Anticipation as Proof of the Unity of Perception and Thought in Early Ontogeny

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Abstract. We present experimental evidence of anticipation of object motion in 6-8 week old infants. The data gives three arguments to support the view that infants from 1,5-2 months of age have the representation of space and can integrate spatial-temporal characteristics of objects before beginning to perform active locomotion. The first argument draws on the fact that anticipation of continuous events develops before discontinuous or periodical events. The second argument reflects the ability to anticipate and "interpret" the disappearance of a moving object behind a screen. For this, the infant should be using a representation of space. The third argument is the use of different actions (visual strategies) by young infants from 2 months of age. Infants use different action strategies, expressed in different eye movements. Therefore, there is an ability to integrate spatial-temporal characteristics in general representation. Continuity forms the basis of spatial knowledge as it provides the highest cohesion of spatial-temporal characteristics of events. We hypothesize that the continuous representation of objects and events should be included as a necessary immanent component in any perceptual scheme that permits to integrate perception and thought and to understand predictable environments.

Keywords: anticipation, eye movement strategies, continuity and discrete moving, invisible object, space representation, young infants

1 Introduction

The traditional scheme of perception-thought interaction separated sensory-perceptual processes and thought (Fig. 1, left). However, according to this scheme it was impossible explain the selection of and subjective preference in environment. If very young infants have the ability to anticipate this suggests a unity of perception and thinking from the beginning of cognition. The effects of anticipation can express themselves in the spatial-temporary characters of actions by selection of objects or events in environment. As such, anticipation is an inevitable and immanent feature of mental organization in phylo- and ontogenesis.

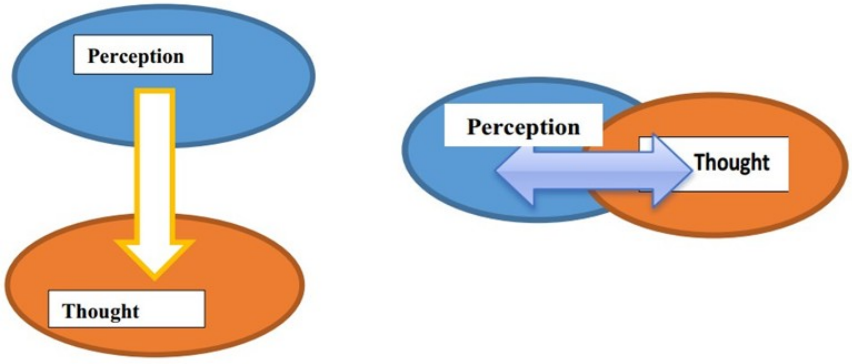

Fig.1. Traditional and modern scheme of interaction perception and thought. The modern point of view (right image) rather unites than divides these processes. Anticipation, extrapolation of events in environment is an index that thinking is active in perception (Fig.2).

Renee Baillargeon pointed out that the continuity of objects existance is a basic innate concept of infants' knowledge.

She wrote two decades ago: “The more I find out about how infants learn – bit by bit, variable by variable, event category – the more I am struck by evidence that 2,5 months-old infants show some understanding of continuity and solidity across a wide range of event categories. This physical knowledge seems so different in nature from the simplistic and event-bound initial concepts and variables infants acquire in the first year of life that it leads me to suspect that this early knowledge in fact reflects innate constraints on infants’ event representations” [1, p.159]

Currently the main method of infant study is habituation design. Renee Bailargeon argued that “the best way to refute the transient-expectation approach would of course be to demonstrate that young infants can produce positive responses even when tested without habituation trails” [1, p.130]. We would like to propose our data that supports the idea of continuity as a basic innate construct of physical knowledge. Our data demonstrates the effects of spatial-temporal anticipation and core knowledge (continuity) as a basic form of selectivity without the habituation phase. This data is highly relevant to the results of R. Aslin [2] Ph. Salapatek [3], C. von Hosten [4-6], M. Hait [7], R. Bailargeon [1], E.Spelke [8-11] and other developmental psychologists who have confirmed this idea.

J.Piaget supported the view that representation develops on the basis of integrating perception and action [12]. According to the Piagetian theory, young infants do not have an active representation of the world. On the contrary our data supports the argument that infants from 2 months of age have a representation of space and can integrate spatial-temporal characteristics before they begin to perform active locomotion [14,15]. Moreover, infants anticipate the spatial-temporal characteristics of events and “understand” that invisible objects continue to exist. We give three arguments for the presence of anticipation in infants over 2 months of age, and consider features of anticipation in different conditions.

