration**.*

Equilibration

Equilibration must ensure two things:

> *(1) It must always open up new possibilities (as life is creative);*
> *(2) it must conserve previous structures as substructures in new and elaborated structures. The second requirement is necessary to account for the fact that logico-mathematical knowledge does not become invalid with the construction of new knowledge.*
> (Piaget 1972a)

- NARS satisfies both the requirements. (E.g., compound)



Equilibration

> *Although Piaget identified several processes as playing an important role in* ***equilibration****, such as* ***dialectics, contradiction, affirmation and negation, the generation of possibilities, and the process of becoming aware****, his theory of equilibration remains unfinished.*
> (Campbell 2009; Piaget 1976b, 1980, 1987)

- In NARS,
  - Contradictory beliefs ($robin \rightarrow bird.\langle 0.9; 0.9\rangle$ and $robin \rightarrow bird.\langle 0.2; 0.6\rangle$)
  - Negation (A and $\neg A$)
  - Mental Operation (self-awareness)

Equilibration

Reflecting abstraction

> ***Reflecting abstraction*** *is an elaborative process by which children discover the structural aspects of their cognitive activity.*
> (Piaget 2001)
> *Reflecting abstraction is central to the construction of more powerful knowledge structures.*
> (Piaget 1971, 1985, 2001)

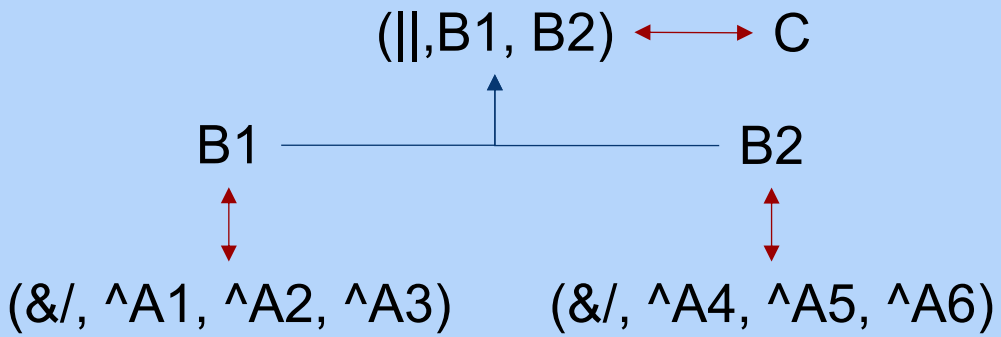
> *For instance, putting marbles, one after the other, in a receptacle is an action with several structural aspects, one of which is based on the creation of a serial order and another on the creation of a set with a growing number of elements.*

Equilibration

Reflecting abstraction

> *By becoming aware of the relations between and coordination of their actions, children **abstract structure** (the coordinatory or operative aspect of actions) **from content** and, in turn, project this structure to a higher cognitive level.*

- Effect of actions as feedback is input to the system
- A guess of what should happen in NARS



Equilibration

> *Piaget (1950a, 1972a, 2001) suggests that the general coordinations of actions (e.g., putting things together, establishing correspondences, ordering) are the source of* ***logico-mathematical knowledge****.*

> *For example, to understand the* ***commutativity of addition*** *(3 + 2 = 5 = 2 + 3), the child needs to put down objects in a different orders (e.g., first 3, then adding 2; after that 2, adding 3) and then realize that the total remains the same (i.e.,* ***the product of the actions is independent of the particular order in which the actions are executed****).*
> (Piaget and Inhelder 1976)

Equilibration

> *The mechanism of reflecting abstraction then ensures that development has an* ***intrinsic logic*** *and proceeds by way of successively conceptualizing the structures or forms of knowledge underlying previous knowing levels.*
> (Piaget 1971, 2001)

- The *intrinsic logic* is similar to the *meta-level* knowledge (i.e., NAL) in NARS
- The *conceptualized structures of knowledge underlying previous knowing levels* is similar to object-level knowledge including the theories learned/discovered by NARS (e.g. NARS discovers predicate logic and develop a theory of it in its mind).

