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The Influence of Infant Curiosity and Caregiver Factors on Early Looking Patterns*

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호기심 성향 및 양육자 요인이 영아 응시 패턴에 미치는 영향

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ABSTRACT

Infants tend to look longer at events that violate their expectations. This study examined whether trait curiosity in infants and caregivers predicts individual differences in infants' visual attention to unexpected outcomes across physical and social domains. Eighty-one infants (Mage = 15.61 months) viewed events involving object relocation, solidity violations, and fairness violations. Distinct dimensions of infant and caregiver curiosity shaped infants' looking responses: caregiver thrill seeking predicted greater attention to physical violations, whereas infant overall curiosity, social curiosity and caregiver joyous exploration were linked to reduced attention to fairness violations. These findings show that distinct dimensions of infant and caregiver trait curiosity predicted infants' looking preferences differently across physical and social domains, suggesting that early curiosity may be expressed differently across domains.

Key words : Early curiosity, Violation-of-expectation paradigm, Infants, Cognitive development, Caregiver trait curiosity, Individual differences

Introduction

Curiosity is typically defined as an intrinsically motivated drive to seek and resolve uncertainty (Berlyne, 1960; Loewenstein, 1994). Classically, it has been distinguished from general attentional reactivity, temperament, or mere novelty seeking, emphasizing its role as a motivational orientation toward knowledge acquisition rather than a transient perceptual bias. Early theorists further differentiated perceptual curiosity, or the desire for novel stimulation, from epistemic curiosity, or the motivation to reduce uncertainty through information seeking (Berlyne, 1960). Epistemic curiosity is therefore conceptually distinct from related constructs such as novelty seeking or general orienting responses, because it entails a goal-directed attempt to reduce informational gaps rather than mere trait-level reactivity.

More recent perspectives highlight that curiosity is multidimensional rather than unitary, encompassing diverse psychological tendencies (Kashdan et al., 2018). For example, adult research has identified five distinct dimensions—Joyous Exploration, Deprivation Sensitivity, Stress Tolerance, Social Curiosity, and Thrill Seeking—each differentially associated with outcomes such as happiness, problem solving, social adaptation, and risk-taking. This multidimensional framework has also been extended to early development through the creation of the Early Multidimensional Curiosity Scale (EMCS; Lee et al., 2023). This multidimensional perspective provides conceptual value (clarifying distinct affective bases and modes of exploration), developmental value (tracing continuities and divergences across the lifespan), and predictive value (linking specific dimensions to well-being, learning, and adaptation).

Even before they can talk or walk, infants show selective attention to novel, ambiguous, or unexpected events (Jirout & Klahr, 2012; Lucca, 2020). This attentional pattern may not be merely reactive to perceptual novelty but may reflect an epistemic orientation toward reducing uncertainty (Kidd & Hayden, 2015). Previous research suggested that infants' attention is guided by principles such as novelty and discrepancy, with the "moderate discrepancy" hypothesis predicting sustained attention to stimuli of intermediate complexity (Kinney & Kagan, 1976; Kidd, Piantadosi, & Aslin, 2012). After observing a physically impossible event, infants not only looked longer but also preferred to explore the object, suggesting an intrinsic motivation to resolve anomalies (Stahl & Feigenson, 2015). Yet infants vary widely in their responses to uncertainty. Some are strongly drawn to surprising events, while others show muted reactions. These differences may

reflect trait-like dispositions rather than transient attentional states (Perez & Feigenson, 2021). Thus, violation-of-expectation (VoE) looking times should be interpreted as potential behavioral markers of curiosity, rather than direct measures. Perez and Feigenson (2021) demonstrated that infants' visual preferences for physically impossible events are stable over time. Infants who looked longer at a solidity violation at 11 months showed similar responses to a different physical violation (support) at 17 months. Moreover, these preferences predicted parent-reported explanation-based curiosity at age 3. These findings raise the possibility that looking times in VoE paradigms may reflect a stable disposition toward epistemic engagement.

Yet several important questions remain unanswered. First, most existing studies have examined the link between visual preferences for unexpected events and curiosity in early childhood, rather than during infancy. As a result, it remains unclear whether infants' responses in VoE paradigms—namely, prolonged looking at events that violate core physical or social expectations—reflect early manifestations of curiosity or whether this link only emerges later in development. Second, few studies have considered the broader ecological context in which curiosity develops. Caregiver behavior plays a central role in shaping children's learning and exploration (Gottfried et al., 2016). Caregivers scaffold children's attention, structure their environments, and encourage autonomous exploration—all of which are likely to support curiosity development. However, empirical work linking caregiver practices to infants' responses to epistemic uncertainty remains limited.