We summarize the results of studies on 1) the continuous and discrete anticipation of objects; 2) visual search strategies; and 3) the presence of spatial representation of the motion of unseen objects in 8-28 week old infants.

2 Continuity vs Discontinuity

Continuity is the basic form of spatial knowledge as it provides most cohesion to the spatial-temporal characteristics of events. We hypothesize that the representation of continuity should be included as a necessary immanent component in any perceptual scheme to permit the integration of perception and thought and to understand and predict the environment. These conclusions are based on the following studies.

The possibility of visual anticipation of moving objects was investigated in conditions of their continuous and discrete motion in two experimental settings, where infant eye movements were recorded with an electrooculogram (EOG).

1. The object moves with sine-wave law continuity. Object movement occurred at a distance of 30 cm from the infant and with a sinusoidal continuity within the child’s sight. The velocities of object motion were 20, 27, and 33 deg/s. The size of the object was 14° and it was presented in two versions - as a black and white image of a face or a circle of the same size with black and white stripes (Fig. 3.).
2. Discontinuous object movement by a square-wave law and with a frequency of 2, 3 and 3.5 seconds. The distance betweenobjects locations was 30 and 50 degrees (fig3. II).

The study was carried out in 2 groups of participants – the first one with twenty 8-28 week old infants and the second one with 5 adults. The study design is presented on Fig. 3.

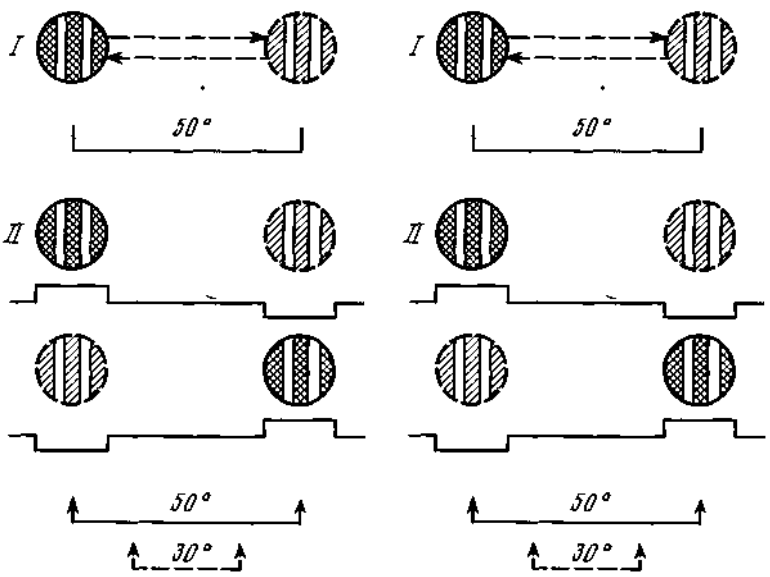

Fig. 3. Experimental design for the study of continuous (I) and discrete object motion (II).

2.1 Summary of Results

Fig. 4. shows examples of the pursuit of continuously moving objects and anticipation in infants of different age. On Fig. 5. examples of eye movement in adult and infants are presented.

