Infants' Attention Patterns to People and Objects: Longitudinal Relations to Cortisol and α-Amylase

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Abstract

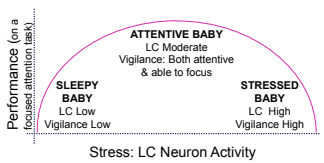
The current study aims to relate past animal and adult research on physiologically mediated vigilance to patterns of infant attention. Infants at 6, 7, and 12 months performed a gaze- and point-cue following task in a controlled laboratory environment. We examined several indices of infant visual behavior. In contrast to a previous study (de Barbaro, Chiba & Deak, 2011), the behavioral measures did not show any significant correlation. This may reflect the longer, repetitive test paradigm. Salivary cortisol and α-amylase, biomarkers of sympathetic activation, were related both within and across months, as well as in moderate relationship to average latency of looking to stimuli.

Background

Aston-Jones et al's (1999) Theory of Attention Modulation.[1]

- Based on visual tasks with animals (rats & monkeys) and human adults.
- Differentiates between focused attention (selective) and flexible attention (scanning); each allow for "successful attention" in specific contexts.
- Emphasizes the role of activation of the locus coeruleus (LC), a nucleus in the brainstem that mediates norepinephrine (NE) which plays a role in attention regulation.

Figure 1: LC activity and Vigilance

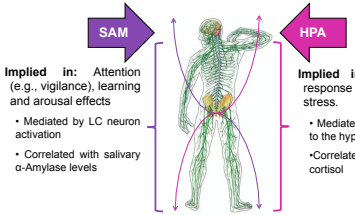


KEY:
LC Low: Tonic (constant low frequency) activation. Baby is non-attentive.
LC Moderate: Tonic activation with phasic bursts in response to relevant stimuli.
LC High: High tonic activity (high frequency). Very flexible attention, extensive scanning.

Neurobiology of stress and its development.[2]

- Two complementary neuromodulatory systems mediate animals' response to environmental challenges.
- The HPA (hypothalamic-pituitary-adrenal axis) and SAM (sympathetic adrenal-medulary) systems affect organ systems and emotions (e.g., anxiety. They also affect cognitive processes: attention and learning.
- Human infants show elevated biomarkers HPA and SAM up-regulation following stressful or fear-inducing experiences.
- This up-regulation, which causes vigilance in animals, is associated with social disengagement in human infants.

Figure 2: SAM & HPA systems



Changes in the HPA axis mediated by corticotrophin-releasing hormone (CRH) are involved in both the HPA and SAM system. However, the two systems are partly independing in modulation, effects, and time course.

Questions

In order to investigate neuromodulatory effects of stress on infant learning and attention, we asked:

1. Can a biological (Aston-Jones & Cohen) theory of attention, vigilance and stress explain human infants' looking behaviors in a complex, dynamic environment?
2. What looking behaviors are predicted by biomarkers of sympathetic nervous system activation, and related changes in vigilance?
3. Will behavioral measures related to vigilance show coherence within- or between-sessions? These measures correlated in de Barbaro et al (2012); however, they might not remain cohesive in a longer, more repetitive task in an increasingly familiar setting and social context.

Method

Participants

N = 30 healthy infants selected from a larger longitudinal sample. All infants who had completed a 6 & 7 month lab visit and provided useable before- and after-session saliva samples were included.

Gender	Infant Age 6mo (days)	Infant Age 7mo (days)
15 Girls 15 Boys	*M* = 195.6 *SD* = 19.1	*M* = 217.4 *SD* = 22.0

Table 1

Behavioral Procedure: "Socially Cued Orienting Task"

Infants and their parent visited the lab and completed several tasks, including a Gaze-and-Point following (GP) paradigm.

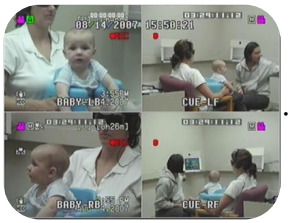


Figure 3: Testing environment

- Infants sat on their mother's lap in the center of the room, with six target monitors positioned to the left, right, front, back, and periphery of the infant.
- Experimenter made gaze, point, or gaze-and-point cues towards a target monitor. This was followed by an 8 sec Baby Einstein video reward (Fig. 3).
- All cues were given to all locations (quasi-randomized trial order).

Behavioral Measures

In a previous experiment (de Barbaro et al, 2011) these measures were found to parallel the attentive behaviors that co-vary with SAM-mediated activation, as described in the animal literature.