To address these gaps, Lee et al. (2023) developed the Early Multidimensional Curiosity Scale (EMCS), a caregiver-report measure designed to assess both infants' everyday curiosity and caregivers' engagement in curiosity-promoting behaviors. The EMCS captures the multifaceted nature of early curiosity and related parenting practices, extending the multidimensional framework of curiosity established in adulthood (Kashdan et al., 2018).

Lee et al. (2023) tested whether infants' everyday curiosity and caregiver curiosity-promoting activities predicted infants' visual attention to physically impossible events. They found that greater Broad Exploration in infants and more frequent Awe-Inducing Activities by caregivers were each associated with stronger looking preferences for impossible over possible events. Infants' temperament and vocabulary size, as well as caregivers' trait curiosity, did not predict infants' VoE responses. These findings suggest that infants' VoE responses may not reflect general attentiveness but rather

specific aspects of exploratory behavior and caregiver-facilitated experiences.

Previous work has shown that infants' everyday exploration of objects is linked to their looking preferences for physically impossible events, suggesting that everyday curiosity may be expressed through responses in VoE tasks (Lee et al., 2023). This raises the possibility that other dimensions of everyday curiosity, such as social curiosity, might be uniquely related to infants' responses to violations of social norms, including fairness or relationship expectations (Ziv & Sommerville, 2017; Liberman et al., 2014).

Building on this idea, we next consider whether curiosity also extends to the social domain. Prior work has focused primarily on infants' responses to violations of physical principles such as solidity or support. Yet infants also form robust expectations about the social world. By six months, they expect agents to act efficiently (Gergely et al., 1995) and fairly (Sloane et al., 2012), and they look longer when such expectations are violated. Importantly, looking responses to events that violate social norms reveal meaningful individual differences. For example, Sommerville et al. (2013) found that infants who shared their preferred toy with an unfamiliar experimenter looked longer at unequal outcomes, whereas those who shared a non-preferred toy showed the opposite pattern. These findings suggest that social VoE paradigms can capture variability in infants' social tendencies, potentially reflecting motivational dispositions such as social curiosity.

Despite these insights, no study has directly examined whether individual differences in infants' attention to violations of social expectations reflect curiosity—that is, a drive to resolve uncertainty in social contexts. Prior work has typically interpreted longer looking in social VoE tasks as evidence of fairness sensitivity, intentional understanding, or early moral evaluation, rather than as expressions of curiosity. This gap leaves open the possibility that infants' attention to social expectancy violations may signal a domain-specific form of curiosity, paralleling their responses in the physical domain. Furthermore, physical and social VoE tasks differ in important ways: physical violations typically involve impossible outcomes, whereas violations of social expectations (e.g., unfair distributions) involve outcomes that are possible but unexpected under social norms. This asymmetry raises key questions about whether infants' responses to violations of expectation across the two domains reflect common curiosity-related processes or distinct mechanisms.

The current study

The present study extends prior work (e.g., Lee et al., 2023) by examining infants' responses to Violation-of-Expectation (VoE) events across both physical and social domains within a single framework. Fairness was chosen as the focal social domain because expectations about equitable resource distribution emerge early in infancy and constitute a foundational component of social evaluation (Sloane et al., 2012). Prior work suggests that infants' responses to social events in a VoE paradigm vary systematically with their social tendencies (Sommerville et al., 2013). For instance, infants who engaged in more prosocial behavior, such as sharing preferred toys, showed heightened attention to unfair outcomes compared with their peers (Sommerville et al., 2013). These findings highlight that looking responses to events that violate social expectation capture meaningful individual differences, raising the possibility that such differences may reflect motivational dispositions like social curiosity.

We test whether social curiosity predicts infants' attention specifically to fairness violations or more broadly to expectancy violations across both social and physical domains, consistent with a domain-general epistemic drive. We also examine whether caregiver curiosity-related characteristics are associated with infants' visual attention, thereby offering an ecological perspective on the development of curiosity. In addition to the EMCS, we included a caregiver curiosity scale to explore how caregivers' trait-level curiosity influences infants' attention to unexpected events. Caregiver influences can be conceptualized at two levels: enduring trait dispositions (e.g., Five-Dimensional Curiosity Scale Revised, 5DCR; Kashdan et al., 2020) and curiosity-promoting behaviors (EMCS).

This study is exploratory, extending prior findings from Lee et al. (2023) in the physical domain to the social domain. Specifically, this study addresses two questions: (1) Do infants' curiosity and their caregivers' curiosity-related characteristics predict infants' looking patterns in VoE tasks? (2) Do specific dimensions of curiosity predict infants' looking differently across domains, such as social curiosity in the social domain?

