Basic processes of cognitive development: missing component in Piaget's Theory
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Abstract
Problems associated with the emergence of new cognitive structures are primarily addressed by studies on cognitive development. However, another side of cognitive development is mostly disregarded. Similar to the process of dissimilation in biological organisms and dissipation in the open systems described in physics, adequate cognitive adaptation to the environment requires not only development of new schemas, but also exclusion of some non-adaptive components. This paper aims to attract attention to this issue. Two possible ways of excluding the “wrong” components are discussed. Because these components are either useless or they function as impediments to the organism’s ability to respond to the demands of the environment, their exclusion can be described in terms of either extinction or as an active process of dissimilation. Cognitive dissimilation is specifically discussed with regard to the problem of blocking the activation of the impedimental component. The relationships between cognitive dissimilation and the processes of assimilation and accommodation conceptualized in Piaget’s theory of cognitive development are emphasized as another issue requiring further investigation.

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1. Introduction

Most of the studies on cognitive development primarily address the problem of emergence of new cognitive structures, although this problem can be conceptualized in a different manner. For example, Jean Piaget, the author of the most comprehensive theory of intellectual development, wrote: “For me, the real problem is novelties, how they are possible and how they are formed” (Piaget, 1971). In Piaget’s theory, all mental structures are built, transformed and connected into functional units in the interplay of two complementary processes, namely assimilation and accommodation. Cognitive development occurs through a process of equilibration, as humans assimilate new information about the world into existing cognitive structures or accommodate their cognitive structures to take the new information into account (see Bringuiér, 1980).

Emergence of new structures is a central problem not only in Piaget’s general theory of intellectual development, but also in some specific theories, such as theories of action (e.g., Adolph & Berger, 2006), theories of learning (e.g., Jacobs & Michaels, 2007; Lattal & Bernardi, 2007), theories of language acquisition (e.g., Bates & Goodman, 1997; MacWhinney, 1999; Ramscar & Yarlett, 2007), and theories of categorization (e.g., Hummel & Holyoak, 2003; Kalish, Lewandowski, & Davies, 2005).

Recent cognitive studies adopt a concept of self-organization from the theory of nonlinear dynamics to account...
for the emergence of new structures. In this framework, self-organization is defined as a tendency of complex adaptive systems, when pushed far from equilibrium, to generate new organizational forms spontaneously. Similar to the new structures in fluid (Lorenz, 1963), lasers (Haken, 1983), single-cell organisms (Webster & Goodwin, 1996), and molecular networks (Sardanyes & Sole’, 2006), self-organization is used to explain new structures in locomotion (Kugler & Turvey, 1987; Swenson & Turvey, 1991), reaching (Mottet & Bootsma, 1999), timing behavior (Kelso, 1995) and even higher-order cognition (Stephen, Dixon, & Isenhower, 2009; Thelen & Smith, 1994; Van Orden, Holden, & Turvey, 2003).

The question as to whether these advanced dynamic models really explain emergent phenomena remains an area of philosophical debate (e.g., see Walmsley, 2010), but discussion of this is beyond the scope of this paper The fact that is important to mention here is that self-organization is a specific process that occurs only in open systems. In an isolated system, the entropy increases to a maximum level leading to a final state of “heat death”. However, open systems can dissipate entropy and maintain their ordered state because they are in constant interaction with the environment. In open systems, the influx of entropy is the process that drives the emergence of new structures as an open system self-organizes into a state of increased order to dissipate entropy (Prigogine, 1976).

The principle of active interaction between the organism and its environment is central to Piaget’s theory as well. Piaget conceptualizes cognitive development as an extension of the biological process of adaptation. This principle is also adopted by recent neutral network models such as Artificial Life simulations that are regarded as a possible tool for investigating Piaget’s theory of cognitive development (e.g., see Parisi, & Schlesinger, 2002).

Thus, cognitive development is commonly regarded as a process of increasing understanding of the world and increasing adaptation to the environment. In other words, cognitive structures are described as increasingly adaptive and flexible. However, although the general principle of increasing adaptability is very plausible at the highest level of analysis, it is not necessarily true when development of new cognitive structures is analyzed in details. In other words, developing cognitive schemas apparently can include some components that are impedimental to further adaptation. These “wrong” parts should be dissimilated to ensure further correct development and application of the entire mental structure.

However, while the issue of emergence of novelties is commonly emphasized, the problem of dealing with the non-adaptive units of cognitive schemas is mostly disregarded. As this deficiency obviously needs to be compensated for, this paper is aimed primarily at attracting attention to cognitive dissimilation as another basic process that is essential for cognitive development and adaptation to the environment.

2. Can the process of development of cognitive structures be unidirectional?

We started this paper by recalling some basic principles of Piaget’s theory. Piaget adopted biological concepts of assimilation and accommodation to describe cognitive development as the process occurring in active interactions between the organism and the environment. The fact that seems to be disregarded up to this point is that these interactions necessarily require biological dissimilation as a process opposite to assimilation. Indeed, a number of dissimilation processes such as respiration, fermentation, and glycolysis play an important role in the metabolism of biological organisms. The analogy between cognitive structures and open systems in physics mentioned above requires a very similar property of the cognitive schemas as well. Open systems exchange energy and matter during their interactions with the environment, thus dissipating entropy.

