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ABSTRACT

This study investigated: (1) whether infants can develop expectations for events that alternate along the vertical axis; and (2) whether infants who form expectations with one action set can transfer them to a different action set--that is, from vertical to horizontal eye movements. A total of 32 infants of 3 months of age saw one of two picture sequences. Babies in the Rule-Rule group saw 30 pictures alternating in up and down locations followed by 30 pictures alternating in left and right locations. Random-Rule babies saw an identical sequence, except that the first 30 pictures appeared in an unpredictable up and down sequence. Findings revealed that Rule-Rule babies produced a higher percentage of anticipations for the up and down pictures and lower optimal-median response times than did Random-Rule babies. For the left and right pictures, there were no significant response time differences between the two groups. However, the correlation between response times for the up and down and left and right pictures was substantially higher for the Rule-Rule babies than for the Random-Rule babies. Evidence was found for transfer of expectations between different action sets. (RH)

Rule-Transfer in the Infant Visual Expectation Paradigm

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ABSTRACT

Recent studies with the Visual Expectation Paradigm have shown that 3.5-month-olds can develop expectations for a sequence of pictures that appear in left-right (horizontal axis, L-R) alternation. Expectations are indexed by a reduction in reaction time (RT) and an increase in anticipatory eye movements.

We asked two questions in this study. First, can infants develop expectations for events that alternate along the vertical axis (Up-Down, U-D)? Second, can infants who form expectations with one action set (vertical eye movements) transfer those expectations to a different action set (horizontal eye movements)?

3-month-old infants saw one of two picture sequences. Rule-Rule babies saw 30 pictures alternating in U-D locations followed by 30 pictures alternating in L-R locations. Random-Rule babies saw an identical sequence, except that the first 30 pictures appeared in an unpredictable U-D sequence.

Rule-Rule babies produced a higher percent of anticipations for the U-D pictures and lower optimal-median RTs than Random-Rule babies. These findings replicate our earlier results with L-R alternating displays, and demonstrate that infants can develop expectations for predictable picture sequences along the vertical axis.

For the L-R pictures, there were no significant RT differences between the two groups. However, the correlation between RTs for the U-D and L-R pictures was substantially higher for the Rule-Rule babies than for the Random-Rule babies. Additionally, Rule-Rule babies produced a significantly higher percent of anticipations for each of the three blocks of L-R pictures than for their baseline series, whereas Random-Rule babies did not for any of the L-R blocks. Thus, we did obtain some evidence of transfer of

expectations between different action sets.

QUESTIONS: It has been demonstrated that babies can develop expectations for predictable horizontal-axis events:

1) Can babies also develop expectations for predictable vertical-axis events?

2) Can babies transfer an alternation rule from one action set to a second action set?

INTRODUCTION: We recently introduced a new paradigm for studying the development of expectations in infants. Babies see a sequence of pictures that appear in different locations separated by a no-picture interval. The timing and location of the pictures is not contingent on the infant's behavior. The series may or may not be predictable, and expectations are inferred from two measures of eye movement behavior. One is a reduction in reaction time (RT) to look at a picture, and the other is a movement of the eyes to a correct location before a picture appears (an anticipation). Haith, Hazan and Goodman (1988) demonstrated that 3.5-month-olds rapidly form expectations for pictures that appear in alternation along the horizontal axis.

One purpose of this study was to examine if infants can also develop expectations for events that appear predictably along the vertical axis. A second purpose of this study was to test whether babies can apply a rule learned with one action set to a second action set.

SUBJECTS: Thirty-two 3-month-olds.

GROUPS: Rule-Rule Group: Babies saw 10 pictures on the Left and Right in an irregular spatial sequence (Baseline). Then, 30 pictures appeared in U-D alternation, followed by 30 pictures in L-R alternation. Random-Rule Group: Identical to the Rule-Rule Group, except that the 30 U-D pictures appeared in an unpredictable spatial sequence.

PROCEDURES: A baby was placed on its back to watch the pictures. Each picture was presented for 700 ms followed by a 1000 ms no-picture (ISI) interval. The baby's right eye was videotaped using standard infrared corneal-reflection techniques. The videotape was later analyzed, frame by frame, and all eye movements were coded. An eye-movement was coded as an anticipation if it was in the direction of the alternative picture location and occurred either during the ISI or within 200 ms of picture onset. Reaction Times (RT) were measured for nonanticipated pictures and represented the time difference between onset of the picture and the onset of an eye movement toward the picture. A median was taken for all the RTs for each subject. In addition, RTs were subdivided into categories of fast (201 - 300 ms), intermediate (301 - 466 ms), and slow (> 467 ms). Finally, the optimal RT was the median of the ten fastest RTs.

RESULTS

CAN BABIES DEVELOP EXPECTATIONS FOR PREDICTABLE EVENTS ALONG THE VERTICAL-AXIS?