Methods

Participants

We recruited 81 full-term Korean infants and toddlers with typical development (35 females, mean age: 15.61 months; range: 10.1-23.3 months) and their caregivers (78

females, mean age: 35.57 years; range: 23.84-44.37 years). In this study, the term caregiver referred to the parent most actively involved in daily caregiving at the time of participation. Caregivers reported completing high school (2.5%), a 2-year college degree (15.7%), a 4-year college degree (53.0%), or a graduate degree (26.5%). All participants were recruited from the Seoul metropolitan area.

An additional 20 infants were tested but excluded from the final analyses for the following reasons: among them, 14 were extremely fussy, 2 were distracted, 2 were reported by their parent to have language delay, and 2 were excluded due to parental interference.

Apparatus

The apparatus was a display booth (200 cm high × 95 cm wide × 64 cm deep) with a large front opening (53 cm × 88 cm), which was covered with a curtain between trials by a supervising experimenter. The side and back walls of the booth were lined with white muslin to minimize visual distractions. A viewing window (84 cm wide × 60 cm high) was positioned at the front of the stage, through which infants observed the experimental videos. During testing, infants sat on their caregiver's lap in a chair placed approximately 60 cm from the stage. Pre-recorded stimuli were displayed on a 27-inch monitor placed on the stage within the infant's direct line of sight.

Procedure

Prior to the experimental session, caregivers completed a series of questionnaires administered via Qualtrics, a subset of which is described in the sections below. Infants were subsequently tested using a VoE paradigm that included both physical and social conditions.

During the VoE tasks, each infant sat on a caregiver's lap, centered in front of the apparatus. Caregivers were instructed to remain silent and maintain a neutral demeanor throughout the experiment. Two naïve observers monitored infants' looking behavior through peepholes in cloth-covered panels on either side of the apparatus. Each observer held a button connected to a computer and pressed it while the infant was attending to the trial events. Looking times recorded by the primary observer were used to determine when each trial ended.

The final phase of each trial ended when infants either (1) looked away for 2 consecutive seconds after having looked for at least 15 cumulative seconds or (2) looked for 30 cumulative seconds without looking away for 2 consecutive seconds. Interobserver agreement reached an average of 89% per

trial per infant.

Violation-of-Expectation tasks

Infants observed two physical events (relocation and solidity) and one social event (resource allocation), with the presentation order counterbalanced across participants. An overview of the stimuli and their presentation sequence is provided in Figure 1. Each physical event consisted of one familiarization trial followed by two test trials, whereas each social event included only two test trials without a familiarization phase. The omission of familiarization in the social events followed prior research paradigms (e.g., Schmidt & Sommerville, 2011) and, together with the inclusion of only one type of social event, was intended to minimize infants' fatigue. Adding a familiarization phase to the social events would likely have extended the session beyond infants' typical attention span, thereby increasing the risk of fatigue and attrition. All test events were presented as video stimuli. We used the same video stimuli created and provided by Lee et al. (2023) for the physical condition. The physical VoE events were presented as animated videos, whereas the social events were presented as live-action videos featuring puppets and a human experimenter. This difference in video format was intentional as real-life social scenarios were expected to better engage infants' attention to other people and thus more directly reflect their social curiosity.

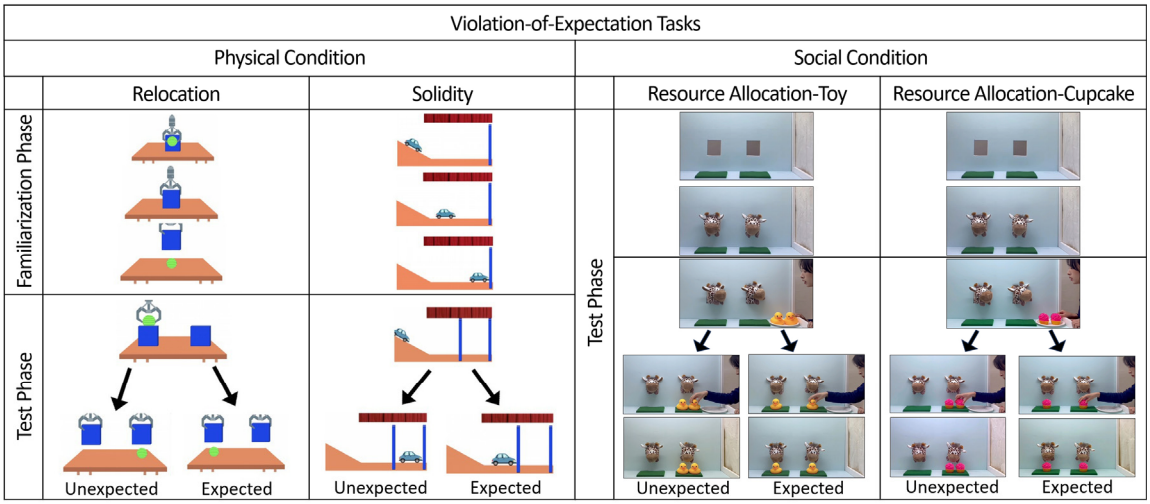

Figure 1. Sequence of physical and social events shown in the violation-of-expectation tasks. The image of physical events was reproduced with permission from the study by Lee et al. (2023).