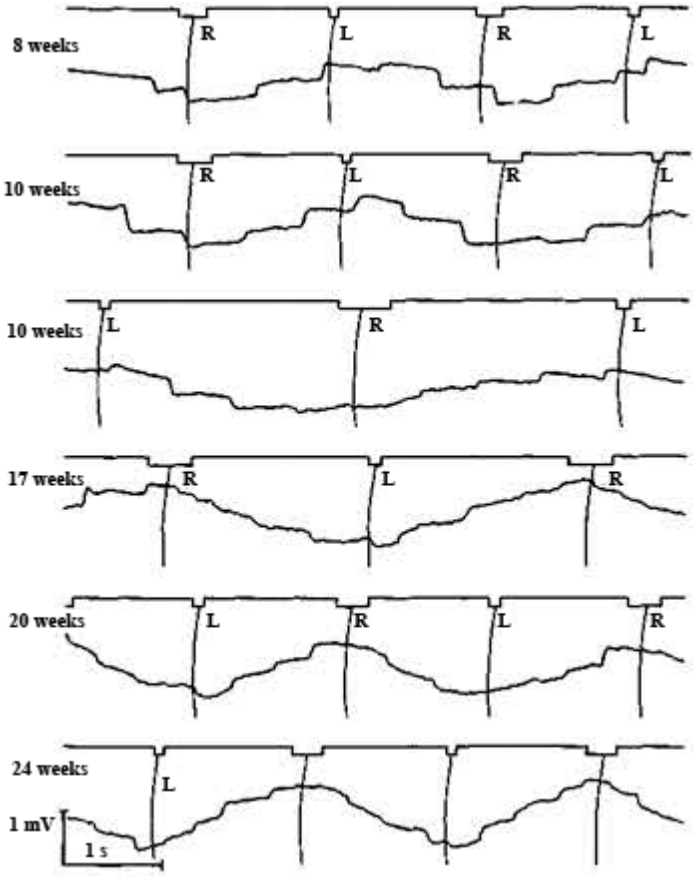

Fig.4. The examples of anticipatory visual responses in conditions of continuous object movement in 8-24 week old infants. Bars mark the extreme positions of the object on the path of motion.

In very young infants, anticipation is based on the continuity of visual afferentation. We studied the number of anticipatory responses in infants united in two age-groups (8-14 and 16-28 weeks old). Both groups showed substantially higher prevalence of antitcipation under conditions of continuous movement as compared to the discrete motion tasks (Fig.6). We found further support for our data in the experiments of Bronstein and Kennard [3]. In the same tasks, patients with Parkinson disease demonstrated disturbed performance in the setting with discrete object motion.

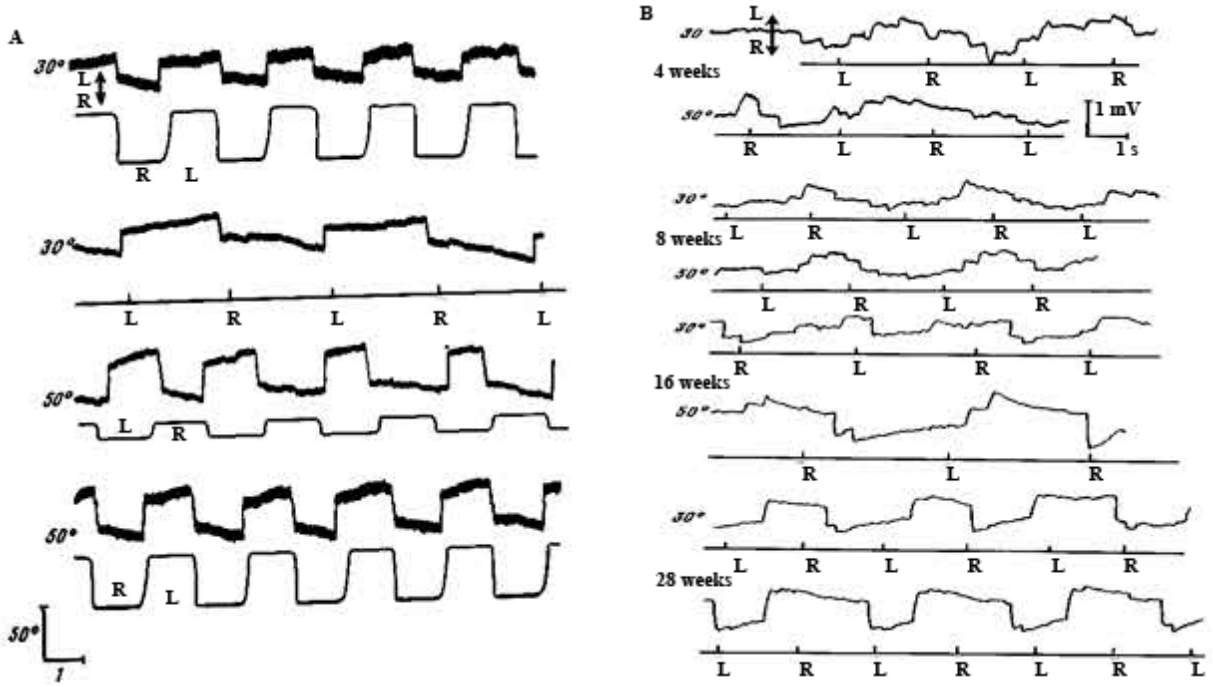

Fig. 5. Example of eye movements in adults (A) and infants (B) of 4, 8, 16, and 28 weeks of age in the condition of discrete object movement.