Rule-Rule babies produced more anticipations in the U-D series than Random-Rule babies, although this difference was of marginal significance (See Table 1, $p<.07$). Rule-Rule babies also had significantly faster optimal scores than Random-Rule babies ($p<.01$). Thus, babies can develop

expectations for events that appear predictably along the vertical axis.

Additional evidence that babies can develop expectations for predictable vertical events comes from an analysis of the median RT and the percent of anticipations for each block of ten pictures. The median RT of the first block of ten U-D pictures was significantly faster for Rule-Rule babies than for Random-Rule babies (496 and 568 ms respectively, $p<.05$), and Rule-Rule babies had more anticipations for the second block of vertical pictures (See Figure 1, $p<.05$).

CAN BABIES TRANSFER EXPECTATIONS ACROSS ACTION SETS?

Babies in both conditions developed expectations for the L-R series, thus extending our previous findings. Overall, there were few significant differences between the groups for the L-R pictures (See lower part of Table 1), which indicates that infants in both Conditions quickly adapted to the change in orientation. However, the mean % anticipations was higher for the Rule-Rule babies for the first two blocks of L-R pictures, and the increment over their baseline % was significant for every block of 10 trials; none of the block increments was significant for the Random-Rule babies (See Figure 2).

Additionally, we found evidence for transfer in the correlations of RT medians between the U-D and L-R sets. The correlations for the Rule-Rule babies were significant for each of the RT measures (See Table 2, $r=.67$ or greater, all $p<.0$[illegible] However, none of these measures correlated significantly for the Random-Rule babies. Thus, RTs are stable across 'axis of orientation' when a rule is transferred but not when the rule is changed. Anticipations were not significantly correlated for either group of babies.

Additional Results: Within-Group differences between the vertical-and horizontal-axis pictures were also examined (See Table 2). The means and medians indicated that babies in both Conditions performed better with the L-R pictures. However, the effect was much larger for the Random-Rule babies, presumably because they benefited from the new predictability of the L-R series. The differences in performance were significant for the Random-Rule babies for all of the RT measures (median RT, $p<.01$; percent fast, $p<.05$; percent slow, $p<.05$), while only one of the differences was significant for the Rule-Rule babies (percent fast, $p<.05$).

CONCLUSIONS

In conclusion, we found that babies did develop more expectations for predictable vertical events than for unpredictable ones. Therefore, our prior expectation findings are not limited to the horizontal axis. Additionally, the increment in % anticipations and the higher RT correlations between sets for the Rule-Rule babies indicate some rule transfer with this paradigm. The absence of significant RT differences between groups for the L-R series may reflect the relative ease with which babies detect and use the alternation rule whether or not they have been previously exposed to it.

TABLE 1:

Means and t-tests between the Rule-rule and Random-rule groups.

	MEANS RULE-RULE	MEANS RANDOM-RULE	SIGNIFICANCE
Baseline Median RT	506	524	
Vertical Axis (U-D) Pictures			
Reaction Time Measures			
Overall Median	495 ms	532 ms	
Opt. Performance Median	420 ms	495 ms	**
Anticipation Measure			
% Anticipation	20.4	14.2	+
Horizontal Axis (L-R) Pictures			
Reaction Time Measures			
Overall Median	470 ms	473 ms	
Opt. Performance Median	396 ms	382 ms	
Anticipation Measure			
% Anticipation	21.3	18.8	

+ p < .10
* p < .05
** p < .01

TABLE 2

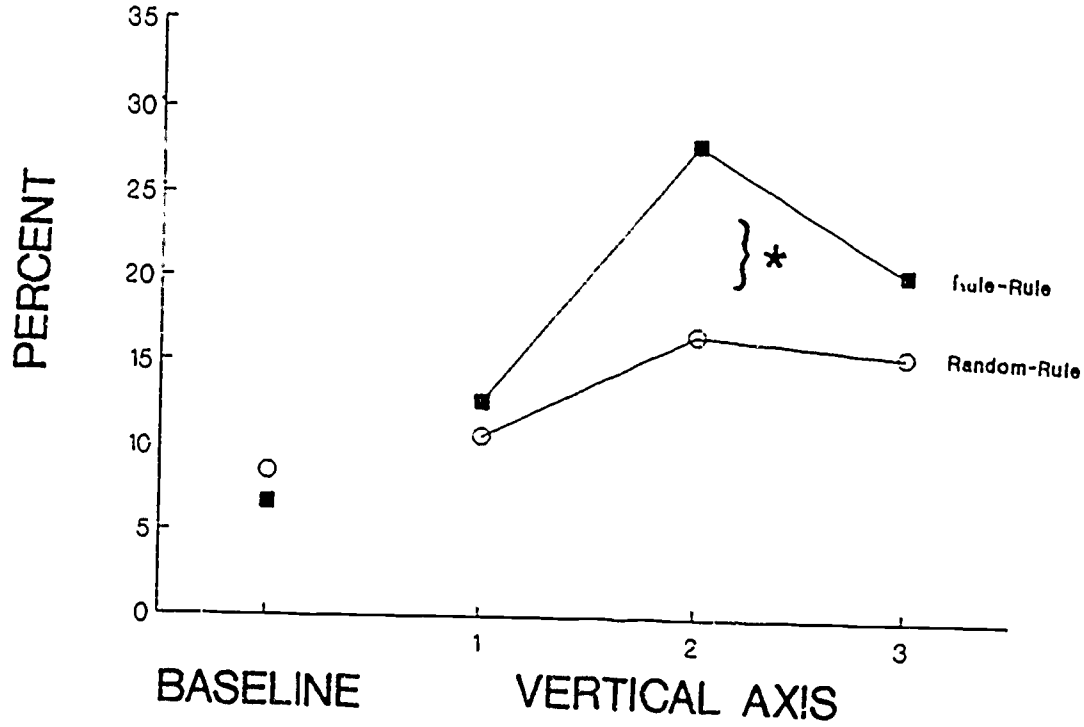
Within group correlations and matched-sample t-tests between the horizontal axis and vertical axis pictures.