Relocation event

During the familiarization trial, a crane dropped a ball behind an opaque box. The crane then lifted the box, revealing the hidden ball. In the test trials, a second box was introduced, and the crane dropped the ball behind one of the two boxes. In the expected event trial, the boxes were lifted to reveal the ball at the location where it had been dropped. In the unexpected event trial, the ball was revealed under the opposite box, as if it inexplicably relocated.

Solidity event

During the initial familiarization trial, a toy car rolled down a ramp and stopped after reaching a wall positioned at the end of the track. In the test phase, a second wall was placed at a short distance beyond the first wall. As the car descended the ramp, a curtain was lowered to occlude the outcome. In the expected event trial, the curtain was raised to reveal the car in front of the first wall. In the unexpected event trial, the curtain was raised to reveal the car in front of the second wall, as if it had passed through the first wall.

Resource-allocation event

At the beginning of each test trial, two identical giraffe puppets emerged from openings in the back wall of the stage, each positioned behind a small placemat. For the first 5 seconds of each trial, the giraffes swayed side to side in synchrony, simulating a dancing motion. For the following 11 seconds, a female experimenter entered through a curtained window on the right side of the stage, holding a tray containing two identical items (toys or cakes). She then announced, “Na-hante jangnangam-i/keikeu-ga isseo (I have toys/cakes!)” to which the giraffes responded with enthusiastic, coordinated exclamations of “Yay! Yay!”. The experimenter then placed one item on the placemat in front of one giraffe. In the unexpected event, the second item was placed in front of the same giraffe, resulting in an unequal distribution. In the expected event, the second item was placed in front of the other giraffe, producing an equal distribution. The type of item was counterbalanced across trials. Each trial concluded with the giraffes remaining stationary and gazing at their respective placemats.

Preference score

To examine individual differences in infants’ sensitivity to expectancy violations, we calculated a preference score for each infant by subtracting looking time to the expected event from looking time to the unexpected event within each trial. For each condition (physical and social), a condition-level preference score was

computed by averaging the scores across the two trials within that domain. Specifically, the physical condition preference score represented the mean of the relocation and solidity trials, whereas the social condition preference score represented the mean of the cake allocation and toy allocation trials. This metric captures infants' selective attention to unexpected outcomes while accounting for baseline attention to expected events.

Parent questionnaire

The Early Multidimensional Curiosity Scale (EMCS)

The EMCS is a 55-item caregiver-report questionnaire developed to assess early curiosity and associated experiences in children aged 10 to 78 months (Lee et al., 2023). The scale consists of 22 items that focus on curiosity-related behaviors among children and 33 items that examine caregiver behaviors that support or promote curiosity. The current study used only a subset of 30 items identified through a previous factor analysis, including 11 items from the child curiosity subscale and 19 items from the caregiver activity subscale.

The EMCS captures four dimensions of infant curiosity: (1) Social Curiosity, reflecting interest in others and in social interactions; (2) Broad Exploration, reflecting engagement with a variety of stimuli or environments; (3) Persistence, reflecting sustained attempts to resolve ambiguity or understand challenging situations; and (4) Information-Seeking, reflecting behaviors such as pointing or vocalizing to request explanations. Caregiver curiosity-promoting behaviors are also captured across five dimensions: (1) Flexible Problem-Solving, reflecting caregivers' encouragement of flexible thinking and autonomous problem resolution; (2) Cognitive Stimulation, reflecting the provision of intellectually engaging and imaginative play experiences; (3) Diverse Daily Activities, reflecting efforts to introduce varied routines and unfamiliar objects; (4) Child-Directed Play, reflecting the caregiver's support for the child's lead during playtime; and (5) Awe-Inducing Activities, reflecting engagement in perceptually rich experiences such as nature walks, live performances, or museum visits.

Caregivers' preference for curiosity-themed books and toys

To assess the real-world preferences of caregivers for curiosity-related materials, the study employed a choice-based measure that presented caregivers with descriptions of hypothetical books and toys. For the books, the participants selected among three options that varied in thematic emphasis, namely, curiosity, prosociality, and counting. Similarly,

the toy options focused on curiosity, animals, and music. The caregivers indicated which item they would prefer to purchase for their child in each choice scenario. This task served as an ecologically valid measure of caregivers' prioritization of curiosity in everyday decisions.

