**Behavioral methods for investigating morphological and syntactic processing in children**

Harald Clahsen (University of Essex)

harald@essex.ac.uk

While most first language acquisition research to date focuses on the development of children's linguistic competence, a number of research teams have also investigated the mechanisms children employ to process sentence- and word-level information in real time, by applying experimental techniques familiar from the adult processing literature to children. McKee (1996) presented an overview of the very few on-line techniques suitable for children that were available at the time. The purpose of the present paper is to provide an updated overview which focuses on different kinds of behavioral tasks for investigating both morphological and syntactic processing in children. Specifically, we will discuss advantages and disadvantages of three techniques that we have explored in our own research on children's on-line language processing.

The speeded production task provides a method for examining automatic processes involved in the spoken production of inflected word forms. In our version of this task (Clahsen, Hadler, Weyerts 2004), participants watching a visual display were asked to produce (as quickly and accurately as possible) inflected verb forms for corresponding verb stems presented auditorily in a sentential context. The experiment manipulates the verb type (regular/irregular) and the frequency (high/low) of the inflected verb forms to be produced. The rationale is that if an inflected word form is stored as an unanalyzed whole, then retrieval should be faster for high-frequency than for low-frequency forms, and this contrast should be reflected in corresponding production-latency differences. Results from this task allow us to determine whether children retrieve inflected word forms as wholes or whether they compute inflected forms from their component parts.

The self-paced listening task in which participants listen to sentences by pressing a pacing button to receive successive words or phrasal segments provides a measure of moment-to-moment sentence processing. The rationale is that increased listening times to a particular segment (relative to the same segment in a control condition) indicate a relatively higher processing difficulty at this point in the sentence. In previous studies with adults, self-paced listening has been shown to be sensitive to the same effects that have been observed in corresponding tasks using visual stimuli. In our version of this task (Felser, Marinis, Clahsen 2003), self-paced listening was used to examine children's processing of temporarily ambiguous sentences.

The cross-modal priming technique provides a useful tool for examining the processing of syntactic dependencies in children and adults. In this task, participants are required to perform a lexical task (e.g., lexical decision or word naming) for visually presented targets while listening to sentences spoken at normal speed. Visual targets are presented at different positions during the auditory stimulus to determine whether dislocated constituents (e.g. fronted wh-phrases) are mentally reactivated at corresponding gap positions. If this is the case, then participants' responses to targets semantically related or identical to the wh-antecedent should be facilitated at the point of a gap, relative to non-gap (control) positions. In our version of this task (Roberts, Marinis, Felser, Clahsen 2006), antecedent-priming effects were obtained at syntactically defined gap sites, for both children and adults.

**Development of sentence context use:**
**When and how do children know that *tag* is a label and not a game?**

Maya M. Khanna & Julie E. Boland (University of Michigan) and Michael J. Cortese (College of Charleston)

khannam@umich.edu

People must use context when assigning meaning to unknown or ambiguous words (e.g., At recess, the children played tag.). There is now evidence that context influences processing very early in adult readers (Sereno, Brewer, & O'Donnell, 2003). However, there is very little evidence concerning how and when context is used for meaning selection by early readers.

To fill this gap, we investigated lexical ambiguity resolution in 2nd, 3rd, and 4th graders as well as in adults. The youngest readers (2nd and 3rd graders) clearly do not have efficient mechanisms for using context for lexical ambiguity resolution, while the 4th graders look much more like our adult participants. This may be because inhibition and selection capabilities are underdeveloped before approximately age 8 (Novick, Trueswell, & Thompson-Schill, in press). The goal of our research is to identify the cognitive mechanisms that mature between 2nd and 4th grade, to allow for more adult-like use of context.

To assess the use of context, we employed a cross-modal paradigm. Auditory sentences ending in an ambiguous word (e.g., "tag") were followed by a to-be-named (visually presented) target word (e.g., game). After naming the target, participants indicated whether or not the target word was related in meaning to the sentence that (s)he heard. The relationship between the sentence context and the target word was either congruent, incongruent, or unrelated (see Table 1).

Naming latencies indicate that successful context use develops along with reading experience (as measured by both age and reading ability) and the development of cognitive mechanisms such as inhibition and selection. The younger readers (2nd and 3rd graders) showed 160 ms and 155 ms facilitation in naming latencies for the congruent and incongruent targets, respectively. However, the 4th grade participants displayed 128 ms of facilitation in naming latencies to only the contextually congruent target words, mirroring the pattern we obtained for adults, using the lexical decision task. In addition, the 4th grade participants were more able to appropriately evaluate the relatedness of the sentences and targets than the 2nd and 3rd graders.

We suggest that this successful use of context displayed by the fourth graders may arise due to the maturation of cognitive mechanisms (e.g., working memory, selection and inhibition). These processes develop along with reading experience and reading ability. In addition, we discuss how this development of language context use could be accommodated by existing models of lexical ambiguity resolution (e.g., Rayner & Duffy, 1986; Vu, Kellas, & Paul,1998) in adults and those of context use in children (Simpson & Lorsbach, 1983; Stanovich, Nathan, West & Vala-Rosi, 1985). Finally, we suggest how our results can guide the development of educational programs that promote successful context sensitivity, which is important for lexical acquisition.

**Table 1.** Example sentence-target pairs.

| Sentence Type | Sentence | Target |
|---|---|---|
| Congruent | At recess, the children played tag. | game |
| Incongruent | Joey was bothered by his shirt's tag. | game |
| Unrelated | Ed was frightened by the loud bark. | game |

## References

Novick, J. M., Trueswell, J. C., and Thompson-Schill, S. L. (in press). Toward the neural basis of parsing: Prefrontal cortex and the role of selectional processes in language comprehension. Journal of Cognitive, Affective, & Behavioral Neuroscience.

Rayner, K., & Duffy, S. A. (1986). Lexical complexity and fixation times in reading: Effects of word frequency, verb complexity, and lexical ambiguity. Memory & Cognition. 14, 191-201

Sereno, S. C., Brewer, C. C., & O'Donnell, P. J.(2003). Context effects in word recognition: Evidence for early interactive processing. Psychological Science, 14, 328-333.

Simpson, G. B. & Lorsbach, T. C.(1983). The development of automatic and conscious components of contextual facilitation. Child Development, 54, 760-772.

Stanovich, K. E., Nathan, R. G., West, R. F. & Vala-Rossi, M. (1985). Children's word recognition in context: Spreading activation, expectancy, and modularity. Child Development, 56, 1418 – 1428.

Swinney, D. A. (1979). Lexical access during sentence comprehension: (Re)consideration of context effects. Journal of Verbal Learning & Verbal Behavior. 18, 645-659.

Vu, H., Kellas, G., & Paul, S. T. (1998). Sources of sentence constraint on lexical ambiguity resolution. Memory & Cognition, 26, 979-1001.

**Relative clause processing by Italian children: A self-paced listening study**

Arosio Fabrizio, Maria Teresa Guasti, Flavia Adani (Università degli Studi di Milano-Bicocca)

fabrizio.arosio@unimib.it

Processing of Italian subject and object relatives reveals that number agreement on the verbs is used to revise previous decisions by some but not all children; different performances among children depend on differences in working memory.

(1) in Italian can be a subject or an object relative (with postverbal subject). Disambiguation is obtained through number agreement on the auxiliary (**stanno**), (2) being a subject (SRCA) and (3) an object relative (ORCA).

(1) il pagliaccio che sta bagnando il giardiniere (lit. The clown that is wetting the gardener)
(2) i **pagliacci** che **stanno** bagnando il giardiniere, (lit. the clown that are wetting the gardener)
(3) il giardiniere che **stanno** bagnando **i pagliacci**, (lit. The gardener that are wetting the clowns).