	MEANS U-D PICTURES	MEANS L-R PICTURES	CORRELATION r	T-TEST
Rule-Rule Group				
Reaction Time Measures				
Overall median	495 ms	470 ms	.70 **	
Opt. Performance Median	420 ms	396 ms	.72 **	
% Fast	6.2	14.1	.72 **	*
% Slow	57.5	51.0	.67 **	
Anticipation Measure				
% Anticipation	20.4	21.3	.13	
Random-Rule Group				
Reaction Time Measures				
Overall Median	532 ms	473 ms	.39	**
Opt. Performance Median	495 ms	382 ms	.39	**
% Fast	4.6	10.9	.39	*
% Slow	62.6	52.1	.58 *	*
Anticipation Measure				
% Anticipation	14.2	18.8	.41	

+ p < .10
* p < .05
** p < .01

Figure 1

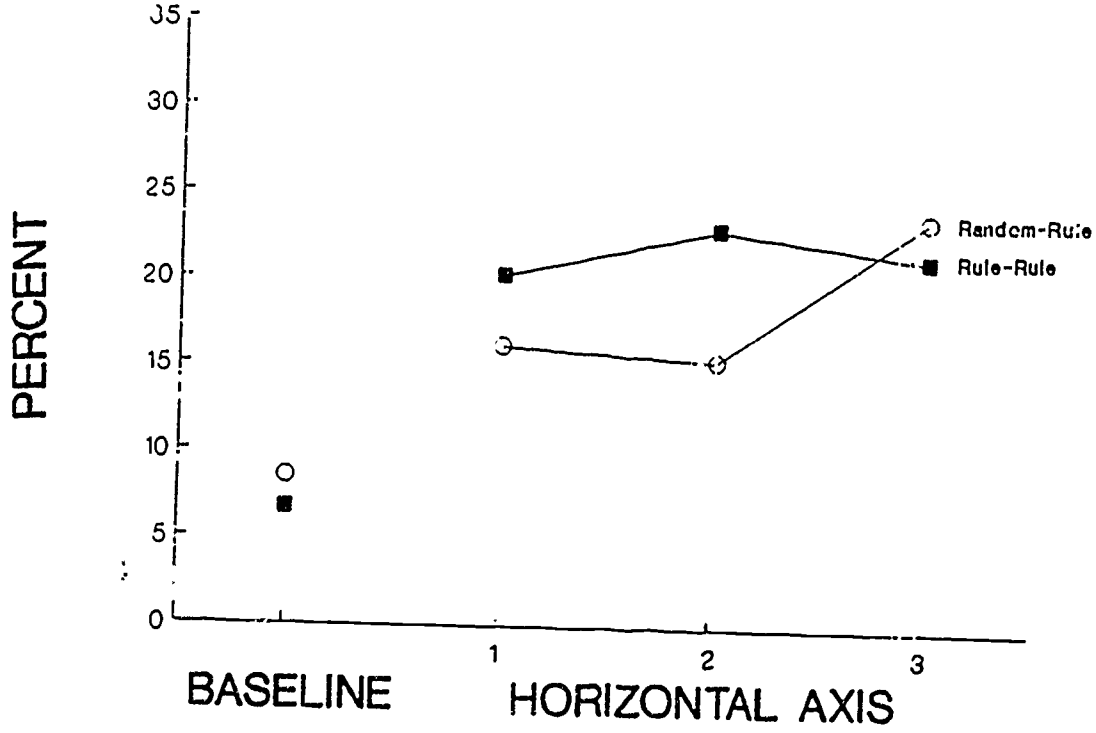
Percent of Anticipations for Blocks of Vertical Axis Events



* p < .05

Figure 2

Percent of Anticipations for Blocks of Horizontal Axis Events



Different from Baseline

Rule-Rule	**	**	**
Random-Rule		+	+

+ p < .10
* p < .05
** p < .01