Research Note

Sensitivity to Morphosyntactic Information in 3-Year-Old Children With Typical Language Development: A Feasibility Study

Patricia Deevy,^a Laurence B. Leonard,^a and Virginia A. Marchman^b

Purpose: This study tested the feasibility of a method designed to assess children's sensitivity to tense/agreement information in fronted auxiliaries during online comprehension of questions (e.g., *Are the nice little dogs running?*). We expected that a group of children who were proficient in auxiliary use would show this sensitivity, indicating an awareness of the relation between the subject–verb sequence (e.g., *dogs running*) and preceding information (e.g., *are*). Failure to grasp this relation is proposed to play a role in the protracted inconsistency in auxiliary use in children with specific language impairment (SLI).

Method: Fifteen 3-year-old typically developing children who demonstrated proficiency in auxiliary use viewed

pairs of pictures showing a single agent and multiple agents while hearing questions with or without an agreeing fronted auxiliary. Proportion looking to the target was measured.

Results: Children showed anticipatory looking on the basis of the number information contained in the auxiliary (*is* or *are*).

Conclusions: The children tested in this study represent a group that frequently serves as a comparison for older children with SLI. Because the method successfully demonstrated their sensitivity to tense/agreement information in questions, future research that involves direct comparisons of these 2 groups is warranted.

Young typically developing (TD) children who are acquiring English go through a developmental period during which they use tense and agreement (T/A) morphemes inconsistently. These morphemes include the verb inflections third-person singular *–s* and past tense *–ed* as well as the copula and auxiliary forms of *be* (e.g., *is*, *are*). Thus, children may alternate between saying, for example, *Mommy like chocolate* and *Mommy likes chocolate*, and *Daddy running* and *Daddy is running*.

In children with specific language impairment (SLI), the period of inconsistency is significantly protracted relative to the period seen in typical language development. For example, even at school age, some English-speaking children with SLI are not yet at mastery levels in the use of these morphemes (Marchman, Wulfeck, & Ellis Weismer, 1999). A hallmark finding is that when 5-year-old children with SLI are compared with younger TD 3-year-olds, the

latter group shows greater use of these morphemes even when the two groups are matched on mean length of utterance or verb diversity (Leonard, Miller, & Gerber, 1999).

One prominent explanation for the period of inconsistency in typical development comes from Wexler and colleagues (Rice & Wexler, 1996; Wexler, 1994), who proposed that children initially operate with a constraint that favors the expression of tense only or agreement only. This constraint is shed with maturation between 3 and 4 years of age in TD English-speaking children. For children with SLI, the constraint remains much longer. In recent years, some scholars have proposed that the age at which the constraint loses its hold is in part influenced by the nature of the input. In a language such as English in which many verbs appear in bare stem form, the input does not clearly reflect a “[+ tense]” language (Legate & Yang, 2007). Therefore, a greater amount of input is required before children arrive at the correct interpretation that English is a tense-marked language.

Other investigators have assumed an even stronger role for the input. In their computational modeling work, Pine and colleagues (e.g., Freudenthal, Pine, Aguado-Orea, & Gobet, 2007) proposed that children may initially base their early productions on those portions of input utterances that they can successfully process. Along with simple T/A

^aPurdue University, West Lafayette, IN

^bStanford University, CA

Correspondence to Patricia Deevy: deevy@purdue.edu

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marked sentences, such as *Daddy is running*, there may be input such as *Is Daddy running?* and *We saw Daddy running* that might lead children to extract sequences that lack T/A marking such as *Daddy running* and use them as stand-alone utterances.

Several experiments with young children seem consistent with this proposal. Theakston, Lieven, and Tomasello (2003) presented children with novel actions and described them using novel verbs that either did or did not include T/A marking on the verb. After exposure, children were prompted to use the novel verb in a sentence that required the T/A form. Theakston et al. found that children were more likely to use novel verbs without T/A (e.g., *It mib*) if they had heard the verbs in input frames such as *Will it mib?* whereas they often produced a T/A form (e.g., *It mibs*) if the input frame contained such a form (e.g., *Look, it mibs*).