Constructivism

> *In the field of psychology, **nativism** is the view that certain skills or abilities are "native" or hard-wired into the brain at birth. This is in contrast to the "blank slate" or tabula rasa view, which states that the brain has inborn capabilities for learning from the environment but does not contain content such as innate beliefs.*
> (Wikipedia: Psychological nativism)

> ***Empiricism** conceives of human beings as passive, emphasizing sense perception, which provides copies of reality, and association as major sources of knowledge.*

> *Piaget argued that empiricists misconstrue the fundamentally active relation between subject and world as a passive, causal relation.*

Constructivism

> *As an alternative to empiricist and nativist interpretations of knowledge, Piaget proposed a* ***constructivist interpretation****, according to which knowledge is neither a simple recording of reality nor preformed, but an active construction that "at its origin, neither arises from objects nor from the subject, but from interactions—at first inextricable—between the subject and the object".*
> (Piaget 1970, p. 704)

- This is the case for NARS. *Knowledge* (*beliefs*) are obtained from its interactions with the environment.
- NARS is a constructivist model?

Stages in the Development of Intelligence

- Sensorimotor Stage
- Preoperational Stage
- Concrete Operational Stage
- Formal Operational Stage

Stages in the Development of Intelligence

Sensorimotor Stage

> *Sensorimotor intelligence is a practical, embodied intelligence on the basis of which infants interact with the world through **perception–action cycles**. At the **sensorimotor stage**, … objects have a functional, practical meaning, they are things at hand, utensils for practical use or manipulation. Infants employ action schemes like sucking, pushing, hitting, and grasping to explore and manipulate the world.*

> *The sensorimotor period ends with the emergence of **symbol** representations, which allow infants to transcend the immediate here and now.*
> *At the completion of the sensorimotor stage, for the infant, his own action is no longer the whole of reality and instead now becomes "one object among others in a space containing them all; and actions are related together through being coordinated by a subject who begins to be aware of himself as the source of actions" (Piaget 1972a, pp. 21–22).*

Stages in the Development of Intelligence

Preoperational Stage

> *The emergence of the symbolic or, as Piaget also termed it,* ***semiotic function*** *marks the onset of the* ***preoperational stage****.*

There are two substages in the preoperational stage.

Stages in the Development of Intelligence

Preoperational Stage -- substage 1 (preconceptual thought)

> *The **semiotic function** underlies children's abilities to engage in a number of different activities, such as deferred imitation (i.e., imitation in the absence of the model), pretend play, drawing, psychological functions based on mental images (e.g., recall memory), and language. These activities are practiced and refined during the first substage of this stage.*

> *Preoperational thought is characterized by profound cognitive limitations. For example, although preconceptual thought is no longer tied to particular objects or events (the here and now), it fails to distinguish between individual members of a concept and the generality of a concept.*

- E.g., thinking of {bird1} and {bird2} as the same one, though they are different instances.

Stages in the Development of Intelligence

Preoperational Stage -- substage 2 (intuitive thought)

> *Symbolic representational schemes become increasingly coordinated, and children become capable of relating two such schemes to each other by means of an* ***unidirectional logical relation****.*
> (Piaget 1970)

> *For example, in comparing the liquid in two differently shaped containers, children may use height in order to infer the amount of liquid, but ignore the width of the container. Intuitive thought thus remains centered on one dimension (e.g., height) and fails to establish bidirectional relations between dimensions.*
> (Piaget et al. 1977)

Stages in the Development of Intelligence

Concrete Operational Stage

> *Operations (i.e., internalized actions such as putting like objects together, putting objects in one-to-one correspondence) become coordinated and integrated into logical systems.*
> (see Bibok et al. 2009)

> *As a result, children no longer center on one aspect of a situation, and they can mentally* ***reverse*** *transformations that have occurred in reality. The coordination of operations into systems also leads to the emergence of* ***logical necessity****.*
> (Piaget 1976a)

- What't the meaning of "mentally reverse transformations"?
- ChatGPT: For example, if you pour water from a short, wide glass into a tall, narrow glass, a child in the concrete operational stage can mentally reverse the transformation and understand that the amount of water is the same, even though it looks different.