This means that continuity is the primary concept – it develops first and is disrupted last. Interestingly, Albert Einstein said the continuous state of matte is the primary, the most fundamental and deep one whereas its discrete state is derivative and secondary.

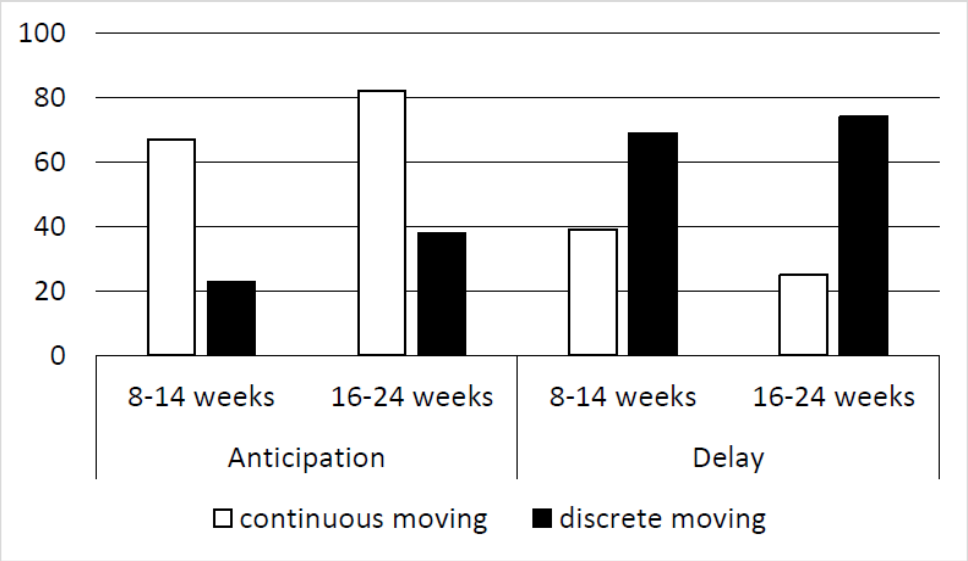

Fig.6. Distributions of anticipatory and delay responses in infants.

2 Visual Search Strategies of Invisible Objects

The second argument that there is a representation of the continuity of an object in early ontogeny is based on experiments involving the search of invisible objects. The study modeled the situation where the object was hidden behind a screen. In the experiment screens of different sizes were used. They accounted for 11 deg. (equal to the size of the object), 15 degrees (larger than the size of the object) and 22 degrees (two times larger than the object) (Fig. 7.). The velocity of the object is constant and equal to 20 deg/s. The moments when the object is hidden behind the screen and of its reappearance on its other side were registered by electromechanical sensors.. The period of time that the object is hidden behind the screen was, depending on the screen size, either 0.1, 0.4 or 0.8 seconds (Fig.7). Participants of the study were 22 infants 8-28 weeks old. Their eye movements were recorded with an electrooculograph (EOG).

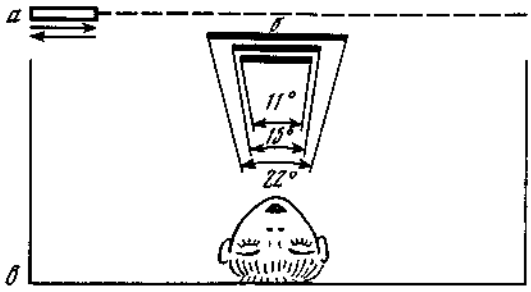

Fig.7. Design of the experiment with screens. Screens are of different sizes: screen = object; screen > object; screen > 2 x the object size.

2.1 Results

Infants use different visual strategies expressed in different types of eye movements, depending on the actual problem. This trend is typical for infants from 2 months of age. Different visual search strategies of the invisible object were:

a) Continuous anticipation – performance in the task with object disappearance engaged anticipatory saccades over the screen.
b) Discrete anticipation – the search for object was executed by saccades near the screen.
c) Anticipation of the future position of the object – there were saccades over the screen, the infant waited for the object to appear (expressed by fixation and/or small saccades).
d) Continuous tracking – the infant continued to pursue the object's movement as if it didn't see the screen (Fig. 8).