Using a similar method, Leonard and Deevy (2011) and Leonard, Fey, Deevy, and Bredin-Oja (2015) reported comparable findings with 5-year-old children with SLI who were inconsistent in their use of T/A morphemes. The children's use or failure to use morphemes such as auxiliary *is* and third-person singular *-s* was very much influenced by whether the input utterances contained these morphemes in declarative position (*Daddy is relling*) or instead contained a sequence such as *Daddy relling* (e.g., *We saw Daddy relling; Is Daddy relling?*). These investigators attributed this input extraction pattern to the children's insufficient understanding of the restrictions placed by earlier appearing forms (a verb in the main clause, an inverted auxiliary) on the subject-verb sequence that followed. For example, although children with SLI may understand the pragmatic function of a question such as *Is Daddy running?* they may not grasp the fact that the subject-verb sequence *Daddy running* is structurally connected to the fronted auxiliary. Seeing no connection, the children may then feel free to extract sequences such as *Daddy running* and use them as independent utterances.

To test this proposal adequately, a method is needed that is capable of assessing children's sensitivity to the connection between a fronted auxiliary and the rest of the question. If this proposal is correct, children who are more proficient in the use of auxiliaries should be sensitive to this connection, whereas children with SLI, who are much less proficient, should be relatively insensitive. Five-year-old children with SLI show significantly less use of auxiliary *is* and *are* than 3-year-old TD children, with the latter group approaching mastery levels. Before testing the hypothesis in children with SLI, however, we need to determine whether younger TD children who are using the auxiliary with high accuracy do show sensitivity to T/A information in this context. For this reason, our feasibility study focused on TD children aged 3;0 (years;months) to 3;11 whose percentages of use of auxiliary forms are in a high range.

The method we used was the looking-while-listening (LWL) paradigm (Fernald, Zangl, Portillo, & Marchman, 2008). In this method, children's eye movements are recorded as they view pairs of pictures and listen to sentences. Eye gaze patterns are plotted frame-by-frame, revealing the time

course of language processing. Studies have shown that children, like adults, process language incrementally, directing their attention to the target picture as the sentence unfolds in time (e.g., Fernald, Perfors, & Marchman, 2006). This method has been used to demonstrate children's online use of grammatical information. Most relevant to the current study, Lukyanenko and Fisher (2016) used the LWL paradigm to test children's sensitivity to the information provided by singular and plural fronted copula forms in *wh*-questions (e.g., *Where is/are the good cookie/s?*) and control sentences (e.g., *Do you see the good cookie/s?*). Two groups of children, ages 2.50 and 3 years of age, heard these sentences while viewing pairs of pictures showing, for example, two cookies and one apple. Both age groups showed anticipatory looking to the correct noun on the basis of number information in the copula. This effect was especially apparent for plural *are*.

Although Lukyanenko and Fisher (2016) demonstrated sensitivity to number information in their study, they did not report measures of copula use for the children tested. Without a measure of production, it is not clear that the children in their study are comparable with the control group we would need for comparison with children with SLI. A further difference is that we tested questions with a fronted agreeing auxiliary *be* (e.g., *Are the nice little dogs running?*). Auxiliary questions provide a more direct test of our hypothesis that children with SLI inappropriately extract subject-verb sequences from input sentences such as these. Because auxiliary *be* is acquired later than copula *be* (Rispoli, Hadley, & Holt, 2012), young children may be less proficient at producing it and at using it online.

To summarize, the purpose of this study was to determine whether 3-year-old TD children who show proficiency in their use of auxiliaries anticipate a singular or plural noun on the basis of the information provided in a fronted auxiliary in questions such as *Are the nice little dogs running?* A finding of anticipatory looking by these children might be interpreted as their understanding of the relationship between the auxiliary and the subject-verb sequence that follows, and it would demonstrate the feasibility of testing the same ability in children with SLI.

Method

Participants

Fifteen TD preschool-age children participated in this study. The children averaged 3;6 in age ($SD = 3.3$ months). Eleven were boys, four were girls. Fourteen were White; one was Hispanic and American Indian/Alaska Native. All children were monolingual and came from homes in which only Mainstream American English was spoken. The children were recruited through preschools and day cares. We obtained informed consent to participate from each child's parent in accord with the policies of the first author's institutional review board. All children met the selection criteria for the study. They passed a hearing screening and received a standard score greater than 85 on the Primary Test of

Nonverbal Intelligence (Ehrler & McGhee, 2008) and greater than 87 on the Structured Photographic Expressive Language Test—Preschool: Second Edition (Dawson, Eyer, & Fonkalsrud, 2005). All the children had normal, uncorrected vision by parent report.