Stages in the Development of Intelligence

Concrete Operational Stage

> *Another concept that children understand at the concrete-operational level is* ***class inclusion****.*
> (Piaget and Inhelder 1969; Piaget 1980)

- For example, children are able to combine two subclasses to form a superordinate class, or A (daisies)+A' (roses) = B (flowers)
- Children can also subtract each subclass from the superordinate class such that A = B − A' and A'=B−A.

- This is related to extentianal/intensional intersection/union/difference in NARS.

Stages in the Development of Intelligence

Formal Operational Stage

> *Piaget and his collaborator Bärbel Inhelder studied formal operations by presenting children and adolescents with concrete material (e.g., different weights, strings of different length) to be manipulated in order to* ***discover scientific laws*** *or* ***the cause of a result*** *from several possible factors (e.g., which factor—weight, length of string, height of dropping point, force of push—determines the frequency of the pendulum's oscillation).*

> *Adolescents* ***formulated hypotheses and derived conclusions*** *from these hypotheses. They then proceeded to test these hypotheses by systematically controlling all variables except the one under investigation.*

> *Adolescents are capable of thinking hypothetico-deductively by drawing necessary conclusions from truths that are considered merely possible.*

Semiotic Function and Intelligence

> *Piaget (1963; Piaget and Inhelder 1971) held that consciousness is always based on signs or, better, signifiers.*

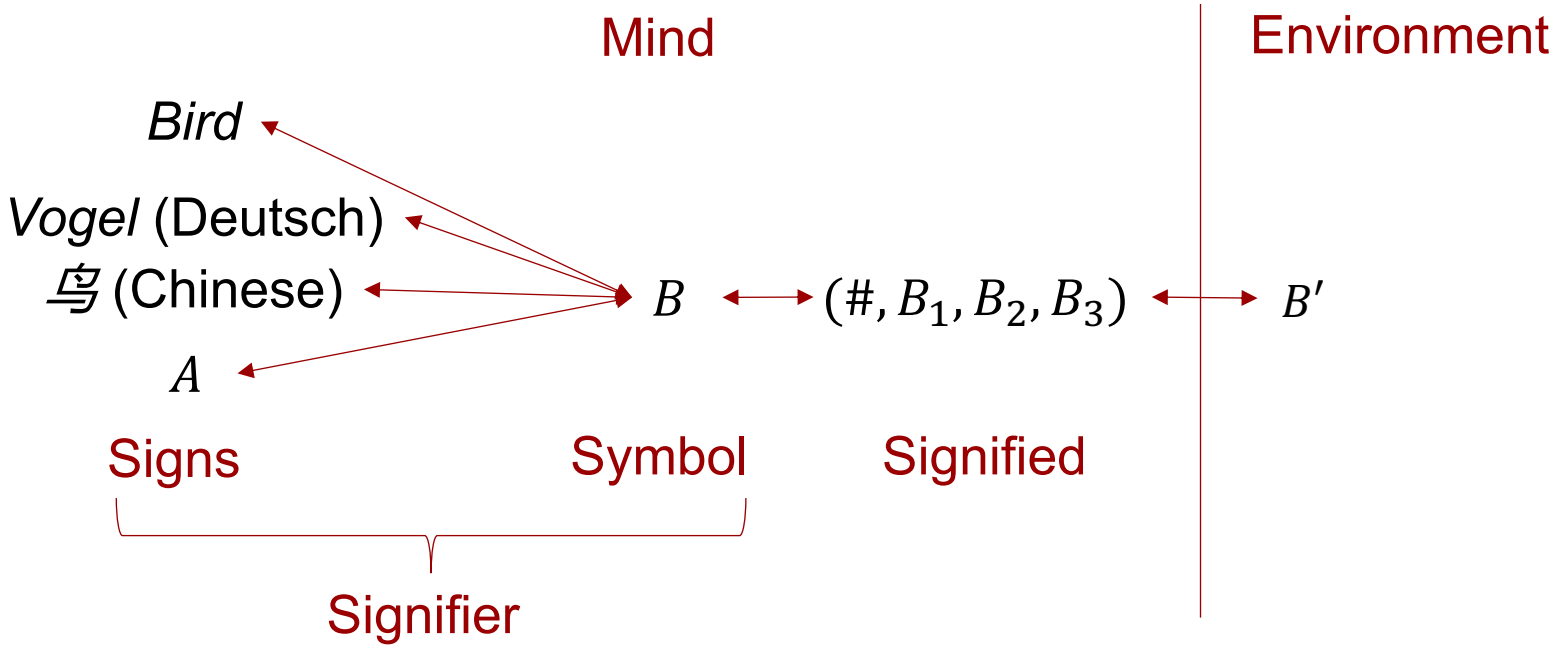
> *At the sensorimotor level, **signifiers** are not yet differentiated from their referent (**signifieds**). Signifiers at this level are termed indications*