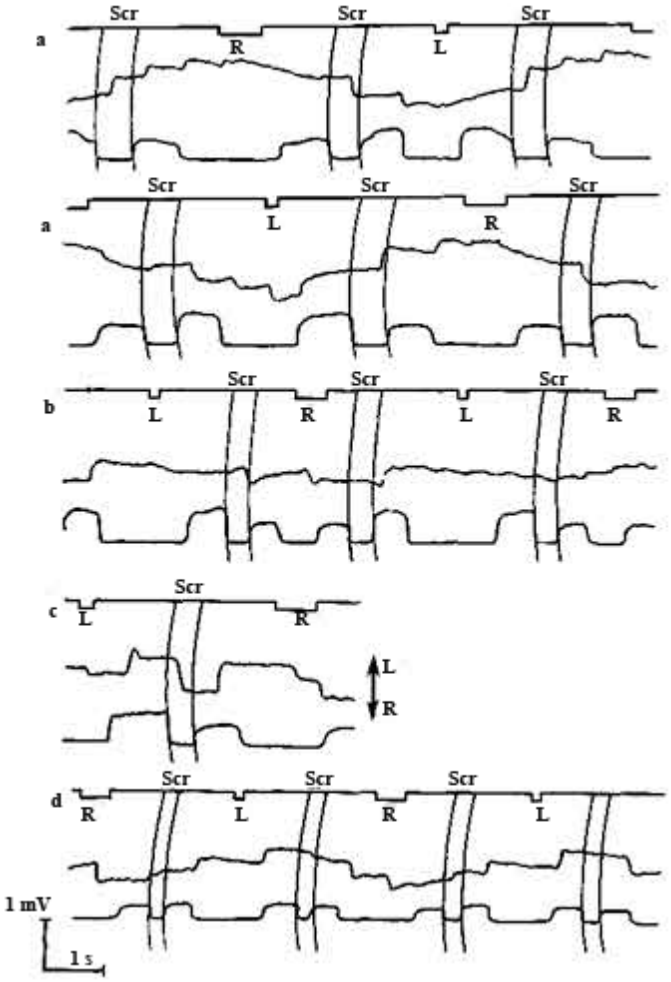

Fig. 8. The example infant eye movements as reflecting different strategies of object search. Bars mark the temporal interval when the object is hidden behind the screen.

Anticipatory strategies of searching for an object behind the screen were divided into continuous (object tracing taking into account its disappearance – Fig. 8.a.) and discrete strategies (searching for the object near the screen and waiting for its appearance on the screen – Fig. 8.b,c). Analysis of the distribution of search strategies showed that they meet the criterion of searching an invisible object. With a small screen the strategy of continuous visual search is predominant, while with big screens – the discrete strategy. This trend was common to all studied 8-28 week old infants. This means that infants from 8 weeks of age use the best strategy to search for hidden objects. These data indicate different visual strategies in task solution by infants. This trend is more pronounced in older infants.