Previous studies of auxiliary *be* forms with TD children in this age range show percentages of use in obligatory contexts to be approximately 70% or higher (Leonard et al., 2003; Rice, Wexler, & Cleave, 1995). In each of these studies, these children were found to produce auxiliary *is* and *are* with higher percentages in obligatory contexts than the 5-year-old children with SLI with whom they were matched on mean length of utterance. We accordingly set our selection criterion at 70% use, measuring degree of use through the auxiliary production probe task used by Leonard et al. (2003) with 10 auxiliary *is* items and 10 auxiliary *are* items. Actions with toys and props were shown to children, and, as the action was occurring, the children were prompted to complete a declarative sentence beginning with either a singular or plural noun phrase as in “Tell me about the babies. The babies....” The children showed considerable proficiency with these morphemes; their range of auxiliary *is* use was 70%–100% ($M = 93.93$, $SD = 10.59$), and the range for auxiliary *are* use was 90%–100% ($M = 98.00$, $SD = 4.14$). Means were similar on the basis of a 125-utterance sample of spontaneous speech ($M = 94.03$, $SD = 10.05$; $M = 88.10$, $SD = 22.86$; for *is* and *are*, respectively). Similar high percentages of use were seen across all contexts (e.g., question/declarative; contracted/uncontracted; pronominal/lexical subject noun).

Procedure—LWL Paradigm

During the LWL procedure, children sat in a chair in front of a 54-in. flat screen, high definition TV and viewed pairs of drawings. Each pair was accompanied by a sentence that described one of the drawings. A digital camera situated directly below the center of the TV screen recorded the child’s face. Children were told they would see pictures and hear a lady talk about them; they were asked to simply watch and listen. A student research assistant stood silently behind the child’s chair while a second experimenter monitored experimental equipment nearby. During four familiarization trials, a drawing appeared on only one side of the screen, accompanied by a simple sentence (e.g., *Look at this monkey!*). Thus, children were familiarized with the idea that sentences would describe pictures on the screen and that pictures would appear in the left and right corners of the screen.

Thirty-two experimental trials were then presented in pseudorandom order using PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993). No more than three consecutive targets appeared on the same side, and no more than three consecutive targets were in the same condition. Each trial lasted 7.8 s, with pictures remaining onscreen throughout. The trial was composed of a 1,500-ms silent preview of the pictures, followed by presentation of the stimulus sentence (3,800 ms) and another 2,500 ms of

silence after the sentence ended. There was a 1,000-ms interval between trials.

A reinforcement trial occurred after every eight experimental trials; these featured a picture of a cartoon character and an encouraging statement (e.g., *You’re doing great! Keep watching!*). After Trial 16, children were given a break of 1 min or less, during which they spoke to the experimenter and had the opportunity to stand up and stretch. The entire procedure lasted about 6 min. To ensure a sufficient number of usable experimental trials, children repeated the task on a subsequent day, viewing a different pseudorandom order. List order was counterbalanced across children. The second viewing was scheduled for a different day to avoid children becoming bored with the task, typically within 1 week. Across the two viewings, there were 64 experimental trials, 16 per condition.

Stimuli

Sixteen color illustrations were created that depicted eight different agent–action combinations (see the example illustration in Appendix A). For each combination, two versions were created, one showing a single agent and one showing a pair of agents (e.g., *dog running*, *dogs running*). On each trial, the target and distractor featured different referents, always contrasting in number but carrying out the same action (e.g., *one boy running*, *two dogs running*). To control for salience, these pairs were yoked, and the plural and singular versions were matched in overall size. Each of the eight agent–action combinations appeared equally often in its singular and plural version, and equally often as target and distractor, with location of the target picture (left or right) counterbalanced.

The auditory stimuli consisted of 32 sentences recorded by a female native speaker of English. Eight sentences were constructed in a cross of two conditions (T/A cue or no T/A cue, singular or plural subject number; the sentence stimuli are provided in Appendix B). Note that whereas the subject–verb sequence is part of the main clause for the T/A cue sentence (e.g., *Are the nice little dogs running?*), it is in an embedded clause in the no T/A cue sentence (e.g., *See the nice little dogs running*). For simplicity, we refer to both as a *subject–verb sequence*.

