Rule-teaching in Preverbal Infants: Early Knowledge Acquisition with Gaze Contingency

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Abstract

This study delves into the cognitive abilities of preverbal infants in understanding abstract rules and their capacity to exhibit rule-compliant behavior, employing a novel experimental technique called gaze contingency. Within an environment where stimuli could be interpreted through either numerical or shape matching, providing explicit rule instructions became imperative. Infants were divided into two distinct groups, namely Self-learning and Guided-learning, based on the way that infants gained the instruction and learned the rules. Furthermore, our hypothesis posited that infants guided through the rule-learning process would display accelerated and improved rule acquisition, leading to more proficient rule-compliant behavior. Our results suggest that preverbal infants possess the ability to grasp abstract rules and that guided teaching significantly enhances their aptitude for comprehending and adhering to rules effectively.

Keywords — Infants, Rule-teaching, Gaze contingency

1. Introduction

Previous Research has shown that even preverbal infants are capable of representing, extracting, and generalizing abstract algebraic rules between stimuli (Marcus et al., 1999). And infants learn better in the presence of informative multimodal cues (Frank et al., 2009). However, most studies examining this ability rely on indirect measures such as looking time to assess infants' learning outcomes. While these measures have been shown to be reliable in many cases, they may not fully capture all aspects of infant learning, particularly when it comes to comparing learning outcomes between instructed and self-directed learning. In this research, we discuss the potential for infants to learn and apply rules through gaze contingency and focus on the effect of teaching guidance in infants' rule-learning process. From the perspective of infants' rational learning, we hypothesized that infants could learn rules through gaze contingency and that they could learn more effectively under intentional guidance.

2. Methods

To test the hypotheses, we first created animations in which infants used their gaze to pair the cards on the screen contingently. The animations comprised three distinct scenarios: combinations of triangles and pentagons, triangles and pentagrams, and pentagons and pentagrams (Figure1.A). In each scenario, a circular card was placed in the central position, exhibiting a hole at its lower midpoint that matched the dimensions of the square cards on the left and right. Together, these three cards formed a rudimentary puzzle, wherein participants controlled their eyesight to manipulate either the left or right card and fit it into the central hole to complete the puzzle. Two rules governed the puzzle: shape and quantity, and the pattern on the central circular card adhered to both rules concurrently. For instance, if the central card contained two pentagrams, the left card contained two triangles (equal number), and the right card contained a solitary pentagram (same shape). Opting for the left card would adhere to the quantity rule, whereas opting for the right card would adhere to the shape rule. Each participant was exposed to only one rule. The 12-month-old infants partaking in the study were neither informed of nor possessed an understanding of the rules beforehand.

Based on the way infants learned the rules, there were two groups in our experiment: Self-learning and Guided-learning.

In the case of the Self-learning group, the familiarization phase involved conveying the concept of matching through the simultaneous enlargement and illumination of patterns sharing the same shape or quantity. Subsequently, the side cards captivated infants' attention via two cycles of expansion and contraction. Then, the screen remained still, with the side cards encased within white borders. A cue indicating attention was established, where the border of the side cards transitioned from white to yellow upon the participant looking at them. One card would be selected if an infant's gaze exceeded 500 milliseconds. In the later feedback period, if the chosen card aligned with the game rule, the puzzle would seamlessly integrate, accompanied by the circular card's background lighting up. Conversely, a selection that did not fit with the rules would prompt the card to be expelled from the screen, leaving the puzzle incomplete and staying gray. If participants refrained from making a selection, a pink circle materialized in the screen's center, alluring the attention and preparing the infants for the subsequent trial.