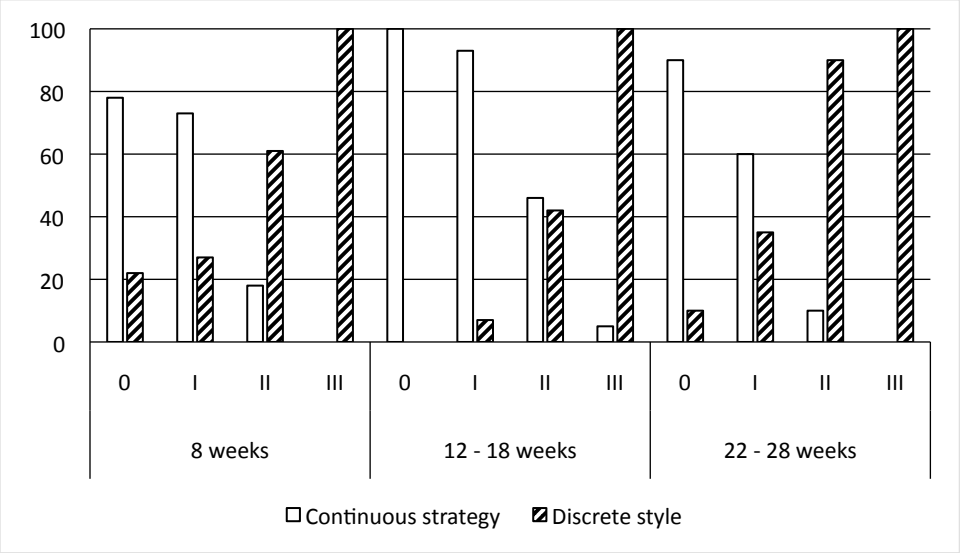

Fig. 9. The distribution of continuous and discrete anticipatory responses in conditions with different screen sizes. I. screen size = object size; II – screen size < object size; III – screen size 2 x > object size. Hatched bars – discrete style; blank bars – continuous strategy. Points indicate the number of reactions.

3 Representation of Moving Objects

The anticipation of object movement in the case of its disappearance indicates the ability to integrate spatial-temporal features of events and the possession of a representation of space. The third argument for active representation comes from studies on the anticipation and interpretation of the disappearance of moving objects behind the distal area of a screen (that covers only the end positions of movement trajectory). If the screen hid only the extreme position of the trajectory of the object, infants showed eye movements indicating that they are waiting for the object to reappear. This means that they have an idea of metricof the metric path of movement, as indicated by their response (Fig.10).

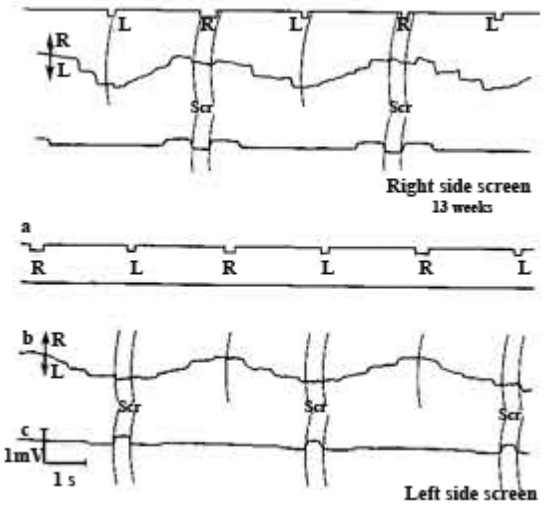

Fig.10. Example of eye movements indicating the expectation of object appearance from behind distal screen (bars mark the moments of the object behind the side screen).

4 Summary

Continuity is the basic form of spatial knowledge as it provides most cohesion to the spatial-temporal characteristics of events. We hypothesize that the representation of continuity should be included as a necessary immanent component in any perceptual scheme to permit the integration of perception and thought and to understand and predict the environment. These conclusions are based on the following considerations:

1. The anticipation of continuous events develops before the anticipation of discontinuous or periodical events. Infants from 2 months of age anticipate the continuous movement of objects that have disappeared behind a screen.
2. The second argument comes from studies on the ability of infants to anticipate and "interpret" the disappearance of a moving object behind the border area of a screen. In this case, to anticipate object motion, infants must use a representation of space.
3. The third argument is the use of different actions (visual strategies) by young infants from 2 months of age. Infants use different performance strategies, expressed in different types of eye movements. Therefore, there is an ability to integrate spatio-temporal characteristics to form general representations.

5 Conclusion

Our data are relevant to disclose the coherence of perceptual and thought processes. Perception and thought are realized not consequtively, but as a united process of cognitive analysis. An infant is able to represent and has the structural ability to select environments. The strong arguments that support this conclusion come from our data on infants' anticipatory abilities from 1.5 months of age onwards. The origin of conceptual activity in infants is the representation of spatial features of object and events.

Anticipation is not only an attribute of a person's activity, but a more universal, immanent property of mental organization and its evolution. Phenomena of an anticipation are considered not only as the spatial-temporal effects of anticipatory actions, but also as effects of selectivity. It is possible to assume that selectivity is closely connected with the primary prototypical mechanism, whereas spatial- temporary anticipation of events reflects a modality-specific mechanism of coding and mental storage. Continuity is a basic attribute of mental organization, which determines the effects of anticipation in the micro- and macrogenesis of cognition. These results will well be coordinated with ideas of a close and indissoluble connection between perception and thought processes, which aren't realized consecutively but represent uniform process of cognitive analysis.

Our research makes a direct contribution to understanding the nature of knowledge and developing ideas of the principle of an anticipation as immanent in mental development.

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