In constructing the stimuli, it was important to control the timing of the onsets of words that provided a cue to the identity of the target picture. It was at these critical onsets that children could begin to identify and retrieve the word and use it to interpret the sentence. In both the T/A and no T/A cue conditions, the target picture could be identified at the noun. In the T/A cue condition, the inverted number-marked auxiliary provided an earlier cue. Nevertheless, if children were not sensitive to the presence of this early cue, the subsequent noun might represent the first point at which they could identify the target. To measure the children’s unfolding response to the auxiliary and to the noun, and to compare across conditions, it was necessary to match the timing of these word onsets across condition (see below).

Two further characteristics of the target sentences should be noted. First, each target sentence was preceded with an exclamation (*Look!*, *Hey!*, *Oh!*, *Hmm!*). These were counterbalanced across conditions and subject nouns. The purpose of this word was to engage the child's auditory attention and to avoid having the onset of the critical word (*is/are/see*) at the beginning of the auditory stimulus. Second, the noun was always modified by two superfluous adjectives (*nice little*), creating a time lag between the T/A cue (*is, are*) and the noun (e.g., *boy*). This ensured sufficient time for our eye gaze measure to capture a response to the early cue, which would not be confounded with a response to the following noun. The interim allowed time to disengage from the current focus of attention and to program an eye movement.

The auditory portion of the trial lasted 3,800 ms, including the initial attention-getter and the sentence itself. The two regions of interest in our analysis were (a) the pre-noun region, beginning at the onset of *see/is/are*, and (b) the noun region, beginning at the onset of the noun. The stimulus sentences were edited in Praat (Boersma & Weenink, 2014) to ensure alignment of onsets of these two regions across conditions. From the recordings of the sentences, we extracted tokens of *see, is, and are*, normalized to match in length (549 ms), as well as *the nice little*. These were used to create single tokens of the pre-noun region, which were matched in length across condition (e.g., *see the nice little; is the nice little; are the nice little*). They were combined with the noun and verb to create each sentence. Because the pre-noun regions were matched in length, the onset of the noun was aligned across sentences. The exclamation words were recorded separately and matched in length; they were then added to the beginning of each sentence so that the onsets of *see, is, and are* were also aligned. The following example shows the overall timing of the auditory stimuli, including region onsets and offsets:

Hey! is/are/See the nice little boy(s) running?
0 834 2,404 3,800ms

Coding

Each child's face was video-recorded as he or she viewed the experimental pictures. This recording was combined with a time stamp as well as information about the timing of trial events (picture on/off, sound on/off) for later coding. Using custom software, videos were first pre-screened to eliminate trials in which the child was not looking at the screen for most of the trial or the child or adult talked during the spoken stimulus, creating auditory interference. Next, the child's eye gaze was coded during each 33-ms frame as *left* (looking at the picture on the left), *right* (looking at the picture on the right), *off* (moving from one picture to the other), or *away* (not looking at either picture and not shifting between pictures). This was completed without access to sound, so coders were blind to sentence condition. Likewise, the coder was unaware of

whether the target picture was on the left or right side of the screen.

Two trained research assistants did the initial coding. Training included familiarization with the lab's coding protocol and application of these rules to increasingly more challenging videos. Working with the first author, six such videos were coded and compared line by line until the trainee had become highly accurate. Afterward, the assistant coded independently with regular, ongoing checks by the first author.

Prior to analysis, coded trials were identified as distractor-initial, target-initial, or away, on the basis of the child's fixation at the onset of the auxiliary or *see*. Away trials were excluded, as were trials in which the child was inattentive more generally (looking away for any period longer than 500 ms during the sentence presentation). The average number of trials per condition (out of 16) was 11.53 ($SD = 0.78$, range = 8–15), with a similar number of trials across conditions.

Intercoder Reliability

To assess intercoder reliability, data from three children were independently recoded by the first author. Following Fernald et al. (2008), we computed intercoder agreement as (a) the proportion of frames in which coders agreed on gaze location (*frame agreement*) and (b) the proportion of shifts in gaze in which coders agreed within one frame (*shift agreement*). When trials differed in the sequence of events, the two coders viewed them together, came to a consensus on the events, and recoded the trials. On the basis of the resulting 100% comparable trials, percentages of agreement for the two measures were 99.30% and 98.60%, respectively.