In a previous off-line study (Arosio et al., 2005; AAG), 5 to 11 year olds were shown to have no difficulties with SRCA, but (3) was still problematic at 9 years, although at 5 years children detected number agreement violations off-line. The AAG material included RC with 2 animate NPs that may be a source of difficulty (Mak, et al., 2002). To understand the on-line course of processing, we carried out a self-paced listening experiment with 28 nine year olds. The material included unambiguous RC (plus fillers): 24 SRC and 24 ORC. In each set, 12 RC included 2 animate NPs, (2) (SRCA) and (3) (ORCA), and 12 an animate S and an inanimate O, (4) (SRCI) and (5) (ORCI) resulting in a 2 x 2 design.

(4) i **pagliacci** che **stanno** bagnando il fiore, (lit. The clowns that are wetting the flower).
(5) il fiore che **stanno** bagnando **i pagliacci** (lit. the flower that are wetting the clowns).

Children were also asked a comprehension question. SRCA and SRCI were comprehended almost 100% correctly, ORCA 69% and ORCI 90%. Listening times were first corrected computing a linear regression for each child in which segment duration was regressed on listening time in ms (see Ferreira & Clifton, 1986; Booth et al. 2000) and then analyzed. We found an interaction between clause type (S/O) and animacy ($F1(1,24)=10,45$, $p<.005$; $F2(1,20)=9,22$, $p<.05$) at the auxiliary (stanno), which was read faster in SRCA than in ORCA. However, this effect is essentially due to those children who comprehended the ORCA correctly. No further effect was found at the verb (bagnando) and at the final NP and no effect of animacy.

We argue that children are guided by structural principles, such as De Vincenzi's (1991) Minimal chain principle and attempt to posit a gap at the embedded subject position. Number agreement on the auxiliary leads some of the children to revise the initial analysis. To gain more insight into children's difficulty with ORCA, we administrated a working memory test. Preliminary results show that children who engage in reanalysis receive high scores in memory tests, supporting Felser et al.'s hypothesis that differences among children lie outside the language processing system.

## References

Arosio, F., F. Adani & M. T. Guasti (2005) Children's processing of subject and object relatives in Italian, Paper presented at GALA, Siena.

Booth, J.R., MacWhinney, B., Harasaki, Y. (2000) Developmental differences in visual and auditory processing of complex sentences. Child development, 71:981-1003

Devescovi, A., A. D'Amico & Gentile (1999) The development of sentence comprehension in Italian: A reaction time study**.** *First Language*. 19: 129-163.

De Vincenzi M. (1991) Syntactic parsing strtaegies in Italian. Dordrecht:Kluwer.

Felser, C., T. Marinis and H. Clahsen (2003) Children's processing of ambiguous sentences: A study of relative clause attachment**,** *Language Acquisition.* 11:127-163.

Mak, Vonk & Schriefers (2002) The influence of animacy on relative clause processing. Journal of memory and language, 47:50-68.

**Language processing in children as measured using self-paced reading and listening**

Edward Gibson (MIT), Mara Breen (MIT), Susan Rozen (Boston University) & Douglas Rohde (Google)

egibson@mit.edu

This paper presents results from three pairs of self-paced listening and self-paced reading experiments investigating the nature of constraint interaction in sentence comprehension in children ages 12-15 (n=39). The first pair investigated subject- vs. object-extracted relative clauses as in (1), controlling for plausibility. The results of both listening and reading experiments demonstrated that object-extractions were processed slower than subject-extractions during the critical region, similar to results for adults (e.g., King & Just, 1991; Grodner & Gibson, 2005).

The second pair of experiments investigated the main-verb/reduced-relative ambiguity as in (2), manipulating three factors: ambiguity (ambiguous/unambiguous); subject-plausibility (plausible/implausible); and frequency of the reduced-relative as a past-participle (high/low) (cf. Ferreira & Clifton, 1986; Trueswell, Tanenhaus & Garnsey, 1994; Trueswell, 1996). The results of both listening and reading experiments demonstrated main effects of ambiguity in the disambiguating region, such that ambiguous items were processed more slowly than their unambiguous controls. Furthermore, there was a three-way interaction ($p<.005$) in the auditory experiment such that all pairs of conditions showed an ambiguity effect except the high-frequency implausible-subject conditions, similar to adult reading results from Trueswell (1996). Notably, there was no such three-way interaction in the reading: all four pairs of conditions showed a similarly strong ambiguity effect. Thus, there was a four-way interaction ($p<.01$) when presentation method (reading, listening) was included as a factor in the disambiguation. The results suggest that children are sensitive to the same factors as adults in language listening, but that the sentence word order cue dominates all other factors in reading.

The third pair of experiments investigated the NP/S-complement ambiguity as in (3), manipulating three factors: ambiguity (ambiguous/unambiguous); direct-object-plausibility (plausible-object/implausible-object); and verb subcategorization bias (DO-biased/EQ-biased/SC-biased) (cf. Ferreira & Henderson, 1990; Trueswell, Tanenhaus & Kello, 1993; Garnsey et al., 1997). The results indicated that there was an ambiguity effect in the reading experiment, but not the listening. Furthermore, verb subcategorization bias interacted with the ambiguity effect ($p<.01$) in the reading version, such that there was: no ambiguity effect for the SC-biased verbs, a medium-sized effect for the EQ-biased items, and a large effect in the DO-biased items (cf. similar results for adult readers, Garnsey et al., 1997). The plausibility of the direct object had no effect on ambiguity resolution. The lack of ambiguity effects in the auditory version of Experiment 3 may have been due to the fact that the ambiguity is not difficult to resolve (Sturt, Pickering & Crocker, 2001), and consequently there is time to resolve the ambiguity during the presentation of the auditory stimuli, in contrast to the visual presentation.

Overall, the results of auditory Experiments 1 and 2 demonstrate that children ages 12-15 are sensitive to the same factors as adults in language processing. The results from the three reading studies demonstrate that some cues are more important initially than others, notably syntactic structure and lexical frequency. Plausibility information appears not be used by maturing readers. We will discuss how these results impact theories of the development of constraint interaction in different language processing tasks.

**Materials (region-by-region display as shown)**

(1) Subject-/Object-extracted RC:
The_plumber who_frustrated_the_janitor / who_the_janitor_frustrated lost_the_key on_the_street.

(2) MVRR: (high-frequency past-part item shown)
The_thief / The_room (that_was) searched by_the_police was_dirty and_smelled_bad.

(3) NP-S: (DO-biased verb item shown)

Plausible object:
The_talented_photographer accepted (that_)the_money could_not be_spent_yet.

Implausible object:
The_talented_photographer accepted (that_)the_fire could_not have_been_prevented.

**The use of eye movements to study the development of spoken language comprehension**

John C. Trueswell (University of Pennsylvania)

trueswel@psych.upenn.edu

I will provide an overview of recent research that uses eye movements to investigate the development of spoken language comprehension. I'll outline the logic of this paradigm and briefly review some foundational studies (e.g., Swingley, Pinto & Fernald, 1999; Trueswell, Sekerina, Hill & Logrip, 1999). I'll then discuss some methodological issues, including issues of linking hypotheses, data analysis, and issues that arise when combining language, vision and action to study development. To do this, I'll focus on a particularly striking developmental phenomenon: young children's inability to revise initial parsing commitments. I'll discuss the generality of this finding cross-linguistically (Choi & Trueswell, forthcoming), as well as how it manifests itself in non-parsing domains (Epley, Morewedge, & Keysar, 2004; Novick, Thompson-Schill & Trueswell, 2005). I'll conclude by sketching a view of how the development of language processing fits within the broader context of cognitive development, especially the development of cognitive control abilities.