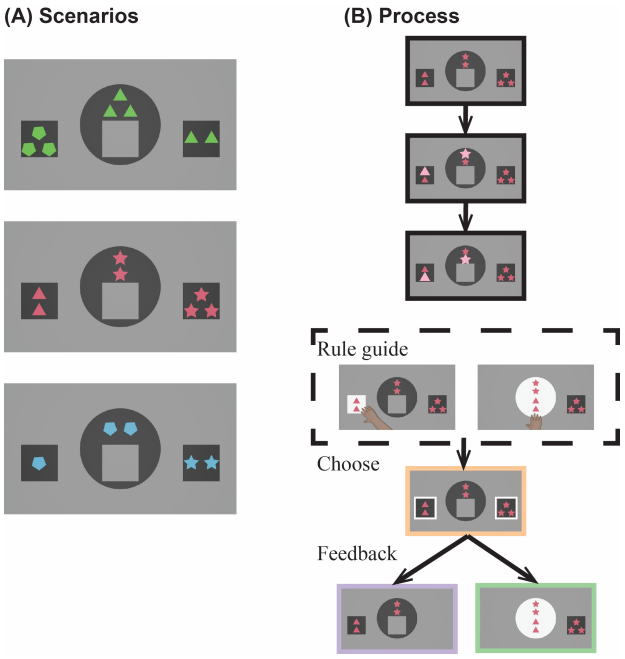

Figure 1 Experiment stimuli

The participants in the Guided-learning group experienced a slight variation from the Self-directed group. During the familiarization phase, a human-like hand emerged, precisely positioning the card fit with the rules into the hole at the center, thereby lighting up the central circular card. This action was repeated twice. Other aspects of the experiment design for the Guided-learning group remained entirely congruous with those of the Self-learning group (Figure 1. B).

In the subsequent test phase, different from the familiarization phase, there was no cue related to the current rules, infants made their own choice based on what they had already learned.

During the familiarization phase, the videos for learning in the Guided-learning group lasted 11.4 seconds, whereas those for the Self-learning group had a duration of 5 seconds. And infants were allotted a total of 10 seconds to make their selection, accompanied by a cartoon countdown chime. The feedback lasted 4.2 seconds each. Each participant underwent a total of 18 trials' experiment. Familiarization and test phases are presented alternately.

3. Results

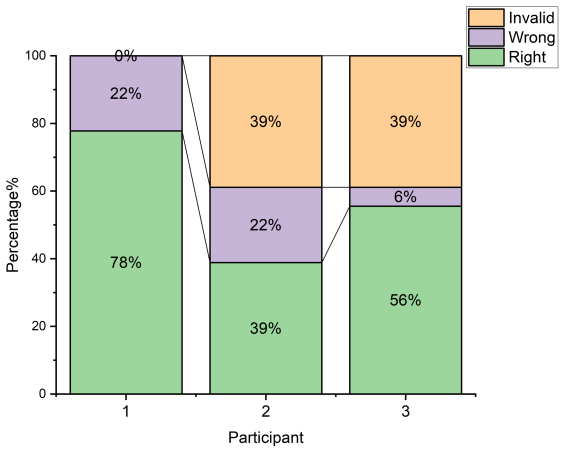

Figure 2 Selection results

Three 12-month-old infants participated in the experiment and were randomly assigned to Self-learning and Guided-learning groups. In the Self-

learning group, we found that participant 1 succeeded in 78%, and failed in 22% of 18 trials. And participant 2 succeeded in 39%, failed in 22%, and did not make a choice in 39% of 18 trials. In the Guided-learning group, participant 3 succeeded in 56%, failed in 6%, and did not make a choice in 39% of 18 trials.

4. Discussion

In the pilot experiment, we discovered promising results. Despite being in the Self-learning group, infants showed a tendency to select cards that aligned with the rules. Additionally, participants in the Guided-learning group made fewer errors. Therefore, we have reasons to believe that infants are capable of understanding and expressing actions fitting with the rules even before they start speaking. In future experiments, we plan to incorporate the Dimensional Change Card Sort (DCCS) task to investigate whether infants can finish rule transitions under the guidance of cues. In conclusion, while it requires further experimentation to verify our hypotheses, it is the first to propose the significance of abstract rule teaching for preverbal infants, which will further illuminate the cognitive learning of infants in their early stages.

5. Reference

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