The Five-Dimensional Curiosity Scale Revised (5DCR)

The 5DCR is a 24-item self-report measure designed to assess trait-level curiosity in adults (Kashdan et al., 2020). It includes five theoretically grounded dimensions, namely, joyous exploration (intrinsic pleasure derived from learning), deprivation sensitivity (drive to resolve knowledge gaps), stress tolerance (comfort in uncertainty), thrill seeking (desire for novel and intense experiences), and social curiosity (interest in the thoughts and behaviors of others). Social curiosity is further classified into overt (e.g., asking questions) and covert (e.g., observing).

MacArthur Communicative Development Inventory (MCDI)

The MCDI is an 89-item caregiver-report vocabulary checklist that is widely used to assess both receptive and expressive language development in early childhood (Fenson et al., 1994). Each item presents a word, and caregivers indicate whether their child understands and says the word. The total number of endorsed items serves as the vocabulary score per child.

The Early Childhood Behavior Questionnaire (ECBQ)

The ECBQ is a 36-item scale designed to evaluate temperamental characteristics in children aged 12-36 months (Putnam et al., 2006). It comprises three subscales, namely, surgency (e.g., high-intensity pleasure and activity level), negative affectivity (e.g., discomfort and frustration), and effortful control (e.g., attention focusing and inhibitory control). Caregivers rate each item using a seven-point Likert-type scale, ranging from "never" to "always."

Results

Preliminary analyses of the test data revealed no significant interactions between condition and event with either infant sex or condition presentation order, all $Fs < 1.93$, $ps > .17$. Therefore, data were collapsed across infant sex and condition presentation order in all subsequent analyses.

Looking times during the final phase of the test trials were analyzed using a 2 (Condition: Physical, Social) × 2 (Event: Expected, Unexpected) repeated-measures ANOVA. A significant main effect of condition was found, $F(1, 79) = 94.94$, $p <$

.001, η^2 = .55, indicating that infants looked significantly longer in the social condition (M = 15.20, SD = 7.74) than in the physical condition (M = 7.75, SD = 4.44), regardless of event type. Neither the main effect of event, $F(1, 79) = 1.84$, p = .178, nor the interaction between condition and event, $F(1, 79) = 0.33$, p = .567, was significant.

These results suggest that although infants showed overall greater attention to social than physical stimuli, they did not differentially attend to expected versus unexpected outcomes.

As noted in the Methods, preference scores were calculated as the difference in looking time between unexpected and expected events, averaged across two trials within each domain. Table 1 presents the descriptive statistics and correlations among the main variables.

We first examined whether infants' preference scores were consistent across the physical and social conditions. A negative correlation was found between preference scores in the physical and social conditions, $r(79) = -.26$, p = .019. This finding suggests that infants who showed a stronger preference for unexpected events in one domain tended to show a weaker preference in the other, indicating a lack of cross-domain consistency.

We next examined whether infants' preference scores in each condition were associated with individual difference variables. In the physical condition, preference scores were positively associated with caregivers' thrill seeking scores, r = .24, p = .033. This suggests that infants of caregivers with

Table 1. Descriptive statistics and correlations among the main variables

	M (SD)	1	2	3	4	5	6	7	8	9	10
1. Preference Score (Physical)	1.08 (4.81)	-									
2. Preference Score (Social)	0.76 (6.54)	**-.26***	-								
3. EMCS Total	11.27 (1.50)	-.06	-.21	-							
4. Child Curiosity Total	4.06 (0.53)	.02	**-.29****	.45***	-						
5. Child Social Curiosity	3.50 (0.83)	.00	**-.29****	.30**	.67***	-					
6. Caregiver Activity Total	3.96 (0.55)	.02	-.03	.68***	.30*	.32**	-				
7. Caregiver Joyous Exploration	5.13 (1.07)	.15	-.19	.17	.10	.24*	.25*	-			
8. Caregiver Thrill Seeking (5DCR)	2.96 (1.14)	**.24***	-.11	.15	.04	.26*	.17	.42***	-		
9. Infant Vocabulary (MCDI)	44.05 (31.0)	.08	-.10	.47***	.00	-.13	.17	.05	.03	-	
10. Infant Effortful Control (ECBQ)	5.05 (1.60)	-.08	-.05	.10	.00	.09	.20	.06	-.16	-.14	-

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

higher thrill seeking tendencies showed greater attention to events that violate physical principles.