## References

Swingley, D., Pinto, J.P., and Fernald, A. (1999). Continuous processing in word recognition at 24 months. Cognition, 71, 73-108.

Trueswell, J.C., Sekerina, I., Hill, N.M. & Logrip, M.L. (1999). The kindergarten-path effect: studying on-line sentence processing in young children. Cognition, 73, 89-134.

Choi, Y. & Trueswell, J.C. (forthcoming). Putting first things last: Children's sentence parsing abilities in a head-final language.

Epley, N., Morewedge, C.K., & Keysar, B. (2004). Perspective taking in children and adults: Equivalent egocentrism but differential correction. Journal of Experimental Social Psychology, 40(6), 760-768.

Novick, J.M., Trueswell, J.C. & Thompson-Schill, S.L. (2005). Cognitive Control and Parsing: Reexamining the Role of Broca's Area in Sentence Comprehension. Cognitive, Affective, & Behavioral Neuroscience, 5, 263-281.

**Can children overcome lexical biases? The role of the referential scene**

Evan Kidd, Andrew Stewart, & Ludovica Serratrice (The University of Manchester)

evan.j.kidd@manchester.ac.uk

Eye-movement studies investigating children's parsing have shown that, unlike adults, 5-year-old children do not readily use information available in the referential scene to resolve either temporary (e.g., Trueswell, Sekerina, Hill, & Logrip, 1999) or global syntactic ambiguity (Snedeker & Trueswell, 2004). These results suggest two important features of children's parsing: (i) children pursue syntactic analyses by attending to the most reliable cues available in the input, and (ii) children are not very adept at reanalysing sentences for which they have pursued the incorrect syntactic analysis (cf. Meroni & Crain, 2003). The current study investigated both of these features of children's parsing in an eye-tracking experiment. Twelve children and 12 adults were presented with 'globally ambiguous' sentences like (1).

(1) Chop the tree with the leaves.

The test sentences pitted two cues against each other: (a) a strong verb bias for VP-attachment, and (b) the plausibility of the final NP (the leaves) as a potential instrument. Although technically ambiguous, the PP in (1) should be resolved by plausibility information as a noun modifier. Participants were required to act out the sentence using toy props; their eye-movements to these props were recorded. Participants were presented with a two-referent scene: for sentence (1) there were two trees (one with leaves, one without), an axe (plausible instrument), and some leaves (implausible instrument). If children rely more on the lexical bias of the verb to parse the sentence they should be garden-pathed. On the other hand, following Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy (1995), adults should not be garden-pathed because they can incorporate referential scene information into their parse. Crucially, the experiment allowed us to investigate reanalysis effects: the implausibility of the VP-attachment analysis makes reanalysis more likely if children are capable of incorporating real world information into their parse.

The dependent variable was the proportion of looks to each referent over time. The children and adults parsed the sentences differently. Both groups looked proportionately longer to the plausible instrument at the preposition with than to the other three referents. These constitute anticipatory eye-movements to objects that hold real-world affordances with the semantics of the verb (Altmann & Kamide, 1999). For children this effect persisted to the end of the sentence. However, after the preposition the adults did not look significantly longer at the plausible instrument; their pattern of eye movements suggested that they were aware of the ambiguity and delayed attachment until the end of the sentence. The on-line data was supported by the off-line act-out data: children made more 'incorrect' instrumental interpretations than did the adults (i.e., chopped a tree using the leaves). The results suggest that children were garden-pathed by the strong bias of the verb; a rapid association of verb and instrument activated a VP-attachment analysis. The results provide support for an account of parsing in development where children parse sentences by first attending to the most reliable cues to interpretation, even if doing so results in an incorrect interpretation. Children's ability to renanalyse sentences is considered in light of further off-line data collected in our lab.

**References**

Altmann, G. & Kamide, Y. (1999). Cognition.

Meroni, L., & Crain, S. (2003). Proceedings of BUCLD-27.

Snedeker, J. & Trueswell, J. C. (2004). Cognitive Psychology.

Tanenhaus, M., Spivey-Knowlton, M., Eberhard, K., & Sedivy, J. (1995). Science.

Trueswell, J. C., Sekerina, I., Hill, N. M., & Logrip, M. L. (1999). Cognition.

**Putting first things last: A cross-linguistic investigation of the developing sentence processing mechanic**

Youngon Choi & John C. Trueswell (University of Pennsylvania)

youngonc@sas.upenn.edu

Five-year-old English-speaking children show strong sensitivity to lexical constraints but not to reference-to-scene constraints in structural ambiguity resolution. For instance, when hearing Put the frog on the napkin into the box children interpret on the napkin as a goal rather than a modifier even when two frogs are present (Trueswell et al., 1999). One explanation is that verb information plays a special role in proposing structure, especially in child parsing. Alternatively, verb priority may be related to the distribution of parsing-relevant information in English sentences: verbs arise early and even sentence-initially in imperatives.

The present study explores this issue by examining child parsing in Korean, a head-final language in which the distribution of morphological/lexical constraints is opposite of English. In spoken Korean, “napkin-[e] frog-acc put/pickup” (Put/pickup the frog on the napkin) contains a temporary ambiguity because -[e] is ambiguous between the genitive and locative case-marker. Thus, napkin-[e] can be a modifier of frog-acc or a goal of the upcoming verb. For these items, morpho-syntactic constraints (syntax/semantics associated with the case-marker) become available earlier than other constraints including referential or prosodic information, with verb information arriving last. Thus, case-marker information has a temporal advantage over verbs. Corpus analyses show that the locative use of the ambiguous [e] marker is much more common than the genitive use. This preference for locative interpretation predicts that upon hearing napkin-[e], Korean listeners will initially consider the goal interpretation and anticipate verbs such as put. Consequently, verbs such as pickup will require a revision of napkin-[e] as an NP modifier rather than a goal. In fact, Korean children may fail to revise this initial commitment and perform goal-related actions even for pickup.

Fifteen 3-4-year-old and 4-5-year-old children and sixteen adults participated in a world-situated eye-tracking study. Eye-gaze and action patterns were recorded while participants heard the temporary ambiguous instruction such as “napkin-[e] frog-acc…” that ended either with put or pickup (see examples). The scenes were always 2-referent and contained a frog on a napkin (Target), a frog in a bowl (Competitor), an empty napkin (Goal), and a giraffe in a basket (Unrelated).

With put-instructions, children and adults were alike in their action and eye-fixation pattern. However, with pickup-instructions, both groups of children made errors, carrying out goal-related actions such as moving either of the frog onto the empty napkin (57% and 34%, respectively). I.e., they interpreted napkin-[e] as a goal and couldn’t revise this initial analysis according to the late-arriving verb information. This interpretation pattern was also reflected in their eye data: children and adults initially looked to the empty napkin upon hearing napkin-[e] but only adults blocked further consideration of the empty napkin at pickup (i.e., children returned to the empty napkin upon hearing pickup).

These results resemble the pattern of the English study in that children rely most on the earliest-arising potent constraints on structure (verb constraints in English and case-marker constraints in Korean). Furthermore, the results support the idea that the parsers are underlyingly universal, in that they reflect a developing constraint-satisfaction system.

**Examples**

Ambiguous: “napkin-[e] frog-acc put.” or “napkin-[e] frog-acc pick up.”
(Put the frog on the napkin or Pick up the frog on the napkin.)

Unambiguous: Napkin-[e]-that’s frog-acc pick up.
(Pick up the frog that’s on the napkin.)
Napkin-[e] frog-acc put (no empty napkin present in the scene)
(Put the frog on the napkin.)