Measures/Data Analysis

The measures most commonly derived from the LWL method are accuracy and reaction time (RT). Studies of word recognition have shown that both measures correlate strongly with language development in young children (Fernald et al., 2006) and are predictive of later language and cognitive attainments (Marchman & Fernald, 2008). In this study, we focused on accuracy in the pre-noun portion of the sentence comparing the T/A cue and no T/A cue conditions.

Accuracy is defined as the mean time spent looking at the target picture as a proportion of the time looking at either the target or the distractor. Mean accuracy is computed over the analysis region for each trial and then averaged over trials for each child. As the sentence unfolds, attention to the target picture is driven by the child's comprehension, leading to an increase in accuracy or proportion looking to the target. In this study, accuracy during the pre-noun region can provide an indication of whether children used the early cue provided by the auxiliary, before hearing the referring noun.

In the LWL method, RT is computed over a subset of trials: only those in which the child is looking at the distractor picture or target picture when the critical word of the stimulus is spoken. RT is computed as the latency to shift from distractor to target picture, within the analysis window. Target initial trials serve as a control. Our inspection of the current data set showed too many children (9/15) with unacceptably low numbers of trials that met these requirements (≤ 2 distractor- or target-initial trials), preventing such an analysis (Fernald et al., 2008). Nevertheless, measuring accuracy in the pre-noun region can allow us to capture an early, time-sensitive response to the auxiliary cue.

As described above, the pre-noun region began at the onset of the auxiliary or *see* and ended immediately before the noun onset (total length of region: 1,570 ms). The noun region began at the noun onset and ended 500 ms after the noun offset (total length of region: 1,125 ms). In the analysis, however, the actual computation of accuracy that encompassed these same windows shifted ahead by 300 ms. This was done to exclude looking that could not reasonably be interpreted as a response to the language that the child had heard at that point (Fernald et al., 2008).

If children were able to quickly detect and use the auxiliary cue, they would show a higher proportion of time looking to the target in the pre-noun region in the T/A cue condition relative to the no T/A cue condition. In addition to the effect of T/A cue, we also considered the effect of number. Singular- and plural-agreeing auxiliaries provided the cue to the reference of the upcoming subject noun. In this study, effects favoring the plural condition could arise either from greater sensitivity to *are* than to *is* or simply from a bias to look at multiple objects. Finally, to ensure that children were generally responsive to the task independent of their tendency to use T/A cues, we compared the children's accuracy after the noun had been heard to their accuracy during the pre-noun period.

Results

Figure 1 provides an overall look at children's performance in the pre-noun region. Accuracy levels were examined in this region using an analysis of variance with T/A cue (T/A cue, no T/A cue) and number (plural, singular) as within-subject variables. Significant main effects were found for T/A cue, $F(1, 14) = 15.56, p = .0015$, partial $\eta^2 = .526$, and number, $F(1, 14) = 18.33, p = .0007$, partial $\eta^2 = .567$. The T/A Cue $\times$ Number interaction was not significant, $F(1, 14) = 0.0001, p = .9986$. In the pre-noun region, significantly longer looking at the target occurred when there was a T/A cue ($M = 60.78, SD = 9.47$) than when there was no T/A cue ($M = 51.23, SD = 5.08$). Looking was also significantly longer for plural items ($M = 62.12, SD = 9.43$) than for singular items ($M = 49.89, SD = 6.61$).

Although the T/A cue clearly influenced the children's looking behavior in the pre-noun region, looking was further influenced, as expected, after the noun was heard. There was significantly greater looking at the target in the noun

Figure 1. Proportion looking to the target in the pre-noun region: from onset of the auxiliary or *see* to the onset of the noun. Error bars represent 95% confidence intervals.

region ($M = 77.30, SD = 6.14$) than in the pre-noun region ($M = 56.01, SD = 5.98$), $F(1, 14) = 140.91, p < .001$, partial $\eta^2 = .910$. Within the noun region, there was no longer a main effect for number, $F(1, 14) = 1.28, p = .276$ (plural: $M = 78.79, SD = 9.18$; singular: $M = 75.81, SD = 6.55$). However, the main effect for T/A cue was maintained, $F(1, 14) = 7.93, p = .014$, partial $\eta^2 = .362$ (T/A cue: $M = 80.39, SD = 6.56$; no T/A cue: $M = 74.21, SD = 8.27$). The T/A Cue $\times$ Number interaction was marginally significant, $F(1, 14) = 3.60, p = .078$.