In the social condition, preference scores were negatively correlated with both the total child curiosity score (r = –.29, p = .009) and the social curiosity subscale score (r = –.29, p = .008). No other significant correlations were found with caregiver curiosity-promoting subscales, infant vocabulary size (MCDI), or negative affectivity as measured by temperament (ECBQ; all ps > .17).

To explore whether individual differences in infants' visual preferences for unexpected events were related to everyday curiosity and related experiences, we conducted multiple regression analyses separately for the physical and social conditions. To account for additional factors that may contribute to variability in looking patterns during the VoE tasks, we included multiple individual difference measures in each model. Infants' preference scores served as the dependent variable. Figures 2 and 3 present the significant predictors of infants' preference scores in the physical and social conditions, respectively.

Physical condition

First, we included the following predictors in a single regression model to examine their association with infants' looking behavior: the total score on the EMCS (reflecting infants' everyday curiosity and caregiver-provided experiences), caregivers' selection of curiosity-themed books and toys, caregivers' trait-level curiosity (Joyous Exploration subscale of the Five-Dimensional Curiosity Scale), infants' vocabulary size (MCDI), and infants' temperament (Effortful Control subscale of the ECBQ). None of the predictors were significantly associated with infants' looking preferences in the physical condition (all ps > .10).

We then separated the EMCS into two components—Child Curiosity and Caregiver Activity—and included both scores in place of the total EMCS score to examine whether these subscales predicted infants' looking preferences. However, neither predictor was significantly associated with infants' looking preferences in the physical condition (ps > .10).

To further examine the association between specific curiosity-related factors and infants' attention to physical events, we conducted follow-up analyses using the subcomponents of both the child curiosity and caregiver activity subscales. For the child curiosity subscale, we conducted a multiple regression analysis with four subdimensions as predictors. For the Caregiver Activity subscale, five dimensions were included as predictors. None of the subcomponents significantly predicted infants'

preference scores in either the physical or social condition (*ps* > .10).

We then examined whether caregivers' trait-level curiosity, measured using the 5DCR, predicted the looking preferences of the infants. We conducted a multiple regression analysis using the six subscales of the 5DCR—joyous exploration, deprivation sensitivity, stress tolerance, thrill seeking, and overt and covert social curiosity—as predictors. The results revealed that caregivers' thrill seeking significantly predicted infants' preference scores in the physical condition, b = 1.14, β = .27, p = .045, such that infants whose caregivers scored high on the thrill seeking subscale displayed greater attention to physically unexpected events than to expected ones. Further regression analysis showed that the thrill seeking subscale score significantly predicted infants' looking preferences, even after controlling for other potential predictors, b = 0.27, β = .40, p = .019.

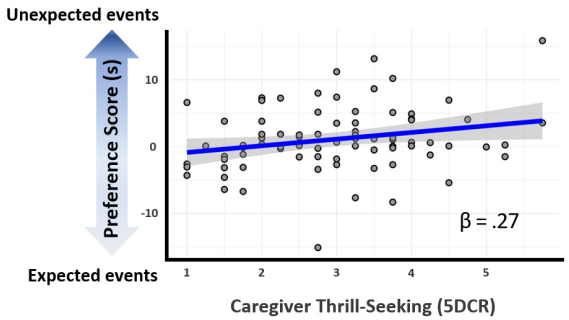

Figure 2. Significant predictors of preference scores of infants in the physical condition

No other individual difference measures, including infants' vocabulary size (MCDI) and temperament (ECBQ), significantly predicted infants' preference scores (*ps* > .10).

Social condition

We conducted parallel regression analyses to examine whether the same set of individual difference measures predicted infants' looking preferences in the social condition.

In the comprehensive model, overall child curiosity scores significantly predicted infants' preference scores in the social condition, b = −3.46, β = −.28, p = .021, indicating that infants with higher curiosity levels tended to show reduced attention to unexpected social events.

A follow-up analysis using the child curiosity subscales revealed that child social curiosity scores significantly and negatively predicted infants' preference scores in the social condition, b = −2.17, β = −.28, p = .017. None of the caregiver activity subscales were significantly associated with infants' preference scores (*ps* > .10).