Vigilance

- **Latency** (higher NE/vigilance = reduced time to orient to peripheral stimuli)
- **Target Fixations** (higher NE/vigilance = increased localization of novel, salient stimuli)
- **Fixation rate** (higher NE/vigilance = more fixations to any stimulus per trial)

Coding

- Videos coded at 30 fps using Mangold INTERACT
- Saccades from monitor to monitor
- Duration of looking time to monitors and cue-giver
- Environment (i.e. testing room)
- Cue-giver (social looking index)

Biomarker Assays: Salivary Cortisol and α-Amylase

Collection & Assay Process

- Saliva collected in sterile dental cotton upon arrival at the lab ("Pre") and 20 min later ("Post"). Samples were assayed at the GCRC Lab using Salimetrics® Salivary Cortisol Kit (EIA).

Results

Cortisol & α-Amylase: Stability Within Months

Pre- and post- task biomarker levels were highly correlated within each month (Table 2). This could be due to low levels of reactivity to the cue-following task, and/or to individual infants' comfort in the laboratory environment.

Table 2: Within-session correlations for Cortisol and α-Amylase

Cortisol "Pre" vs. "Post"		α-Amylase "Pre" vs. "Post"	
6 Months	0.681***	6 months	0.776***
7 Months	0.823***	7 months	0.881***
12 Months	0.942***	12 months	0.695***

****p* < .001

Paired *t*-tests between pre- and post-test levels for each biomarker confirmed that there were no significant within-session changes at any month. Such stability has been found in pre- and post-test levels for moderately arousing social situations (Lewis & Ramsey 2005).

Cortisol & α-Amylase: Stability Across Months

Significant correlations were found among biomarker levels at 6, 7, and 12 months.

Table 3: Correlation Coefficients Among Biomarkers Across Months

	Cortisol "Pre"	Cortisol "Post"	α-Amylase "Pre"	α-Amylase "Post"
6 & 7 Months	0.510**	0.316	0.672***	0.726***
6 & 12 Months	0.340	-0.012	0.591***	0.258
7 & 12 Months	0.206	0.240	0.594***	0.544**

*p <.05; **p<.01; ***p < .001

Behavior – Behavior Relationships Differ From Previous Study and Past Literature

We did not replicate the correlations reported in de Barbaro, Chiba & Deak (2011). There are many possible reasons for this:

- In our previous study infants completed six trials, versus 20 in the current study. As vigilance is inversely related to uncertainty (Yu & Dayan, 2005) , increasing the number of trials could minimize uncertainty, reducing variability between infants and thereby reducing correlations.
- Our measure of looking rate was operationalized differently: here, "looks" to a target could contain multiple small saccades, whereas "fixations" were ended by any saccade.

References

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Results

Biomarker – Behavior Relationships Individually Relate to Past Literature

We found several isolated relations between biomarkers and behavioral measures that were consistent with the animal literature on HPA and SAM regulated vigilance (bolded below). Namely:

- Latency was negatively correlated with increases in cortisol and α-Amylase, suggesting faster orientation time when sympathetic activation increased.
- Looking rate was positively correlated with increases in α-Amylase, suggesting increased scanning (sampling) behaviors with SAMactivation.

However, these relationships were not consistent across months.

The lack of systematic patterns over time suggests that the biomarkers were not reliable indicators of vigilance or, more likely, that behavioral measures were related to many factors besides vigilance (e.g. attention-following, sociability, and reward-value of target cues).

	Physiological Relationships				
Average Latency	Cort "Pre" 6mo r = 0.491	Cort "Post" 6mo r = 0.416	**Cort Percent Change 7 mo r = -0.422**	**Amyl "Post - Pre" 12 mo r = -0.526**	**Amyl Percent Change 12mo r = -0.457**
Target Hits	Cort "Pre" 7mo r = -0.519	Cort "Post" 7mo r = -0.570	Looking Rate	**Amyl "Post-Pre" 6 mo r = 0.452**	**Amyl Percent Change 6mo r = 0.665**

Conclusions

1. **Biomarker stability was found across and within months**
2. **Behavioral–biomarker and behavior-behavior relations did not support predictions.**

The current paradigm differs from our previous study. Sessions were longer in length, and were averaged over 3x the number of trials.

Next Steps: Examine measures across first six trials. Test for habituation effects across session trials. Analyze spatial differences in looking (i.e. adult vs. environment).

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