Discussion

We tested the feasibility of a method designed to assess children's sensitivity to T/A information in fronted auxiliaries. We recruited TD children 3 years of age because these children show considerable use of auxiliary forms and should therefore show the type of sensitivity of interest here. Indeed, the TD 3-year-olds in this study did show anticipatory looking as a function of the T/A information provided by the fronted auxiliary. This was a main effect, indicating that it applied to both *is* and *are*, as is apparent in Figure 1. We interpret this anticipatory looking as evidence that children relate the initial agreeing auxiliary to the subject-verb sequence downstream. Understanding this connection, these children would be unlikely to extract subject-verb sequences from questions of this type. A failure to grasp this connection would place no constraints on extraction, leading to inconsistent T/A use.

There is an alternative interpretation of our findings. Perhaps instead of treating the auxiliary forms as forecasting the appearance of nouns with the same singular or plural value, the children were treating the auxiliaries themselves as referring expressions, where *are* had the meaning of "more than one" and *is* had the meaning of "one." In this case, the

children's looking toward the target in the pre-noun region would not be characterized as anticipatory but rather as the children looking at the already-named referent. However, it is not clear that TD children actually process T/A morphemes in such a semantically based way. If they did, it seems unlikely that they would perform so poorly on offline tasks that require reliance on T/A morphemes to interpret sentences (Johnson, de Villiers, & Seymour, 2005).

Along with demonstrating the feasibility of this task for future studies comparing SLI and TD groups, particular details in our findings suggest the need for considerable care when applying this method. The children displayed a clear bias for pictures containing plural subjects. Lukyanenko and Fisher (2016) also noted a preference for plural in their study of copula forms. These investigators did not report the children's use of T/A morphemes. However, our study suggests that a bias for multiples occurs even when children make considerable use of T/A morphemes that can be distinguished by number (*is*, *are*).

One source of this bias may be nonlinguistic. Presented with a single-object picture and a multiple-object picture with no verbal information, young children often show a preference to look at the multiple-object picture (Brandt-Kobe & Hohle, 2010). Our use of the no T/A cue (*See the nice little*) control sentences prevented the plural bias from interfering with our ability to detect sensitivity to the T/A cue. However, it suggests that researchers must use both singular (as in *is*) and plural (as in *are*) forms as stimuli to get a clear sense of the precise degree of looking that occurs with a T/A cue.

In summary, our findings support the feasibility of a future investigation of children with SLI. We obtained clear results using the LWL method with 3-year-old TD children. This group was especially appropriate because children in this age and auxiliary ability range often serve as comparison groups for older children with SLI. It has been proposed that children with SLI may extract subject-verb sequences from questions because they fail to grasp that these sequences are structurally tied to the fronted auxiliary. If this is the case, these children should show less sensitivity to T/A information than the younger TD children used in this study.

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Appendix A

Example Illustration Paired With Target Sentences

- a. Finiteness Cue-Plural:
- b. Finiteness Cue-Singular:
- c. No Finiteness Cue-Singular:
- d. No Finiteness Cue-Plural:

Are the nice little dogs running?
Is the nice little boy running?

See the nice little boy running?
See the nice little dogs running?

Appendix B

Sentence Stimuli Used in the Experimental Task

Is/Are the nice little cat/s running?
See the nice little cat/s running?
Is/Are the nice little dog/s running?
See the nice little dog/s running?
Is/Are the nice little girl/s running?
See the nice little girl/s running?
Is/Are the nice little boy/s running?
See the nice little boy/s running?
Is/Are the nice little cat/s eating?
See the nice little cat/s eating?
Is/Are the nice little dog/s eating?
See the nice little dog/s eating?
Is/Are the nice little girl/s eating?
See the nice little girl/s eating?
Is/Are the nice little boy/s eating?
See the nice little boy/s eating?