> ***Signifieds** at this level are sensorimotor schemes that confer meaning on the elements interacted with.*

> *At the end of the sensorimotor stage, the coordination and differentiation of schemes culminate in the emergence of signifiers that are differentiated from their signifieds. Piaget (Piaget and Inhelder 1969, 1971) termed a system of such signifiers the **semiotic function**.*

Semiotic Function and Intelligence

> *The semiotic function subsumes both **symbols** and **signs**. Piaget defined symbols (such as mental images) as signifiers (i.e., they resemble the things signified) and signs (such as words) as arbitrary and conventional signifiers.*



Semiotic Function and Intelligence

> - *The semiotic function makes it possible for children to form mental representations and to think about absent objects as well as past, future, and even fictitious events.*
> - *It also increases the speed of processing because it makes it possible to imagine at the same time the successive phases of an action.*
> - *Finally, it opens up the possibility of reflecting on and understanding the reasons why some actions are successful and others not.*
>
> (Piaget 1954)

Affectivity and Intelligence

> *There is a long tradition of treating intelligence and emotion as distinct. Even in present-day psychology, IQ and EQ are thought of as separate (or even opposing) constructs (Goleman 1990).*
> *In contrast to dualistic conception, Piaget (1981; see Sokol and Hammond 2009) believed that* ***all behaviors involve an affective aspect and a cognitive aspect****.* ***The affective aspect is responsible for motivating*** *the organism's interaction with the environment by assigning a* ***value*** *or* ***goal*** *to the behavior.*

> *Affect provides the values and ends for actions, whereas cognitive functions are the means for achieving the ends.*

Social Interaction and Intelligence

Individualism and Collectivism

> *By reducing the social to the aggregation of ready-made individual consciousnesses, **individualism** provides an atomistic explanation of the social and rationality.*

> ***Collectivism**, on the other hand, considers the social as a whole that cannot be derived from an additive composition of individuals.*
> *The collective whole is characterized by emergent, novel properties and structures, and it modifies its members (i.e., individual persons; see Piaget 1995).*

Social Interaction and Intelligence

> *Piaget criticized both individualism and collectivism and proposed an **interactive relational position** as an alternative explanation of the role of social interaction in intellectual development.*

> - *"there are neither individuals as such nor society as such. There are just interindividual relations"(Piaget 1995, p. 210).*
> - *These relations between individuals are primary and “constantly modify individual consciousnesses themselves”(Piaget 1995, p. 136).*

Piaget's Definition of Intelligence

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Conclusion

> *Piaget defined intelligence as the cognitive organization of an organism.*
> *More specifically, Piaget argued that*
> - *intelligence can be defined **functionally** as resulting in increasing spatiotemporal distances between subject and world and*
> - *structurally in terms of a sequence of stages that move toward increasing reversibility.*

Conclusion

> *There are three features of his theory are essential to any comprehensive and coherent theory of intelligence.*
> - *First, theories of intelligence must **address the biological dimension of intelligence**.*
>   - *Elegantly, Piaget's insight into self-organization grounded his conception of intelligence in the very feature of life itself.*
> - *Second, inte**lligence is not passive**, not a process triggered by an input and, in turn, triggering some sort of output.*
>   - *Theories of intelligence must capture the fact that **human beings are active** and transform through their actions the world. Intelligence is not just comprised of a set of theoretical abilities; it includes, and is grounded in, practical skills.*
> - *Third, **intelligence has a normative dimension**.*
>   - *This normative dimension includes values, moral norms, and logical necessity.*
>
> *(Smith 1993, 2009)*