**Table 1.** Proportion of NP-attachment and VP-attachment action type of each age group.

| | | Unambiguous | | Ambiguous | |
|---|---|---|---|---|---|
| | | Pickup | Put | Pickup | Put |
| 3-4 years | NP action | 59% | 4% | 43% | 3% |
| | VP action | 41% | 96% | 57% | 97% |
| 4-5 years | NP action | 90% | 0% | 66% | 6% |
| | VP action | 10% | 100% | 34% | 94% |
| Adults | NP action | . | . | 100% | 0% |
| | VP action | . | . | 0% | 100% |

**Spoken-word recognition in Russian preschoolers**

Irina Sekerina (College of Staten Island & Graduate Center, CUNY)

sekerina@mail.csi.cuny.edu

Eye-tracking studies in English found that when the onsets of two words are identical, adults' fixations of the target word are delayed in the presence of its phonological cohort (Allopenna et al., 1998). Swingley et al. (1999) showed that 2-year-old infants also exhibit a similar cohort effect with a restricted set of spoken materials. The present experiment investigates the gap in developmental progression in spoken-word recognition from 2 year-olds to adults by using free-viewing eye-tracking with 5-and 6-year-old children. We sought to overcome methodological limitations of the Swingley et al.'s study (the preferential looking task, absence of fine-grained data, and the materials with only four target nouns) and employed adult-like design and materials to analyze both coarse- and fine-grained eye movement data.

Thirty-two Russian preschoolers viewed a computer display showing 4 pictures of familiar objects and clicked on them. In half of the 24 trials (the Cohort condition), the names for the 2 of the pictures started with an identical three-phoneme onset (bant 'bow' - Target, banka 'jar' - Competitor); in the other half (the NoCohort condition), the names for all of the pictures were different (vilka 'fork' - Distractor). The target was embedded in a carrier phrase, 'Show where the bow is here'. Our coarse-grain eye movement data (i.e., percent of trials with eye movements to Competitor in the Cohort condition vs. Distractor in the NoCohort condition) revealed that the pattern of eye movements of preschool children was different from those of infants and Russian adults (Marian & Spivey, 2003). While there was a significant difference in the percent of trials (18% Competitor vs. 7% Distractor) for the adults, Russian preschoolers equally often considered Competitor (65%) and Distractor (69%). However, their fine-grained eye movements did reveal the cohort effect not found in the coarse-grain data. The children were significantly faster in launching their first eye movement to Target in the NoCohort (at 627 ms from the onset of the Target) than in the Cohort condition (at 823 ms), $F1 = 6.01$, $p < 0.02$; $F2 = 5.83$, $p < 0.03$. This disadvantage for the Cohort condition stemmed from competition between Target and Competitor and persisted throughout the trial resulting in 200 ms longer clicking RTs for the Cohort vs. NoCohort conditions (4965 vs. 4763 ms). Analysis of time-course of the cohort competition at 33-ms intervals showed that divergence of the looks between Target and Competitor/Distractor occurred 250 ms faster in the NoCohort condition than in the Cohort condition.

Thus, while the preschoolers show adult-like continuous interpretation of spoken input revealed by the cohort effect in fine-grained eye movement dynamics, they make many more eye movements than adults irrespective of presence or absence of the cohort competitor (Nation et al., 2003). In contrast to the preferential-looking findings with infants, the cohort effect in eye movements of older children is very robust: It persisted even under the serious adult-like task demands, and generalized over a wide variety of Russian nouns with different onset types and less familiar words.

**References**

Allopenna, P., Magnuson, J., & Tanenhaus, M. (1998). Tracking the time course of spoken word recognition using eye movements: Evidence for continuous mapping models. Journal of Memory and Language, 48, 419-439.

Marian, V., & Spivey, M. (2003). Competing activation in bilingual language processing: Within- and between language competition. Bilingualism: Language and Cognition, 6(2), 97-115.

Nation, K., Marshall, C. M., & Altmann,G. T. M. (2003). Investigating individual differences in children's real-time sentence comprehension using language-mediated eye movements. Journal of Experimental Child Psychology, 86, 314-329.

Swingley, D., Pinto, J., & Fernald, A. (1999). Continuous processing in word recognition at 24 months. Cognition, 71, 73-108.

**The processing of sentences containing the focus particle *auch* by German adults and 4-year-olds: An eye-tracking-Study**

F. Berger (University of Potsdam), A. Müller (Humboldt University Berlin), B. Höhle (University of Potsdam) & J. Weissenborn (Humboldt University Berlin)

berger@ling.uni-potsdam.de

Focus particles like only and also signal that one of the constituents of the sentence they appear in is contrasted against a set of alternatives given in the discourse model. Sentence (1) is true if there are no other people than Ken owning a car while (2) is true if Ken owns nothing but a car. The identification of the constituent for which a set of alternatives has to be constructed (domain of application) depends on positional and prosodic information. Previous studies found that children up to 12 years of age still have difficulties comprehending sentences containing focus particles [e.g. 1; 2]. This late receptive mastery of focus particles stands in contrast to their production already in the first multi-word utterances [3; 4] suggesting that the acquisition of focus particles could be an instance of an unusual pattern of productive knowledge preceding interpretative knowledge [5].

We will present the results of a study on German 4-year-olds' interpretation of sentences containing the focus particle auch (engl. also) questioning this suggestion. In contrast to off-line methods used in previous experiments we used an eye-tracking paradigm that allows tracking the processing of the input without the need of any conscious reaction by the child. The sentences contained the focus particle auch (engl. also) postverbally (see example 3). If the subject (Tobi) is the domain of application of the particle auch in sentence (3) the particle itself is stressed, meaning There are other people than Tobi owning a car. In contrast, if the object (ein Auto) is the domain of application the object is stressed and the particle is unstressed, meaning Tobi owns a car besides other things.

Subjects were presented with sentences containing a stressed particle, sentences containing an unstressed particle and sentences without any focus particle. As visual stimuli, two children (a boy and a girl) were displayed on a monitor (see figure 1). One child had one object (e.g. a doll), the other child had two objects, one of them being identical to the other child's (e.g. a doll and a duck). The child with the two objects appeared as subject in all sentences.

We hypothesized that presenting a sentence with a stressed particle should result in a higher proportion of fixations of the child not mentioned in the sentence and the object associated to her than presenting a sentence that contains a non-stressed focus particle or no focus particle at all.

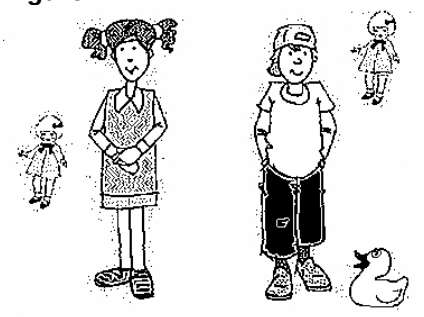
Preliminary results of 14 children are in line with our prediction. We found significantly longer fixations of the side where the alternative set is presented in sentences containing the stressed focus particle as compared to sentences with unstressed focus particles or with no focus particles at all. These results exactly mirror those of a control group of students.

Our findings point to better comprehension performance for sentences with focus particles for children as young as 4 years than indicated by previous studies. This suggests that previously used off-line techniques underestimate children's capacities in this area.

**Examples**

(1) Only Ken has a car.
(2) Ken only has a car.
(3) Tobi hat auch ein Auto.
(Tobi also has a car).

**Figure 1.**



**References**

[1] Gualmini, A.; Maciukaite, S. & Crain, S. (2003). Children's insensitivity with contrastive stress with ONLY. Penn Working Papers in Linguistics 8.1., 87-110.
[2] Paterson, K.; Liversedge, S.; Rowland, C. & Filik, R. (2003). Children's comprehension of sentences with focus particles. Cognition 89, 263-294.
[3] Nederstigt, U. (2001). The acquisition of additive "focus particles" in German. A. H.-J. Do et al., BUCLD 25 Proceedings, Sommerville, MA: Cascadilla Press, 554-565.
[4] Penner, Z.; Tracy, R. & Weissenborn, J. (2000). Where scrambling begins: Triggering object scrambling at the early stage in German and Bernese Swiss German. In C. Hamann & S. Powers (eds.) The Acquisition of Scrambling and Cliticization. Dordrecht: Kluwer, 127-164.
[5] Hüttner, T.; Drenhaus, H.; van de Vijver, R. & Weissenborn, J. (2004). The acquisition of the German focus particle auch 'too': Comprehension does not always precede production. In: BUCLD 28: Proceedings of the 28th annual Boston University Conference on Language Development. On-line Supplement.

**Using structural priming to investigate children's early grammatical representations**

Malathi Thothathiri & Jesse Snedeker (Harvard University)

malathi@wjh.harvard.edu

There is a longstanding debate in the literature about the nature of children's early grammatical representations. Are early grammatical rules lexically-specific, with generalizations emerging gradually over childhood (Tomasello, 2000)? Or are children's initial generalizations of roughly the same grain as adults', bridging lexical items and employing syntactic primitives (Fisher, 2002)? Experimental studies that test generalization to novel verbs are subject to two problems. First, children may fail because it is difficult to learn the meaning of a novel verb from a visual scene. Second, children may succeed only because they analogize based on known verbs in a difficult learning situation. In contrast, structural priming allows us to study children's use of known verbs under experimental conditions. If children have only lexically-specific representations, priming should occur only when two utterances have high lexical overlap. In contrast, priming across lexical items is evidence for abstract representations. Previous production-priming studies have found contradictory results with 4-year-olds, and 3-year-olds (Song & Fisher, 2004; Gamez, et al., 2005). Using eye-tracking, we examined priming during comprehension instead, for three reasons. First, comprehension measures may be more sensitive to children's linguistic knowledge. Second, we can observe whether priming unfolds predictively and thereby rule out alternate explanations such as discourse-matching. Third, convergent evidence from a different method can bolster one or the other view of children's representations.

Children followed recorded instructions involving sets of toys while we videotaped their eye-movements. Within each block, they heard two prime sentences followed by a target sentence. Primes were either double-object (DO: Give the lion the ball) or prepositional-object (PO: Give the ball to the lion) datives. The target was either the same or different kind of dative as the primes, resulting in four experimental conditions: DO-DO, DO-PO, PO-DO, PO-PO. The target sentences were temporarily ambiguous: the initial part of the first noun (bird…) could refer to either the recipient (DO: Give the bird the dog bone) or the theme (PO: Give the birdhouse to the sheep). To determine subjects' interpretations, we calculated the proportion of looks to the potential theme (birdhouse) after noun-onset.

Experiment I examined within-verb priming in 4-year-olds (M=4;1). Both prime and target sentences used give. An ANOVA (Prime-Type x Target-Type) revealed a significant effect of prime-type ($N = 20$. $F(1,16) = 12.887$; $p<0.01$). Children primed with PO datives looked at the potential theme more than those primed with DO datives, irrespective of the target-type. Experiment II examined across-verb priming in 4-year-olds (M=4;0). Prime and target sentences contained different verbs (Prime: show/bring; Target: give). Again, an ANOVA revealed a significant effect of prime-type ($N = 38$. $F(1, 34) = 6.754$; $p<0.02$).

In Experiment III, we extended these priming results to 8 dative verbs other than give, and to younger children (M=3;1. $N = 32$. $F1(1,28) = 7.858$; $p<0.01$. $F2(1,28)=8.928$; $p<0.01$).

These experiments demonstrate across-verb priming in young children for a variety of dative verbs. They show that 3- and 4-year-olds have abstract representations of verbs and that they use these representations during online processing of known verbs.

**References**

Fisher, C. (2002) Structural limits on verb-mapping: The role of abstract structure in 2.5-year-olds' interpretations of novel verbs. Developmental Science, 5(1), 55-64.

Gamez, P. B., Shimpi, P. M. & Huttenlocher, J. (2005) Emerging syntactic representations as evident through priming. Poster presented at the 2005 SRCD Biennial Meeting, Atlanta, GA.

Song, H.-J. & Fisher, C. (2004) Syntactic priming in 3-year-old children. Paper presented at the 29th Annual Boston University Conference on Language Development, Boston, MA.

Tomasello, M. (2000) The item-based nature of children's early syntactic development. Trends in Cognitive Sciences, 4(4), 156-163.

**Event-related brain potentials as a window to children's language processing: From syllables to sentences**

Angela D. Friederici (Max Planck Institute for Human Cognitive and Brain Sciences)

orendi@cbs.mpg.de

A central question of language acquisition is whether it proceeds in a continuous or discontinuous manner. Behavioral studies have provided evidence for either view. The use of event-related brain potential (ERP) measures may help to answer this question, as there are particular ERP components that have been related to different aspects of language processing and their temporal course in adults. A particular ERP component reflecting the discrimination of phonological features is already present in newborns and allows the investigating of language development during the first months of life. The N400 component reflecting lexical-semantic processes in adults can be observed in 14 months old children when processing their first words and can thus be used to investigate word recognition and the processing of lexical-semantic relations between verbs and their arguments in sentences. Within the syntactic domain an adult-like biphasic ERP pattern (ELAN-P600) is observable by the age of 32 months for the processing of structural dependencies within phrases and shortly after that an adult-like ERP pattern is found for syntactic dependencies between phrases, e.g., subject-verb agreement. These ERP patterns are sometimes delayed as compared to the adult ERPs, although their relative timing matches that of the adults' ERPs. That is, local phrase structure building precedes lexical-semantic processes and thematic role assignment. Thus, the combined results are in support of a continuity view of language development.

**Word recognition in continuous speech by 7-month-old infants**

Valesca Kooijman (F.C. Donders Centre for Cognitive Neuroimaging, Max Planck Institute for Psycholinguistics), Peter Hagoort (F.C. Donders Centre for Cognitive Neuroimaging) & Anne Cutler (Max Planck Institute for Psycholinguistics)

valesca.kooijman@fcdonders.ru.nl

An important step in language acquisition is learning to segment words from continuous speech. Behavioral studies have shown that infants between 7 and 10 months of age listen longer to continuous speech containing a word they have recently heard in isolation, suggesting that they can segment the familiar word from the speech surrounding it. Early on, Dutch (and English) infants seem to make use of the trochaic stress pattern of their native language to do this. Later, other cues in the language start playing a role as well.

In a previous ERP study, we demonstrated word segmentation abilities in 10-month-old infants (Kooijman, Hagoort & Cutler, 2005). The ERP paradigm we used consists of a Familiarization and Test phase. In each Familarization phase, infants were presented with ten tokens of the same bisyllabic trochaic word (e.g. serre, ‘conservatory’). Immediately following each Familiarization phase, infants heard eight sentences, of which four contained the familiarized word. The remaining four sentences contained a different word with similar structure (e.g. krekel ‘cricket’). Ten-month-olds show a clear ERP repetition response during the Familiarization phase. Further, in the Test phase they initiated a differential response to the familiarized words (in comparison to the unfamiliarized words) by halfway into the critical word in the sentence. Here we present data from a study with 7-month-old infants, and compare the electrophysiological responses of the 7- and 10-month-olds.

This study used the same materials and procedure as the study with 10-month-olds. In the Familiarization phase, the 7-month-olds showed an electrophysiological response to the isolated words similar to that of the 10-month-olds: a negative, frontally distributed, repetition effect in the 200-500ms latency range. Even though peak latency of the N2 and P350 were slightly delayed, the ERP repetition effect to the isolated words was similar in both latency and distribution. In the Test phase, the 7-month-olds also showed a different response to familiarized and unfamiliarized words. However, in this case the response differed from that of the 10-month-olds. Contrary to our expectation based on behavioral studies with Dutch infants as well as our 10-month-old data, a repetition effect appeared as early as 350 to 450 ms. However, this repetition effect had a positive polarity and a frontal distribution, unlike the repetition effect the 10-month-olds showed in the sentences. In a slightly later time window, starting at about 475ms, the 7-month-olds showed a left-lateralized negative repetition effect, more similar to what was observed in the 10-month-olds.

Thus even though the electrophysiological response of the 7- and 10-month-old infants to the isolated words is highly similar, different processes seem to be involved at the sentence level. This may suggest that 10-month-olds are able to combine different cues in the language to initiate word segmentation whereas 7-month-olds, although to some extent sensitive to the same cues, are not able to combine them and may rely more on the stress cue alone.

**References**

Kooijman, V., Hagoort, P., & Cutler, A. (2005). Electrophysiological evidence for prelinguistic infants’ word recognition in continuous speech. Cognitive Brain Research, 24, 109-116.

**Processing of sentence-level prosody in 4-year-old children: ERP responses to intonational phrasing**

Claudia Maennel, Ann Pannekamp & Angela D. Friederici (Max Planck Institute for Human Cognitive and Brain Sciences)

maennel@cbs.mpg.de

Previous event-related brain potential (ERP) studies on sentence-level prosody in adults revealed on-line parameters for the processing of intonational phrases (e.g., Steinhauer et al., 1999). These studies discovered a so-called Closure Positive Shift (CPS) that occurs at the boundary of intonational phrases (IPh) (Selkirk, 1984). In children, behavioral studies demonstrated the importance of prosodic cues in language acquisition, enabling them to segment the incoming speech stream into structural units (see Jusczyk, 1997). The aim of our study was to examine on-line measures of sentence-level prosodic processing in 4-year-old children by means of ERP.

In particular, we sought to answer the following questions: First, do normally developing children show ERP responses following IPh boundaries and, if so, are these ERP patterns similar to those obtained in adults? Second, are there ERP differences in the processing of intonational phrases between normally developing children and children with problems in their language development, as determined by the German language development test (SETK-2; Grimm, 2000)?

While an EEG was recorded, children passively listened to active German sentences of two types: sentences that were constructed of two intonational phrases (containing one IPh boundary), e.g., Lena promises Mama to run /IPh 1/ and to buy drinks /IPh 2/, and sentences that consisted of three intonational phrases (containing two IPh boundaries), e.g., Lena promises /IPh 1/ to help Mama /IPh 2/ and to buy drinks /IPh 3/. For normally developing children, ERP analyses revealed the expected CPS in correlation to the IPh boundaries. However, these shifts were somewhat delayed and exhibited a more posterior distribution as compared to the adult data. In contrast to the normally developing children, children with a previously determined risk for language impairment demonstrated a lack of the expected CPS effects. Most importantly, besides their language problems, these children did not have any neurological, sensory, or physical deficits.

The present study provides on-line measures for children’s processing of prosodic cues at sentence level. Similar to adults, children showed positive shifts in response to IPh boundaries, which lends further support to the notion that prosodic information is used to segment the language input at different developmental stages. The fact that children with problems in language acquisition do not exhibit the ERP effects associated with the processing of intonational phrasing suggests that at least a subgroup of language-impaired children suffers from an inability to process suprasegmental prosodic information in a normal manner.

**Exploring the relationship between environment, proficiency, and brain organization for language in children from different socioeconomic backgrounds**

Eric Pakulak and Helen Neville (University of Oregon)

pak@uoregon.edu

Previous event-related potential (ERP) research has identified components related to semantic processing (N400) and syntactic processing (LAN/P600) in both adults (e.g., Neville et al., 1991; Hahne, Pfeifer, & Friederici, 1993; Hagoort & Brown, 1994) and children (Hahne, Eckstein, & Friederici, 2004; Harris, 2000), as well as an index of speech segmentation (Word Onset Negativity) in adults (Sanders & Neville, 2004) and children (Sanders et al., 2006). Evidence from adults suggests that ERPs reflect differences in brain organization for language processing related to individual differences in proficiency in adult monolingual native speakers (Pakulak & Neville, submitted). This raises the working hypothesis that the effects of experience in childhood may endure into adulthood. We will present evidence from an ongoing ERP study of language processing in 3-8 year-old children which seeks to shed further light on the effects of experience on language development. In this study, ERPs were elicited, using an auditory sentence processing paradigm, from children from different socioeconomic status (SES) environments and, for some, before and after an 8-week focused intervention. Our preliminary results suggest, consistent with much behavioral evidence (e.g., Noble, McCandliss, & Farah, 2004), that children from lower SES families have reduced linguistic abilities compared to children of the same age from higher SES families, and further that these behavioral differences are reflected in different neural organization for language. Our results also suggest that focused intervention might enhance certain language subsystems in 3-5 year-old children.

**ERP investigations in typically developing and language-impaired children reveal a domain-specific neural correlate for syntactic dependencies**

Heather K. J. van der Lely (University College London) & Elisabeth Fonteneau (Goldsmiths College, University of London)

h.vanderlely@ucl.ac.uk

Electrophysiological, event-related measurements can differentiate neural systems that appear to be automatic, fast and specific to grammatical (syntactic) processing— "Early Left-Anterior Negativity (ELAN)[1] -- from systems not specific to grammar or even language; such as an anterior or central positive response around 600 ms (P600), often associated with structural syntactic re-analysis of sentences[1-4] and a posterior negative electrical response around 400 ms (N400) associated with semantic processing[5]. We used this technique to differentiate neural systems associated with sentence processing in children. We show how investigating typically developing (TD) children alongside children with specific language impairment (SLI) provide insight that is not possible when investigating one population alone. Further, we discuss particular methodological issues related to testing young children and teenagers using ERP techniques.

The study aims to 1) provide insight into the underlying nature of language processing mechanisms in children; 2) identify whether a particular language processing mechanism can be developmentally impaired alongside residual normality of other mechanisms; 3) test the computational grammatical complexity (CGC) hypothesis that Grammatical-specific language impairment (G-SLI) children's syntactic deficit is with structural syntactic dependencies incurring "Movement"[6].

G-SLI is a disorder of language acquisition- specifically grammatical acquisition[6]. These individuals with G-SLI continue to make grammatical errors into adulthood[6]. Some researchers claim that G-SLI is caused by a domain-general deficit in auditory processing speed or capacity[7,8], whereas others claim that the impairment is to a domain-specific system devoted to grammar itself[6]. Thus, the nature of G-SLI can elucidate whether neural circuitry subserving grammar is common to human cognition or unique to language.

We presented 18 10-21 year-old participants with G-SLI, 18 age matched, and 20, 7-9 year-old language control groups with questions containing syntactic violations and sentences containing semantic violations. We manipulated the animacy property of the first noun following a verb so that in Experiment 1 it created the syntactic violation, and Experiment 2 the semantic violation. We found evidence for a selective impairment to grammatical processing in G-SLI. The brain's automatic detection response to syntactic violations, reflected electrically as the ELAN, was elicited in all control groups, but not the G-SLI group. In contrast to the controls, the G-SLI participants exhibited an N400 to the syntactic violations, indicating that they were compensating for their syntactic deficit semantically. However, the G-SLI group, like the control groups, exhibited a normal P600 to the syntactic violations and an N400 to semantic violations. Our results, showing dissociation between the ELAN (missing) and P600 (normal) when processing the same word in a sentence in the G-SLI individuals, strongly indicate that these two components reflect different computations in syntactic processing[1]. These data provide an objective measure for a developmental, domain-specific grammatical deficit alongside residual normality of systems underlying other language related abilities. The findings indicate that at least one neural circuitry associated with grammar is a developmentally unique system in the functional architecture of the human brain.

## References

1. Friederici, A. D. Toward a neural basis of auditory sentence processing. Trends in Cognitive Sciences 6, 78-84 (2002).
2. Kaan, E. & Swaab, T. Y. Repair, revision, and complexity in syntactic analysis: An electrophysiological differentiation. Journal of Cognitive Neuroscience 15, 98-110 (2003).
3. Kutas, M. & van Petten, C. K. in Handbook of Psycholinguistics. (ed. Gernsbacher, M. A.) 83-143 (Academic Press, San Diego, 1994).
4. Hagoort, P., Brown, C. & Osterhout, L. in The neurocognition of language (eds. Brown, C. & Hagoort, P.) 273-316 (Oxford University Press, Oxford, 1999).
5. Kutas, M. & Hillyard, S. A. Reading senseless sentences: brain potentials reflect semantic incongruity. Science 207, 203-205 (1980).
6. van der Lely, H. K. J. Domain-specific cognitive systems: Insight from Grammatical specific language impairment. Trends in Cognitive Sciences 9, 53-59 (2005).
7. Bishop, D. V. M. Uncommon understanding: Comprehension in specific language impairment (Psychology Press, Hove, 1997).
8. Joanisse, M. & Seidenberg, M. Specific language impairment: a deficit in grammar or processing? Trends in Cognitive Sciences 2, 240-247 (1998).

**Speech perception recruits frontal cortex during a pivotal period of language acquisition**

Elizabeth Redcay (University of California San Diego), Frank Haist (University of California San Diego), Eric Courchesne (University of California San Diego & Children's Hospital Research Center San Diego)

elizabeth@brain.ucsd.edu

A pivotal period in the development of language occurs in the second year of life, the toddler years, when language comprehension undergoes rapid acceleration. We investigated the neural basis of speech comprehension in this critical age period by measuring functional magnetic resonance imaging (BOLD) activity during passive speech comprehension in toddlers and older children (3 year olds) during natural sleep. Three year olds were chosen as children at this age are no longer experiencing a 'vocabulary burst', but are still young enough to be studied under natural sleep methods. The toddler group (n=10) ranged in age from 13 to 24 months (mean±SD; 21±4 mo), and the older child group ranged in age from 35 to 44 months of age (39±3 mo). During sleep, the children were presented passages of forward and backward speech in 20-second blocks separated by 20-second periods of no sound presentation. Two types of forward speech were presented: one with short sentences containing simple, high-frequency words (simple speech) and one with longer sentences containing a greater proportion of low frequency words (complex speech). Both groups were presented with stimuli after approximately 50 minutes of sleep, and thus we estimate that they are in comparable sleep stages. We found activation in classic adult receptive language regions within temporal cortex in response to both forward speech conditions in both toddlers and older children. However, only toddlers utilized left inferior and medial frontal cortex during speech-specific processing (i.e. forward vs. backward speech comparison). Additionally, in response to speech (as compared to rest), toddlers showed a greater extent of activation than older children within an extended number of brain regions including frontal, occipital, and cerebellar regions. Contrasts between simple and complex speech revealed greater activation within basal temporal areas (BA 37 & 19) for complex speech at both ages; these regions are known to play a role in semantic processing in the adult brain. While activity in these inferior temporal regions was bilateral in toddlers, it was left lateralized in the older children. Our results suggest that rapid language acquisition during the second year of life is not accounted for by classical superior temporal language areas alone, but instead appears to result from the developmental emergence and utilization of frontal cortical functions as well as other brain regions. These findings provide some support for the hypothesis that multiple neural functional systems support language acquisition. Moreover, the results are consistent with the interactive specialization hypothesis, which proposes that behavior emerges from the interaction of brain regions that include and extend beyond those used by an adult.

**Online speech processing efficiency in infancy is related both to vocabulary growth and to school-age language accomplishments**

Virginia A. Marchman & Anne Fernald (Stanford University)

marchman@psych.stanford.edu

Over the 2nd and 3rd years, children become increasingly efficient in understanding spoken language. In same period when children experience rapid growth in lexical production, they also become faster and more reliable at interpreting speech in real-time and more challenging contexts. Researchers have speculated about how receptive language competence is linked to advances in linguistic knowledge, but the nature and direction of these interactions are not well-understood. While some cross-sectional studies found correlations between speech processing efficiency and vocabulary size (e.g., Fernald et al. 2001; Zangl et al., 2005), others have not (Swingley & Aslin, 2002). When and how do developmental increases in processing efficiency influence lexical and grammatical development? Here we explore the potential of two different kinds of research design to elucidate this question: 1) longitudinal designs with English- and Spanish-learning children exploring online measures in relation to traditional measures of lexical and grammatical competence, concurrently and at later ages; 2) cross-sectional designs manipulating task complexity to determine which kinds of linguistic processing challenges reveal associations between processing efficiency and vocabulary size at different ages.

We first report a longitudinal study of speech processing and language abilities in English-learning infants (n = 63) at 15-, 18-, 21- and 25-months. Eye-movements were video-recorded as infants looked at pictures while listening to speech naming one of the pictures, and then coded frame-by-frame (33 ms). Individual growth curve analyses (HLM) indicated that children who responded more quickly and accurately at 25 months demonstrated faster and more accelerated rates of growth in reported vocabulary (see Figure 1). Parallel results were found removing trials for which children did not "understand/say" the stimulus words; thus, these findings are not explained by the fact that older children "knew" more target words, but reflected direct links between rates of vocabulary growth and children's efficiency in online language processing. In a follow-up study at age 8 years, 29 children from this sample were assessed using standardized measures of cognitive and language skills. Mean RTs of these children when tested as infants were highly correlated with later performance on both CELF-4 (r = -.52 to -.55) and K-ABC-II (r = -.43 to -.70), with RT scores accounting for unique variance ($r^2$-change: 19-32%) over reported vocabulary. These findings reveal substantial long-term continuity in the skills used in early spoken language processing and those that underlie cognitive and linguistic skills in later school years. A parallel longitudinal study with Latino children learning Spanish is now in progress.

Cross-sectional designs provide another powerful strategy for investigating how speech processing efficiency relates to lexical development. Such studies show that associations between vocabulary and processing efficiency vary with stimulus complexity: e.g., with 28-month-olds we find ceiling effects with simple sentences (Where's the dog); however, with more complex stimuli requiring semantic integration of content words (Find the big dog), RT is strongly related to vocabulary size. Thus longitudinal and cross-sectional designs both reveal robust concurrent and/or long-term relations between speech processing efficiency and the emergence of linguistic skills, underscoring the importance of incorporating processing factors into theories of language learning.

**Learning to listen ahead in English and Spanish:**
**Infants use multiple linguistic and non-linguistic cues in online sentence interpretation**

Anne Fernald, Renate Zangl, Kirsten Thorpe, Nereyda Hurtado, Casey Williams (Stanford University)

afernald@stanford.edu

Extensive research on early segmentation abilities (e.g.,Jusczyk, Saffran) and the shaping of phonological categories through linguistic experience (e.g.Kuhl, Werker) shows that infants are becoming "native listeners" in the first year, months before words are perceived as meaningful. However, less is known about the further development of these language-specific processing strategies, as the child begins to listen for meaning in the second year. How do children learn to listen efficiently, using their growing knowledge of language and the world to take advantage of multiple linguistic and non-linguistic cues in interpreting spoken language? Here we explore both methodological challenges and theoretical insights emerging from a cross-language research program designed to investigate this question. Using eye-tracking measures of spoken language understanding, we explore online processing by both English- and Spanish-learning children.