Finally, caregivers' joyous exploration scores negatively predicted infants' preference scores in the social condition, b = −2.42, β = −.40, p = .021, suggesting that infants whose caregivers derive intrinsic enjoyment from learning and exploration

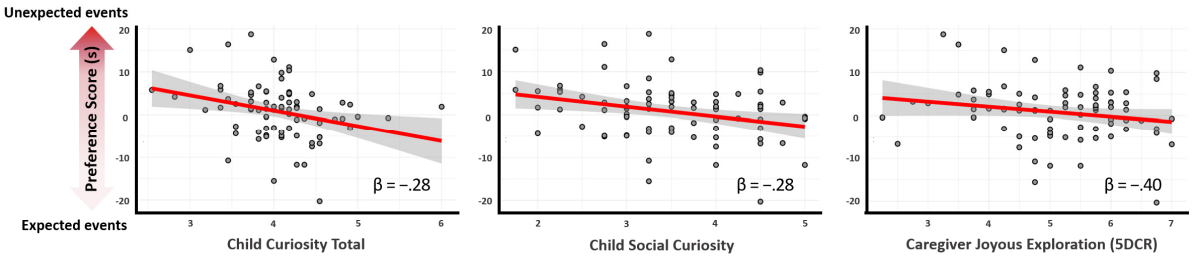

Figure 3. Significant predictors of preference scores of infants in the social condition

tend to show reduced attention to violations of social expectations.

Discussion

The present research examined whether infants' visual attention to events that violate expectations in the physical and social domains is related to individual differences in infants' curiosity and their caregiver characteristics.

In the physical domain, the study found that infants whose caregivers scored high on the thrill seeking subscale of the 5DCR exhibited a stronger preference for unexpected events. Thrill seeking, defined as the desire for intense and novel experiences, may reflect a broader family context that encourages exploration and exposure to uncertainty. One interpretation is that thrill-seeking caregivers may provide infants with more stimulating and unpredictable environments, thereby heightening infants' emerging sensitivity to physical anomalies. Another possibility is that thrill seeking shares heritable components with infants' exploratory tendencies, suggesting contributions from both environmental and genetic pathways.

In the social domain, caregivers' joyous exploration curiosity negatively predicted infants' preference for unexpected outcomes. This finding suggests that while caregiver trait-level curiosity may influence infants' epistemic attention in both domains, the type and direction of that curiosity may matter in different ways. Unlike thrill seeking, joyous exploration may reflect a tendency to create highly structured and affectively positive learning environments, which could reduce the salience of surprising events. For example, infants might update their expectations more quickly or interpret the event as part of a playful or teaching context, so the violation feels less surprising. From this perspective, reduced looking times at unexpected outcomes do not necessarily mean that infants are less curious, but rather that their surprise signals are

reduced by the context. There is no direct evidence for this idea, so future research is needed to test whether home routines, scaffolding, and pedagogical cues influence how infants respond to social violations. Alternatively, the observed negative association may indicate infants' heightened engagement with expected, norm-consistent outcomes, which they may perceive as particularly informative for calibrating and refining future expectations.

Taken together, these findings suggest that distinct dimensions of caregiver curiosity may create different epistemic environments for infants, shaping their attentional responses in domain-specific ways. This also suggests that genetic influences cannot be ruled out, as trait-level characteristics are likely to reflect both heritable dispositions and the cumulative impact of prior experiences. Future work will be needed to clarify how these factors jointly shape infants' developing curiosity.

The absence of predictive effects for curiosity-promoting behaviors in our study may reflect cultural differences in how such behaviors are expressed. The EMCS caregiver activity subscale, developed in a Western context, may not fully capture how Korean caregivers foster curiosity. Western parents often encourage curiosity through spontaneous exploration, whereas East Asian caregivers tend to emphasize structured learning and guided engagement. This highlights the need to interpret infants' epistemic attention within culturally specific caregiving frameworks.

Contrary to our hypothesis, higher scores on both overall child curiosity and social curiosity were negatively associated with the looking preferences for unexpected social events.

One possibility is that infants with high levels of social curiosity are more attuned to the normative structure of social interactions. For these infants, expected, coherent outcomes may be more meaningful and informative than unexpected or anomalous ones. This pattern is consistent with that of Kuhlmeier et al. (2003), who showed that infants preferred rational actions consistent with an agent's prior behavior (e.g., approaching a helping agent). From this perspective, social curiosity may lead infants to prioritize interpretable, norm-consistent events over perceptual novelty.

Another explanation is that infants may exhibit familiarity preferences instead of novelty preferences under conditions of high task complexity or limited familiarization (Schilling, 2000; Rose et al., 1982; Moore & Johnson, 2011). In the present study, the social condition lacked a familiarization phase and featured complex stimuli (e.g., agents and fairness violations), potentially

increasing cognitive demands. Infants with high levels of social curiosity may have engaged more deeply with the expected outcome, especially if the unexpected event was not fully encoded.

These interpretations align with previous research (Cashon & Cohen, 2000; Clearfield & Westfahl, 2006), suggesting that infants' increased looking at events may reflect not only surprise but also deeper cognitive engagement with expected social outcomes.

Although the direction of the association differed from our initial predictions, the finding that both overall infant curiosity and social curiosity significantly predicted infants' looking patterns in the social domain is meaningful. This suggests that infants' looking responses in VoE tasks may indeed reflect one expression of their underlying curiosity, even if that expression manifests as heightened engagement with expected, coherent outcomes rather than with unexpected anomalies.

It is also important to note that the unexpected outcomes differed in nature across domains: physical violations depicted impossible events that directly contradicted causal laws, whereas social violations involved possible but normatively unexpected outcomes (e.g., unfair allocations). This distinction may partly explain why caregiver thrill seeking predicted sensitivity to physical violations, while infant and caregiver social curiosity were linked to responses in the social condition.

Procedural considerations and design limitations

Group-level analyses revealed that infants looked significantly longer at social events than at physical events, regardless of whether the events violated expectations. This pattern may reflect procedural differences: the social condition featured more dynamic and socially engaging stimuli (e.g., puppet interactions and emotional cues) and lacked a familiarization phase. Alternatively, the inherent salience of social stimuli may have captured infants' attention more effectively (Kuhlmeier et al., 2003).

In the present study, no significant difference in looking times was found between expected and unexpected events, diverging from the classic VoE effects reported in previous research. Importantly, as this study was not designed to replicate group-level surprise responses, it offers new insights by extending individual-difference analyses to the social domain, which remains largely underexplored in prior VoE research. The primary aim was to investigate how infant trait curiosity and related caregiver characteristics predict individual differences in infants' looking preferences for unexpected versus expected events across the physical

and social domains. As such, the design may not have been optimal for eliciting clear differences in looking patterns between expected and unexpected events. Moreover, the within-subjects design required infants to process both physical and social events, which may have increased cognitive demands and obscured clear expectancy effects.

Although the current design was not optimized to confirm whether Korean infants, at the group level, exhibit novelty versus familiarity preferences in VoE tasks, it was uniquely suited to reveal individual differences and to identify their developmental and contextual factors. Future research should further investigate contextual factors, such as socioeconomic status, in shaping the development of curiosity. Because parental education in our sample may have been relatively high and potentially reflect greater access to resources that support children's learning and exploration, the generalizability of these findings to more socioeconomically diverse populations remains uncertain.

Conclusions

In direct response to our research questions, the findings indicate that infants' looking preferences for expectancy-violating events may serve as early indicators of curiosity, but in domain-specific ways. Caregiver thrill seeking predicted greater attention to physical violations, whereas infant social curiosity and caregiver joyous exploration were associated with reduced attention to social violations, suggesting that social curiosity in infancy may manifest as deeper engagement with expected, coherent outcomes rather than anomalous ones.

This study offers new insights into the developmental nature of curiosity by demonstrating that individual differences in infants' attentional responses to unexpected events are shaped by distinct dimensions of curiosity in both infants and caregivers. Conducted with Korean infants, this study also provides one of the first empirical demonstrations of how curiosity-related traits shape responses to both physical and social expectancy violations in a non-Western context. This contributes cross-cultural evidence to the developmental study of curiosity and highlights the need to consider cultural variation in caregiving practices when interpreting infants' epistemic engagement. These findings provide initial evidence that early curiosity may not be a unitary trait, but rather a multidimensional construct that manifests differently across domains. They further contribute to the importance of considering both individual differences and contextual factors when interpreting infants' looking responses as possible indicators of early curiosity.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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호기심 성향 및 양육자 요인이 영아 응시 패턴에 미치는 영향

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본 연구는 영아의 호기심 성향과 양육자의 특성이 물리적 및 사회적 영역에서의 예상치 못한 결과에 대한 영아의 시각적 주의의 개인차를 예측하는지를 검증하였다. 기대 위배 패러다임에서 영아 81명(평균 월령 = 15.61개월; 월령 범위: 10.1-23.3개월)은 물리적 법칙 또는 사회적 규범을 위반하는 사건들을 보았다. 그 결과, 영아와 양육자의 호기심 하위 차원은 서로 다른 방식으로 영아의 응시 반응에 영향을 주는 것으로 나타났다. 구체적으로, 양육자의 스릴 추구 성향은 물리적 위반 사건에 대한 응시 시간을 정적으로 예측한 반면, 영아의 전반적 호기심 성향, 사회적 호기심 성향, 그리고 양육자의 즐거운 탐색 성향은 공정성 위반에 대한 응시 시간과 부적 연관성이 있었다. 이러한 결과는 영아와 양육자의 특성적 호기심의 물리적 영역과 사회적 영역 사건에 대한 영아의 응시 선호를 다르게 예측함을 보여주며, 초기 호기심이 영역에 따라 상이한 방식으로 표현될 수 있음을 시사한다.

주요어 : 초기 호기심, 기대 위배 패러다임, 영아, 인지 발달, 양육자 호기심, 개인차