However, the story gets interesting here. No component of cognitive schema once integrated to a cognitive structure can be simply dissimilated beyond the bounds of mental structures. An assumption that every new component of the cognitive system is functionally useful and improves the adaptability of the organism would help to overcome this problem and avoid any need for the concept of dissimilation with reference to cognitive development. But this is not true in the case of developing mental structures. “Wrong” components can obviously occur in acquisition of new skills; the examples can easily be found for motor skills (throwing a ball in a basketball game, manner of typing, holding a hammer or any other tool, to name just a few areas) and for more complex formal operations such as the use of algorithms for solving a mathematical problem.

In all these examples, etiology of the “wrong” non-adaptive components can be different. For example, new objects can be mistakenly assimilated to an existing cognitive structure. Conditions of the environment can change so that an existing schema becomes inappropriate or at least partly incorrect. Another possibility is a kind of redundancy of the developing schema. Some “extra” components may at first guarantee robustness of the
developing schema but later become superfluous for further adaptation because of their comparative inefficiency. Whatever were the origins of these non-adaptive components of a cognitive schema, they should be somehow excluded to ensure further correct development and adaptation. Possible ways of excluding them are discussed in the next section.

3. What happens with the non-adaptive components of the cognitive schemas?

As soon as cognitive development is conceptualized in terms of adaptation to the environment, all components of a schema that were denoted above as “non-adaptive” can be classified in two main groups. With regard to further adaptation, they can be either neutral or impedimental. We suggest that the process of exclusion of the “wrong” component depends primarily on its potential role in the further development of the adaptive cognitive structure.

Thus, when a component of the cognitive schema is just useless but remains neutral with regard to the efficiency of the interactions between the organism and the environment, there is no objective need in any active process for its exclusion from the entire schema. We suggest that existence of such a component of the schema can be best described in terms of extinction. Although these components are not completely removed, they are never activated in response to events in the environment. As time goes by, these superfluous components become extinct. The problem of exclusion of these elements is very close to the more frequently investigated problem of forgetting in general, and thus remains outside the focus of this paper.

However, some of the components of the developing cognitive schemas are not as harmless to adaptation. Holding a hammer incorrectly, thus leading to an injury, provides a good example of this type of non-adaptability of the developing schema. In such a case an impedimental component is activated in response to some event in the environment (event A); the organism fails to react adequately. Thus, the main precondition for further successful adaptation is to prevent the activation of this harmful component in response to the event A. From the perspective of adaptation, the most secure way would be simply to exclude the “wrong” part of the schema from the cognitive structure. However, this simple possibility does not exist for the human cognitive system. Therefore, the process of exclusion of the impedimental component is rather complicated and requires active “cognitive dissimilation”. A general framework for an explanation of this process is proposed in the next section.

4. How does the active process of cognitive dissimilation occur?

As discussed above, activation of the harmful component in response to the event A should be blocked so that the organism could meet the demands of the environment. In other words, this “wrong” component should be dissimilated from the cognitive schema activated by the event A. However, it cannot be dissimilated “to nowhere”. Moreover, it is not plausible that this component can be simply transferred to some other cognitive schema. In our opinion, a model of cognitive dissimilation should conceptualize it as a process including several steps.

First, the isolation of the impedimental component requires a very specific “buildup” of an existing schema. This additional part of the schema plays the role of an “internal policeman”. It is activated in response to the event A, together with the entire cognitive schema. However, the function of this new structure is to block an activation of the “wrong” component and to prevent a harmful (or just unnecessary) reaction of the organism. In this step of dissimilation, total loading on the cognitive system becomes much higher in response to the event A. The higher the probability of activation of the “wrong” component was, the more loaded would be the process of its active blocking.

As a result of active isolation, activation of the impedimental component in response to the event A decreases as time goes by. Finally the whole “built up” structure transforms to a separate declarative schema outside the entire schema. As a result, the cognitive system includes a correct cognitive schema (the “wrong” component is dissimilated) and an additional declarative schema is created based on the dissimilated component. This means the organism has knowledge of what is wrong. When the event A occurs, only the correct schema is activated. However, the declarative schema described above can also be activated in response to some other event (event B). Continuing the example of holding a hammer incorrectly, the event A is the necessity to actually use this tool, while the event B could be a situation that requires teaching another person how to use the hammer on a nail.
5. Concluding remarks

The problems associated with emergence of new cognitive structures have been the most commonly investigated issue in the psychology of cognitive development. However, the problem of dissimilation of the components that were once included in the cognitive system seems to be even more intriguing, from the perspective of our understanding of human cognitive development.

The developing cognitive schemas can apparently include components that are useless or even impedimental to the adequate response of the organism to the demands of the environment. When a component is just superfluous, its exclusion can be described in terms of extinction. However, when a component of a cognitive schema leads to a non-adaptive reaction from the organism, this component should necessarily be blocked and actively dissimilated from the active schema in order to ensure the organism’s adaptability.

The process of cognitive dissimilation was underestimated in Piaget’s theory. In the framework proposed by Piaget, any transformation of the existing cognitive structures had to be regarded as accommodation. However, a process of exclusion of the “wrong” units of the cognitive schemas is too specific by its function and its occurrence to be simply classified as a particular case of accommodation. Moreover, conceptualization of cognitive dissimilation as a third basic process of cognitive development that is to some extent, opposite to assimilation is in line with Piaget’s view of cognitive development as an extension of biological adaptation.

This paper did not aim to propose any detailed model of cognitive dissimilation. Some aspects of this problem were mentioned here, although this discussion was necessarily too concise to allow for expansion. The main purpose of this paper was to emphasize the importance of this aspect of cognitive development and to encourage systematic studies of cognitive development as a process that is characterized by both emergence of the new structures and active dissimilation of the non-adaptive components.

References:


