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Temperament in Toddlers With and Without Prelingual Hearing Loss

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ABSTRACT

Purpose: The purpose of this study is to examine parent-reported ratings of temperament in toddlers with and without prelingual hearing loss.
Method: The parent-completed Early Childhood Behavior Questionnaire (ECBQ) was used to assess temperament in toddlers aged 18–36 months. Three dimensions of temperament were examined: surgency, negative affectivity, and effortful control. Analyses were conducted to (a) examine differences in temperament across toddlers with and without prelingual hearing loss; (b) examine possible associations between temperament, demographic, and communication factors; and (c) determine if the ECBQ is sensitive to differences in hearing, communication, and listening skills among toddlers with prelingual hearing loss.
Results: The parent-completed ECBQ revealed that toddlers with prelingual hearing loss differed from their hearing peers on some but not all dimensions of temperament. Specifically, children with prelingual hearing loss were rated as displaying higher levels of surgency and lower levels of effortful control but comparable levels of negative affectivity when compared to their hearing peers. Regression analyses revealed that chronological age and communication strategy predicted scores of effortful control in toddlers with prelingual hearing loss, whereas chronological age alone predicted scores of effortful control in toddlers with hearing. Finally, the ECBQ appears to contain "listening" items that skew (lower) levels of effortful control in toddlers with prelingual hearing loss, such that only the group effect of higher levels of surgency remained after removing these "listening" items. Correlations between the original and our modified ECBQ (removing the "listening" items) revealed strong associations, reflective of high construct validity.
Conclusions: This was the first study to measure temperament in toddlers with prelingual hearing loss using the ECBQ. Our results revealed differences between children with and without prelingual hearing loss centering on the dimension of surgency. Examining differences in temperament during the toddler period of development may be particularly important and useful for predicting functional outcomes following prelingual hearing loss.

Temperament is an umbrella construct that refers broadly to traits of arousal, emotionality, sensory thresholds, reactivity, and inhibition (Goldsmith et al., 1987). Our theoretical perspective aligns with Rothbart and colleagues who describe temperament as individual differences in behavioral and physiological responses to environmental or stimulus changes (Rothbart et al., 2011). Temperament can be reliably assessed in young children with both questionnaire and experimental measures (Rothbart, 2011). Temperament in typically developing hearing infants has been found to play a significant role in outcomes including language skills at ages 18–24 months (Dixon & Smith, 2000; Spinelli et al., 2018), anxious behaviors at age 2.5 years (Crockenberg & Leerkes, 2006), withdrawal behaviors at age 4 years (Pérez-Edgar et al., 2008), school performance at ages 7–12 years (Valiente et al., 2007), and internalizing and externalizing behaviors at age 17

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years (Leve et al., 2005). In children who are deaf and of hearing (DHH), temperament has been associated with language skills at ages 3–8 years (Bowdrie et al., 2022) and social skills at ages 8–18 years (Warner-Czyz et al., 2015, 2018).

Rothbart and colleagues pioneered research on questionnaire measures of temperament in typically developing hearing children and developed two questionnaires for use in young children: the Early Childhood Behavior Questionnaire (ECBQ; Putnam et al., 2006), which is applicable for toddlers aged 18–36 months, and the Children's Behavior Questionnaire (CBQ; Putnam & Rothbart, 2006; Rothbart et al., 2001), which is applicable for preschoolers aged 3–7 years. Both the ECBQ and CBQ assess three major dimensions of temperament, which includes surgency, negative affectivity, and effortful control. Surgency and negative affectivity describe a child's positive or negative excitability and responsivity to changes in the environment. Surgency describes behaviors of positive emotionality (the child derives happiness) such as impulsivity, high levels of gross motor activity, and pleasure/enjoyment from high-stimulus activities such as rough and rowdy games. Its dimensional counterpart, negative affectivity, describes behaviors of discomfort, fear, and sadness. Effortful control describes a child's self-regulation of reactivity to environmental and stimulus changes such as attention focusing, attention switching, and inhibitory control.

While it is well accepted that children with prelingual hearing loss are at a greater risk than their hearing peers for developing delays and/or disturbances in spoken language and executive functioning skills (self-regulatory goal-directed behavior; Kronenberger et al., 2014), we know very little about how temperament may be influenced by a history of prelingual hearing loss and atypical language development. Research on children with diagnosed communication disorders may help inform associations between temperament and atypical language development. For example, preschool-age children diagnosed with specific language impairment (Spaulding et al., 2008) or disfluency (Kefalianos et al., 2012) typically differ from their peers on domains of effortful control (display lower attentional skills). Preschool-age children diagnosed with disfluency also display higher surgency (higher activity levels; Kefalianos et al., 2012) than their peers. Furthermore, Fujiki et al. (1999) observed that teacher-reported measures of effortful control (impulse control) were lower for school-age children diagnosed with specific language impairment when compared to their peers. Taken together, these studies suggest that domains of temperament (specifically lower effortful control and higher surgency) may be associated with atypical language development, which may result from reduced access to language. Temperament may also be directly influenced by differences in sensory input. For example, it is plausible that having less access to auditory input may result in heightened responsivity when the auditory input is accessible. Or, children who are DHH may have heightened responsivity to input from other sensory modalities and respond less to auditory input *even* when it is accessible (Houston & Bergeson, 2014; Houston et al., 2003; Wang et al., 2018). Either possibility may lead to general differences in temperament.

There is reason to predict that children with prelingual hearing loss and atypical language development may differ from their hearing peers in dimensions of temperament in which language and executive functioning skills may contribute to the manifestation of a behavior, namely, the dimension of effortful control, which involves how well a child can self-regulate attention and the capacity to stop, moderate, or refrain from behaviors, and the dimension of surgency, which involves the speed of response initiation (impulsivity). In one of the first studies to examine the association between temperament and language in children who are DHH, Bowdrie et al. (2022) observed that children with hearing loss aged 3–8 years display lower regulatory skills than their age-matched hearing peers. They also observed positive associations between effortful control and spoken language skills, but only in their sample of children with hearing loss. Given the association between temperament and language skills in preschool- and school-age children with hearing loss, evaluating temperament during toddlerhood may provide early predictive value for later language development. However, it remains unknown if differences in temperament between children with and without hearing loss appear before age 3 years. Toward this goal, the present study sought to determine if toddlers with hearing loss differ from their hearing peers on parent-reported measures of temperament, with a particular focus on the domains of surgency and effortful control. Doing so will advance our knowledge about the developmental time course in which hearing loss may impact aspects of temperament.

As discussed, the ECBQ and CBQ have almost exclusively been used to study temperament in typically developing hearing children, and consequently, questionnaire items have not been specifically evaluated for use in children, with hearing loss. As such, it is unknown if the ECBQ is sensitive to differences in hearing, communication, and listening skills among toddlers with hearing loss. It is plausible that individual items on the ECBQ may be tied to hearing, communication, and listening skills in ways not relevant to the underlying theoretical constructs of temperament being assessed. For example, given the reported associations between temperament and language skills in children, factors related to spoken language acquisition such as communication strategies (oral or simultaneous

communication) and listening skills in toddlers who are DHH may influence parent reporting. The second goal of the present study was to evaluate the appropriateness of items on the ECBQ in a sample of children who are DHH and to examine the extent to which communication strategies and perceived listening skills may influence parents' report of their DHH toddler's temperament.

Previous studies provide additional insight into factors that may influence parental reports of temperament such as sex and chronological age. Else-Quest et al. (2006) conducted a meta-analysis of 205 studies of temperament in hearing infants aged 3 months to 13 years. This meta-analysis included parent-, teacher-, and self-completed questionnaires, along with experimental measures of temperament. The authors reported that female children differ significantly from male children on effortful control and surgery such that female children display significantly greater levels of effortful control and lower levels of surgency than their male peers. Else-Quest et al. (2006) reported little to no evidence of gender differences in negative affectivity for children within this age range. However, other studies focusing on only one questionnaire with a narrower age range have revealed sex differences in dimensions of negative affectivity. Putnam et al. (2006) used the ECBQ to assess temperament in a sample of 317 toddlers aged 18–36 months, and results revealed that female toddlers display greater levels of fear, shyness, and positive anticipation (dimensions of negative affectivity) and lower levels of high-intensity pleasure (a dimension of surgency) than their male peers. Together, these discrepant findings suggest that several factors may influence parental reports of child temperament and provide us with the motivation to evaluate the potential contribution of sex and chronological age on reports of temperament in toddlers with and without hearing loss.

The present study investigated if mean scores on parent-reported measures of temperament in young children differ as a function of the child's hearing status. Three primary questions concerning temperament were investigated: First, do toddlers with hearing loss display differences in temperament (specifically surgency and effortful control) when compared to their typically developing hearing peers? Consistent with previous findings of children with atypical language, we predicted that toddlers with hearing loss would display higher levels of surgency and lower levels of effortful control than their hearing peers. Second, are there associations between demographic or communication factors and temperament in toddlers with and without hearing loss? We predicted sex–temperament associations in the hearing sample and predicted age–temperament associations across the DHH and hearing samples. Finally, is the ECBQ sensitive to differences in communication and listening skills among toddlers with hearing loss? We predicted that items requiring listening skills would skew (lower) ECBQ composite scores in the DHH sample compared to the hearing sample. The present study is the first to examine temperamental as indexed by the parent-reported ECBQ scores in toddlers with hearing loss.

Method

Participants

Participants were evaluated as part of a larger study on the development of speech-language skills in early childhood. To be included in the present study, participants were required to fall within the 18- to 36-month age range at the time of ECBQ administration. Forty toddlers with hearing loss (19 with hearing aids [HAs] and 21 with cochlear implants [CIs]) and a control sample of 34 typically developing peers with normal hearing participated in the present study. Parents/guardians reported living in a household with spoken English as the primary language. Demographic and hearing history characteristics of the samples are summarized in Table 1.

Sample With Hearing Loss

Toddlers with hearing loss were recruited from two large hospital-based CI clinics located in the Midwestern United States and met the following inclusionary criteria: (a) cochlear implantation or HA fitting by age 24 months; (b) English as the primary language (> 70%) at home; (c) spoken language identified as a goal of the family; (d) no

Table 1. Toddler demographics and hearing history.

Variable	Hearing loss (*n* = 40)	Hearing (*n* = 34)
	Count (% of samples)	
Hearing device		
Bilateral CIs	20 (50.0%)	n/a
Bilateral HAs	18 (45.0%)	n/a
Bimodal CI and HA	1 (2.5%)	n/a
Unilateral HA	1 (2.5%)	n/a
Sex		
Female	22 (45.0%)	18 (52.9%)
Male	18 (55.0%)	16 (47.1%)
Race		
White	36 (90.0%)	26 (76.5%)
Black	0 (0.0%)	2 (5.9%)
Multiracial	3 (7.5%)	6 (17.6%)
Not reported	1 (2.5%)	0 (0.0%)

Note. CIs = cochlear implants; HAs = hearing aids; n/a = not applicable.

syndromic diagnoses of hearing loss such as Noonan syndrome or Usher syndrome Type 2A; and (e) no significant developmental, neurological, or cognitive delays such as epilepsy. The final sample of toddlers with hearing loss included 40 toddlers aged 18–32 months (M = 21.65, SD = 3.66). Etiology of deafness included genetic (n = 19, 47.5%), unknown (n = 16, 40.0%), large/enlarged vestibular aqueduct (n = 3, 7.5%), and auditory neuropathy spectrum disorder (n = 1, 2.5%). The etiology for one toddler with hearing loss (2.5%) was not reported. Age at device activation ranged from 2 to 23 months (M = 10.15, SD = 5.66). Toddlers' communication strategy was coded as simultaneous (speech is used along with manually coded English for communication) or oral (speech is used exclusively and with no formal sign language included for communication, other than natural gestures). At the time of testing, 22 (55%) parents of toddlers with hearing loss reported using simultaneous communication strategies, whereas 18 (45%) reported using oral communication. Maternal education was coded by years of schooling and, at the time of testing, was reported ranging from 9 to 20 years (M = 15.45, SD = 2.76).

Sample With Normal Hearing

Toddlers with hearing were recruited from advertisements placed in social media outlets and in the community. Parents/guardians of the hearing sample of toddlers reported no hearing loss and no significant developmental, neurological, or cognitive delays. The final sample of toddlers with hearing included 34 toddlers aged 18–34 months (M = 22.65, SD = 4.28), and maternal education, at the time of testing, was reported ranging from 12 to 20 years (M = 16.18, SD = 2.40).

Procedure

All study procedures were reviewed and approved by local institutional review boards, and written informed consent was obtained from parents/guardians prior to initiation of study procedures.

Measures

The parent-completed short form of the ECBQ (Putnam et al., 2006) for toddlers aged 18–36 months was used to assess temperament. The present data were collected from parents/guardians using the paper-and-pencil version of the short ECBQ form. The psychometrics of the short form of the ECBQ is based on data from over 421 typically developing infants aged 18–36 months, and analyses revealed strong psychometric attributes, including internal consistency (Cronbach's α values range from .60 to .80; Putnam et al., 2006), test–retest reliability (r values range from .32 to .79 over 6-month time spans; Putnam et al., 2006), and construct validity (average r value of .76; Putnam et al., 2010).

The ECBQ consists of 107 items with 18 dimensions/subscales that are aggregated to create three composite scales: negative affectivity, surgency, and effortful control. Negative affectivity is a composite of eight subscales measuring the degree to which children react to situations by displaying negative affect, such as discomfort, fear, motor activation/fidgeting, sadness, perceptual sensitivity, shyness, frustration, and ability to sooth. Surgency is a composite of five subscales measuring the degree to which children react to situations by displaying high levels of impulsivity, activity level/energy, sociability, positive anticipation, and high-intensity pleasure derived from high stimulus intensity, rate, complexity, novelty, and incongruity such as rough and rowdy games. Finally, effortful control is a composite of five subscales measuring the degree to which children react to situations by displaying inhibitory control, attentional shifting, attentional focusing, cuddliness, and low-intensity pleasure derived from low stimulus intensity, rate, complexity, novelty, and incongruity such as being gently rocked. Each item describes a child behavior, and parents are instructed to rate items on a 7-point Likert scale from 1 = *never* to 7 = *always*, indicating how often they observed the behavior during the last 2 weeks.

Data Analysis

Two-tailed independent-samples t tests were used to compare toddlers with and without hearing loss on parent-reported subscale and composite scores from the ECBQ. We predicted that toddlers with hearing loss would display higher levels of surgency and lower levels of effortful control than their hearing peers. The second set of analyses examined potential associations between demographic and communication factors (sex, chronological age, communication mode) on parent-reported ECBQ composite scores. Correlations between ECBQ composite scores and demographic and communication factors were carried out separately for toddlers with and without hearing loss. Consistent with previous research with hearing children, we predicted that (a) chronological age and effortful control would be associated in toddlers, such that older toddlers would be rated by parents as displaying higher levels of effortful control than their younger peers, and (b) female toddlers with hearing would be rated by parents as displaying lower levels of surgency and higher levels of effortful control than their male hearing peers. To evaluate the independent contribution of demographic and communication factors on temperament, hierarchical regression analyses were conducted with each dimension of temperament (surgency, negative affectivity, effortful control) as the criterion variable and independent variables (sex, chronological age, hearing age, communication mode) entered using a forward stepwise entry technique.

In the last set of analyses, we reviewed all 107 items in the ECBQ and identified items with potentially poor validity due to the role toddlers' hearing abilities would likely have on parent responses (e.g., "During everyday activities, how often did your child seem to be disturbed by loud sounds?"). The authors independently reviewed items before reaching census about "listening" versus "not listening" category inclusion. To examine temperament without skewing results by including "listening" items, we recalculated subscale and composite scores, and these new scores were then used in one-tailed independent-samples *t* tests to compare toddlers with and without hearing loss. We predicted that toddlers who are DHH would be rated as displaying lower scores on the "listening" items than their hearing peers.

Results

Toddlers did not differ on chronological age, $t(72) = 1.08$, $p = .28$; sex ($p = .52$ by Fisher's exact test); or maternal education, $t(71) = 1.19$, $p = .24$. Results revealed no significant differences between HA and CI users on ECBQ subscale and composite scores (ps > .05, two-tailed). Therefore, for all subsequent analyses, we collapsed across device (HA, CI) and compared all toddlers with hearing loss to toddlers with hearing. Kolmogorov–Smirnov and Shapiro–Wilk tests of normality indicate that the data are normally distributed ($p \geq .20$), and Leven's test of equality of variances indicates that the variances are equal across our groups of toddlers ($p \geq .36$).

Between-Group Differences

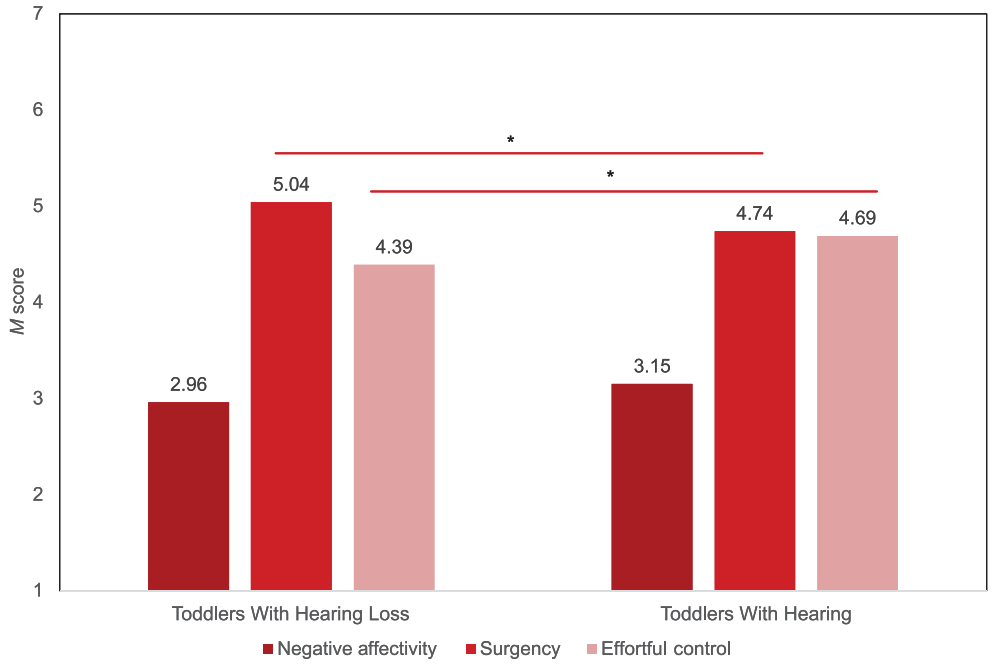
Parent-reported ECBQ composite and subscale scores for toddlers with hearing loss and those with hearing are shown in Table 2. Toddlers with hearing loss differed significantly from toddlers with hearing on the ECBQ composite score of surgency, $t(72) = -2.01$, $p = .048$, $d = -0.47$, and effortful control, $t(72) = 2.09$, $p = .040$, $d = 0.49$, but were not significantly different on negative affectivity, $t(71) = 1.42$, $p = .16$, $d = 0.33$. Specifically, toddlers with hearing loss displayed significantly higher levels of surgency and lower levels of effortful control than their hearing peers (see Figure 1). In terms of ECBQ subscale scores, toddlers with hearing loss differed significantly from toddlers with hearing on four out of 18 (22%) subscales with group differences approaching moderate (d =

Table 2. Descriptive statistics for parent-reported toddler temperament.

	Toddler hearing status					
	Hearing loss			Hearing		
Temperament	*n*	*M* (*SD*)	Range	*n*	*M* (*SD*)	Range
Negative affectivity						
Discomfort	40	2.25 (0.93)	1.00–4.71	34	2.55 (1.11)	1.00–6.14
Fear	40	2.25 (0.89)	1.00–4.63	34	2.34 (0.82)	1.00–4.25
Motor activation	40	2.71 (1.06)	1.00–5.33	34	2.68 (0.74)	1.50–4.50
Sadness	40	2.81 (1.03)	1.00–5.33	34	2.92 (0.79)	1.67–4.20
Perceptual sensitivity	40	3.72 (1.05)	1.75–6.60	34	4.34 (1.33)	1.33–6.25
Shyness	40	3.58 (1.33)	1.40–6.75	34	3.97 (1.29)	1.60–6.40
Soothability	40	5.19 (0.89)	2.40–6.80	34	5.21 (0.68)	3.40–6.40
Frustration	40	3.61 (1.19)	1.67–6.00	34	3.58 (0.91)	2.00–5.17
Surgency						
Impulsivity	40	4.86 (0.96)	3.00–7.00	34	4.05 (0.88)	2.50–6.33
Activity level / energy	40	5.01 (0.92)	2.88–6.63	34	4.75 (0.93)	3.25–6.25
High-intensity pleasure	40	5.20 (1.00)	2.75–7.00	34	4.39 (1.03)	2.83–6.33
Sociability	39	5.51 (1.10)	2.67–7.00	34	5.57 (1.16)	3.00–7.00
Positive anticipation	36	4.58 (1.55)	1.00–6.80	34	4.97 (1.35)	1.00–6.80
Effortful control						
Inhibitory control	40	3.52 (0.96)	1.83–5.33	34	4.08 (1.02)	2.00–6.00
Attentional shifting	40	4.47 (0.78)	2.67–5.88	34	4.72 (0.76)	3.38–6.50
Low-intensity pleasure	40	4.60 (1.08)	2.20–6.83	34	4.82 (0.93)	2.67–6.67
Cuddliness	40	5.00 (0.92)	2.50–6.50	34	5.16 (0.72)	3.17–6.67
Attentional focusing	40	4.35 (0.81)	2.83–6.00	34	4.65 (0.92)	2.00–6.17

Note. Eight subscales are aggregated to create the negative affectivity composite score. Five subscales are aggregated to create the surgency composite score. Five subscales are aggregated to create the effortful control composite score.

Figure 1. Mean observed toddler temperament as reported by the parent-completed Early Childhood Behavior Questionnaire. *$p \leq .05$.



−0.47) to large ($d = -0.88$) in magnitude.[1] In terms of the subscales comprising the negative affectivity dimension, toddlers with hearing loss displayed significantly lower levels of perceptual sensitivity, $t(72) = 2.24$, $p = .028$, $d = 0.52$, than their hearing peers. In terms of subscales comprising the surgency dimension, toddlers with hearing loss displayed significantly higher levels of impulsivity, $t(72) = -3.77$, $p < .001$, $d = -0.88$, and higher levels of high-intensity pleasure, $t(72) = -3.42$, $p = .001$, $d = -0.80$, than their hearing peers. Finally, in terms of subscales comprising the effortful control dimension, toddlers with hearing loss displayed significantly lower levels of inhibitory control, $t(72) = 2.41$, $p = .018$, $d = 0.56$, than their hearing peers.

Correlational Analyses and Regression Models

Correlations between dimensions of temperament and demographic and communication factors (sex, chronological age, communication strategy) are shown in Table 3. In toddlers who are DHH, correlational analyses revealed a significant association between communication strategy (oral, simultaneous) and effortful control ($r = -.35$, $p = .03$), such that toddlers who use oral communication strategies were rated as displaying higher levels of effortful control ($M = 4.64$, $SD = 0.56$) than peers who use simultaneous communication strategies ($M = 4.19$, $SD = 0.66$). No other associations between ECBQ composite scores and demographic factors were uncovered for toddlers who are DHH. In toddlers with hearing, correlational analyses revealed a significant association between chronological age and effortful control ($r = .47$, $p = .004$), such that older toddlers with hearing displayed higher (better) effortful control than younger toddlers with hearing. No other associations between ECBQ composite scores and demographic factors were uncovered for toddlers with hearing.

Table 4 displays a summary of results from regression analyses using demographic and communication factors (sex, chronological age, communication strategy) as predictors of temperament. In toddlers who are DHH, communication strategy and chronological age predicted 23% of the variance in scores of effortful control ($p = .008$), such that younger children or children who use oral communication displayed higher effortful control. Further analyses revealed a significant correlation between chronological age and age at device activation, such that younger-aged toddlers had their devices activated earlier than older-aged toddlers ($r = .33$, $p = .04$). No demographic or communication factors predicted surgency or negative affectivity in toddlers who are DHH. In toddlers with hearing, chronological age alone predicted 22% of the variance in scores of effortful control ($p = .004$), such

[1]Positive values of Cohen's d represent higher subscale/composite scores for toddlers with hearing, while negative values represent higher subscale/composite scores for toddlers with hearing loss.

Table 3. Associations between dimensions of temperament and demographic and communication factors.

Dimension	Toddlers with hearing loss			Toddlers with hearing		
	Sex	Chronological age	Communication strategy	Sex	Chronological age	Communication strategy
n	40	40	40	35	35	35
Negative affectivity	$r = -.07$ $p = .69$	$r = .18$ $p = .28$	$r = .22$ $p = .17$	$r = .03$ $p = .89$	$r = -.05$ $p = .77$	N/A
Surgency	$r = -.12$ $p = .47$	$r = .19$ $p = .23$	$r = -.23$ $p = .16$	$r = -.08$ $p = .66$	$r = .17$ $p = .34$	N/A
Effortful control	$r = .09$ $p = .58$	$r = -.23$ $p = .16$	**$r = -.35$** **$p = .03$**	$r = -.15$ $p = .39$	**$r = .47$** **$p = .004$**	N/A

Note. Bolding indicates statistically significant associations at p < .05. N/A = not applicable.

that older children were rated as displaying higher scores of effortful control. No demographic factor (sex, chronological age) predicted surgency or negative affectivity in toddlers with hearing.

Identifying "Listening Items"

After reviewing the 107 items on the ECBQ, 12 items (11%) were deemed to require listening skills from toddlers. Out of these 12 items requiring listening skills, six items (50%) revealed significant group differences such that toddlers with hearing loss were rated as displaying significantly lower levels of reactivity than their hearing peers (see Table 5). As originally designed in the ECBQ, these 12 listening items are used in calculations to derive five subscales (attentional shifting, discomfort, fear, low-intensity pleasure, and perceptual sensitivity) and two composite scores (negative affectivity and effortful control).[2] Correlations between the originally designed ECBQ and the modified scale removing the 12 items requiring listening skills reveal strong associations: negative affectivity: $r = .986$, $p < .001$, $n = 39$, and effortful control: $r = .969$, $p < .001$, $n = 40$, reflective of high construct validity.

Between-Group Differences

When we recalculated composite scores to exclusively use the "listening" items, toddlers with hearing loss displayed significantly lower levels of effortful control, $t(72) = 2.31$, $p = .02$, $d = 0.54$, and negative affectivity, $t(72) = 2.28$, $p = .03$, $d = 0.53$, than their hearing peers. However, when we recalculated composite scores to remove the "listening" items, toddlers with hearing loss did not differ significantly from toddlers with hearing on levels of effortful control, $t(72) = 1.60$, $p = .12$, $d = 0.37$, or negative affectivity, $t(72) = 0.84$, $p = .40$, $d = 0.20$.

[2]The surgency composite score did not include items that were deemed to require listening skills from toddlers. As such, it was not necessary to reexamine the significant group difference of surgency between toddlers with and without hearing.

Correlational Analyses and Regression Models

We reexamined the association between communication strategy (oral, simultaneous) and effortful control in toddlers who are DHH. When we exclusively examined the "listening" items, the significant correlation between communication strategy and effortful control was retained ($r = -.36$, $p = .02$). However, after removing the "listening" items, the correlation between communication strategy and effortful control only trended toward significance ($r = -.30$, $p = .06$). This finding, representing a medium effect size, suggests that toddlers with hearing loss who use oral communication strategies tended to be rated as displaying higher levels of effortful control (better; $M = 4.63$, $SD = 0.54$) than peers who use simultaneous communication strategies ($M = 4.26$, $SD = 0.63$), even after removing items deemed to require listening skills. Finally, we reexamined regression models predicting effortful control using demographic and communication factors in toddlers who are DHH. When predicting the "listening" items, communication strategy predicted 13% of the variance in scores of effortful control ($p = .02$). However, after removing the "listening" items, no demographic or communication factors predicted effortful control.

Discussion

Most of the research on temperament has focused on children with normal hearing and typical language development, with only three studies focusing on how temperament presents in older children and adolescents who are DHH (Bowdrie et al., 2022; Warner-Czyz et al., 2015, 2018). The present article is the first to examine if toddlers with prelingual hearing loss differ across domains of temperament when compared to their hearing peers. We used the ECBQ to collect parent-reported temperament in toddlers aged 18–34 months with and without prelingual hearing loss. Our findings indicate that toddlers with prelingual hearing loss (using HAs or CIs) display differences in certain components of temperament when

Table 4. Regression models predicting effortful control in toddlers with and without prelingual hearing loss.

	Effortful control			
	Toddlers with hearing loss		Toddlers with hearing	
Variable	β	*SE*	β	*SE*
Sex				
Chronological age	–.34*	0.03	.47**	0.02
Communication strategy	–.44**			
R^2	.23**	0.19	.22**	

Note. The standardized regression coefficient (β) and the standard error (*SE*) of β are provided. Only demographic and communication factors significant at the $p < .05$ level are displayed.

*$p < .05$. **$p < .01$.

compared to their hearing peers. Consistent with our hypothesis, toddlers who are DHH were rated by their parents as displaying significantly higher levels of surgency (tendency to react to situations by displaying high levels of impulsivity and extraversion) and lower levels of effortful control (tendency to react to situations by displaying low levels of focused attention and control) than their same-aged hearing peers. However, levels of negative affectivity, the tendency to react to situations by displaying anger, discomfort, or fear, were rated by parents comparably across toddlers with and without hearing loss, also supporting our hypothesis. Our findings of higher levels of surgency and lower levels of effortful control in our sample of toddlers who are DHH are consistent with previous studies indicating that preschool children, adolescents, and young adults with prelingual hearing loss are at a higher risk of displaying inattentive and hyperactive–impulsive behaviors as compared to their hearing peers (Castellanos et al., 2018; Kronenberger et al., 2014). Because previous studies have found associations between early temperament and long-term outcomes in children with hearing (e.g., Leve et al., 2005; Valiente et al., 2007), measuring temperament during the early years of development may serve as a first step toward explaining

Table 5. Items on the Early Childhood Behavior Questionnaire identified as requiring toddler listening skills.

	Toddler hearing status					
	Hearing loss		Hearing			
Temperament	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*p* value	Cohen's *d*
Negative affectivity						
Discomfort						
Disturbed by loud sounds	40	2.48 (1.40)	34	3.24 (1.58)	**.02**	0.51
Bothered by sounds	40	2.23 (1.29)	33	2.67 (1.47)	.09	0.32
Fear						
Afraid of loud sounds	40	2.38 (1.50)	34	3.06 (1.59)	**.03**	0.44
Afraid of noises	39	1.97 (1.56)	31	2.61 (1.58)	**.048**	0.41
Perceptual sensitivity						
Listens to very quiet sounds	40	3.43 (1.96)	34	4.47 (1.62)	**.008**	0.58
Notices low-pitched noises	40	2.50 (1.78)	32	3.22 (1.90)	.051	0.39
Effortful control						
Attentional shifting						
Switches attention between play and conversation	38	3.61 (1.35)	32	4.44 (1.41)	**.007**	0.61
Switches attention between speakers	34	4.21 (1.59)	31	4.58 (1.29)	.15	0.26
Attends when called	40	4.75 (1.56)	34	4.85 (1.13)	.75	0.07
Low-intensity pleasure						
Enjoys being quietly sung to	37	4.19 (1.66)	34	4.82 (1.47)	**.047**	0.40
Enjoys being talked to	37	5.22 (1.25)	34	5.53 (1.44)	.17	0.23
Enjoys the sound of words	39	4.67 (1.69)	34	4.91 (1.52)	.26	0.15

Note. Twelve items across five subscales were identified as requiring child listening skills. Significance values are based on one-tailed independent-samples *t* tests, and bolding indicates significant group differences at $p < .05$.

variability in long-term outcomes in samples of children who are DHH.

Currently, there is a relative dearth of information on what underlying processes contribute to differences in temperament, how temperament presents across developmental time, and if early measures of temperament may predict functional long-term outcomes with toddlers who are DHH. However, since our group differences center on emotional and behavioral reactivity (surgency and effortful control), one interpretation to draw is that dimensions of early parent-reported temperament may be broadly associated with executive functioning and language skills. Previous research on children who are diagnosed with specific language impairment converge in support of this hypothesis. Children diagnosed with specific language impairment experience executive functioning delays and/or disturbances in addition to atypical language development (Wittke et al., 2013). Also, similar to children who are DHH, children diagnosed with specific language impairment also display differences in the dimensions of surgency and effortful control (e.g., Kefalianos et al., 2012; Spaulding et al., 2008). From this perspective, we may posit that variability in children's temperament may in part be due to underlying self-regulatory and language delays and/or disturbances, which challenge effective communication with their parents and adjusting to the world around them (Castellanos et al., 2020).

We next examined associations between demographic and communication factors on dimensions of temperament. Consistent with previous literature (Putnam et al., 2006), chronological age was found to be significantly predictive of levels of effortful control such that older-aged toddlers were rated as displaying higher (better) levels of effortful control than younger-aged toddlers, but this was only the case for toddlers with hearing. Seemingly paradoxically, younger-aged toddlers who are DHH of hearing were rated as displaying higher (better) levels of effortful control than their older-aged peers. Further analyses revealed that younger-aged toddlers with hearing loss received significantly earlier auditory intervention (age at device activation) than their older-aged peers; consequently, it is not unexpected that younger-aged toddlers with hearing loss were rated as displaying higher levels of effortful control. Indeed, it is well established that earlier access to sound (age at device activation) is associated with improved speech-language and executive functioning skills (Castellanos et al., 2014; Culbertson et al., 2022; Houston, 2022).

Communication strategy was also found to be significantly predictive of effortful control in toddlers who are DHH. Toddlers with hearing loss who use oral communication strategies were rated as displaying higher levels of effortful control than peers who use simultaneous communication strategies. It should be noted, though, that the directionality of this effect is unknown, and several possibilities could underlie this association, which may not be mutually exclusive. First, communication strategy may influence parent-reported measures of child temperament, but secondly, it may also be the case that child characteristics, such as temperament, influence the communication strategy selected by the parents. Thirdly, previous studies have documented associations between effortful control and language skills (e.g., Bowdrie et al., 2022); therefore, it may be possible that toddlers with hearing loss who use oral communication strategies tended to have better language skills than peers who use simultaneous communication strategies. In support of this third possibility are studies that indicate that the early adoption of oral communication strategies in pediatric CI users is associated with better long-term speech-language and executive functioning skills (Castellanos et al., 2016; Freeman et al., 2017). To better delineate our current findings, studies are underway in our laboratories to examine the association between early temperament, communication strategy, and language outcomes in toddlers who are DHH.

Moreover, in line with previous findings from a meta-analysis of children aged 3 months to 13 years (Else-Quest et al., 2006), we predicted that female toddlers would be rated by their parents as displaying significantly higher levels of effortful control and lower levels of surgency than their male peers. Our current findings did not support this hypothesis as toddlers across sex were reported to display comparable temperament. There is some evidence, however, to corroborate our null sex findings, suggesting that sex differences in temperament may not be reliably detected until the preschool years (Eaton & Enns, 1986). Several avenues for further research appear fruitful, including how dimensions of temperament may alter across developmental time as a function of sex and hearing skills.

Lastly, we examined if the parent-reported ECBQ, which was developed and validated for typically developing hearing toddlers, can provide a valid measure of temperament in children who are DHH. That is, are patterns of group differences influenced by toddlers' hearing and listening skills? In exploring individual items on the ECBQ, it became clear that responses on some items could be tied to hearing in ways not relevant to the construct of temperament being assessed. For example, the construct of fear in the ECBQ consists of items measuring toddlers' fear of loud sounds. In these cases, scores of fear for toddlers who are DHH could be skewed, as compared to peers with hearing, as *fewer* events are perceived as "loud." Said differently, parents may report that events elicit more fear responses from children with hearing than

those with hearing loss. Children who are DHH experience *fewer* loud sounds compared to their hearing peers due to hearing abilities (e.g., higher hearing thresholds and smaller dynamic ranges; Peixoto et al., 2013) and properties inherit to their hearing technology. Hearing devices are specifically designed and programmed to amplify speech sounds while automatically reducing loud environmental sounds (noise reduction algorithms support speech recognition and mental fatigue in complex listening situations) and have directional processing in that microphone arrays are positioned in front of the child listener to support suppression of sounds from the sides and back (American Academy of Audiology, 2013; McCreery et al., 2012).

Twelve items comprising the composite of negative affectivity and effortful control were deemed to require listening skills. All items comprising the composite of surgency were deemed to not require listening skills, indicating that group differences between toddlers' surgency were not associated with parents' perception of their toddlers' listening skills. Analyses quantifying the construct validity between the original ECBQ and our modified ECBQ revealed strong psychometric support for the removal of the "listening" items within our sample of toddlers who are DHH. On all the 12 "listening" items (which measured discomfort, fear, perceptual sensitivity, attentional shifting, and low-intensity pleasure), toddlers with hearing loss displayed lower reactivity than their hearing peers, providing support for our prediction that parents would rate items requiring listening skills lower in the DHH sample than the hearing sample. Indeed, after removing the "listening" items and recomputing subscale and composite scores, analyses revealed that the two groups of toddlers were comparable across measures of effortful control and negative affectivity. These findings suggest that the original ECBQ was validated with items that are associated with hearing and listening skills, which skew data in toddlers who are DHH. A more nuanced approach should be considered when examining temperament using scales like the ECBQ that were not originally developed to account for variability in toddlers' hearing and listening skills. We advise caution when interpreting scores for constructs that rely on items measuring temperament through toddlers' listening skills. Further research is warranted with a larger and more diverse sample toddlers with and without hearing loss.

Several limitations should be considered when interpreting the present results. First, it is possible we may have altered the psychometric attributes (internal consistency, test–retest reliability, and construct validity) of the ECBQ by removing the 12 items deemed to require listening skills. Although the focus of the present article was not on the psychometric properties of the ECBQ, correlations between the originally designed ECBQ and the modified scale revealed high construct validity, which supports our view that these 12 listening items are not relevant to the construct of temperament being assessed. This study was an important first step in providing guidance for developing a more psychometrically sound scale for use within the population of toddlers who are DHH. Secondly, temperament was only measured using the parent-reported ECBQ. Although the ECBQ has been extensively validated in typically developing hearing toddlers (e.g., Putnam et al., 2006), this is the first study to use the ECBQ in toddlers who are DHH, and it is possible that factors such as parent experiences and bias may affect ratings of temperament. Future studies should consider collecting performance data on the dimensions of surgency, negative affectivity, and effortful control to complement parent-reported data from the ECBQ. Thirdly, the present data are limited to one time point, and there are no previously published studies indicating the predictive validity of the ECBQ in samples of toddlers who are DHH. Finally, the present study is limited by a lack of available data on toddlers' speech-language outcomes. Studies are currently underway in our laboratories to examine the longitudinal association between temperament in infancy and toddlerhood and functional skills in preschool children with and without prelingual hearing loss.

In summary, we found significant differences in parent-reported temperament between toddlers with and without prelingual hearing loss centering on the domain of surgency. Initial analyses also suggested differences in effortful control. However, item analyses suggest that this difference may be an artifact caused by several items that depend on hearing. Surgency and effortful control may be two domains of temperament that are particularly important for predicting later language skills in children with prelingual hearing loss. This line of research is particularly important as we seek to identify early predictors of long-term functional outcomes following early identification and amplification/implantation. By examining and longitudinally tracking temperament from infancy through toddlerhood, we may be able to identify children who may be at an early risk for developing delays and disturbances in speech-language skills. Studies are currently underway in our laboratories to examine the longitudinal association between temperament in infancy and functional skills in preschool children with and without prelingual hearing loss.

Data Availability Statement

De-identified data are available to qualified individuals within the scientific community upon request from the authors.

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