First we describe what was involved in establishing a new research facility to work with children learning Spanish as a first language. Because Latino families living near the university were unable or reluctant to visit our campus laboratory, we set up a separate lab in a neighboring community of families recently immigrated from Mexico. Here we are conducting experimental studies with monolingual and bilingual Spanish-learning children from 18-months to 4-years, along with observational research on parental speech in Spanish.

Next we present findings from two series of studies exploring how children exploit language-specific cues in online interpretation. One series focuses on morphosyntactic cues in word recognition. While English articles reveal little about the subsequent noun, Spanish articles are gender-marked. Spanish-learning 3-year-olds take advantage of this cue, identifying the referent significantly faster on Different-gender trials than on Same-gender trials, i.e. when target and distracter differ in gender and the article is thus informative. The second series focuses on semantic integration of adjectives and nouns in both languages. Integrating prenominal adjectives (red car) is at first challenging for young English-learners, because the child must hold the property term in mind until the noun class is identified. In contrast, Spanish adjectives are postnominal, enabling the Spanish-learning child to identify the object category first and then interpret the property term, an apparently less difficult integration task.

Finally, we consider implications of the confound in our research between language and SES. The monolingual English-speaking children in our studies come from affluent and highly educated families, while the Spanish-speaking children come mostly from very poor families with minimal schooling. Our primary goal is to track the development of speech processing efficiency within each language group, not to make direct comparisons between such different populations, and indeed we find parallel age-related changes in processing efficiency in English- and Spanish-learning children. However, we also find differences too striking to ignore, with high-SES children showing more rapid development of online processing skills than low-SES children. We conclude with a discussion of how SES factors including particular features of parental language input may influence the emergence of early processing efficiency, another dimension of the overarching question of how early language experience contributes to the development of competence in language understanding.

## Uncovering early grammatical knowledge: Different methods and measures capture specific aspects of infants' linguistic processing competence

Yarden Kedar (Cornell University)

yek2@cornell.edu

Focusing on children's acquisition of Functional Categories (FC) – the grammatical elements such as conjunctions (e.g., and), determiners (e.g., the) and inflectional morphemes (e.g., -ed) – this paper demonstrates the close relation between different theoretical views on early grammatical knowledge and the methodologies (or even specific measures within a method) their proponents have used:

1. Production versus detection/discrimination tasks: Several researchers have taken young children's omission of FC in their speech as evidence that FC are absent from early periods of language acquisition (e.g., Radford, 1997; Tomasello, 2002). On another view, FC play a critical role in the acquisition of language (e.g., Höhle et al., 2004; Lust, in press). This latter view now seems to prevail following several studies using electrophysiological and behavioral (e.g., pointing, preferential-looking, headturn preference) methodologies, in which 'telegraphic-speaking' infants and even newborns (Shi et al., 1999) have demonstrated their ability to discriminate between function words (FW) versus content or nonsense words (e.g., Golinkoff et al., 2001; Santelmann & Jusczyk, 1998; Shafer et al., 1998), and to classify FW based on their grammatical role in a sentence (e.g., Höhle et al., 2004).

2. Next, I present results from a set of studies using the Intermodal Preferential Looking Paradigm (IPLP) in which 12-, 18- and 24-month-olds were presented with a pair of images after hearing either a grammatical or an ungrammatical sentence referring to one of these images (Kedar et al., 2006; in prep.). These studies have both replicated and extended previous findings with two-year-old infants who were tested on similar linguistic conditions but using a different type of task (pointing to pictures in a book; Gerken & McIntosh, 1993):

a. A dichotomous, First Look to Target measure yielded identical results to Gerken & McIntosh's (1993) correct/incorrect pointing measure. At 24 months, infants were better in orienting to the target image on their first look after hearing a grammatical sentence (e.g., "Can you see the ball?") rather than ungrammatical sentences in which the determiner 'the' was replaced by a nonsense word or by another English FW ('and') that was ungrammatical in the context used.

b. However, a continuous, time-sensitive Latency to Target measure enabled the extension of Gerken & McIntosh's (1993) results to younger age groups (12- and 18-month-olds) and yielded a significant difference between infants' response to the grammatical condition versus an ungrammatical condition in which the FW had been omitted.

3. Even within a specific method (i.e., IPLP) - significant differences may arise depending on the specific measures used. Measures which focused on infants' immediate looking response (i.e., Latency and First Look to Target) were more sensitive in detecting infants' linguistic competence than indexes of infants' overall looking behavior throughout a test session (e.g., Proportion of Looking Time). Thus, omitting or replacing a single FW in a sentence was significant enough to severe infants' sentence computation and noun reference, but this ungrammaticality effect had faded once the target image had been located.

### References

Gerken, L.A., & McIntosh, B.J. (1993). Interplay of Function Morphemes and Prosody in Early Language. Developmental Psychology, 29 (3), 448-457.

Golinkoff, R., Hirsh-Pasek, K., & Schweisguth, M. (2001). A Reappraisal of Young Children's Knowledge of Grammatical Morphemes. In: Weissenborn, J. and Höhle, B. (eds.), Approaches to Bootstrapping: Phonological, lexical, syntactic and neurophysiological aspects of early language acquisition, pp. 167–188.

Höhle, B., Weissenborn, J., Kiefer, D., Schulz, A., & Schmitz, M. (2004). Functional elements in infants' speech processing: the role of determiners in the syntactic categorization of lexical elements. Infancy, 5 (3), 341–353.

Kedar, Y., Casasola, M. & Lust, B. (2006). Getting There Faster: 18- and 24-month-old Infants' Use of Function Words to Determine Reference. Child Development.

Kedar, Y., Casasola, M. & Lust, B. (in prep.). From Phonological Detection to Syntactic Incorporation: 12- and 15-month-olds' Processing of Function Words in English Sentences.

Lust, B. (in press). Child Language: Growth and Acquisition. Cambridge University Press.

Radford, A. (1997). Syntactic Theory and the Structure of English. Cambridge University Press.

Santelmann, L., & Jusczyk, P. (1998). Sensitivity to discontinuous dependencies in language learners: evidence for limitations in processing space. Cognition. 69, 105–134.

Shafer, V.L., Shucard, D.W., Shucard, J.L., & Gerken, L.A. (1998). An electrophysiological study of infants' sensitivity to the sound patterns of English speech. Journal of Speech Language and Hearing Research, 41 (4), 874-886.

Shi, R., Werker, J., & Morgan, J. (1999). Newborn infants' sensitivity to perceptual cues to lexical and grammatical words. Cognition, 72, B11–B21.

Tomasello, M. (2002). The emergence of grammar in early child language. In T. Givón & B. Malle (Eds.), The Evolution of Language out of Prelanguage. John Benjamins.

**When one cue is better than two: Syntactic vs. lexical information in infant verb learning**

Jeffrey Lidz (University of Maryland), Ann Bunger, Erin Leddon and Sandra Waxman (Northwestern University)

jlidz@umd.edu

Based on adult simulations of word learning, Gillette et al. (1999) argue that verb learning is most successful when the learner is provided with phrase structural cues together with information regarding the lexical content of the verb's arguments. The combination of phrase structural and lexical information, however, could place a processing burden on infant learners, since the use of both kinds of information requires the integration of lexical information with syntactic structure. Indeed, we show that infant learners were able to learn a novel intransitive verb when its subject was a pronominal but not when it was a lexical NP, suggesting that the extra processing demands associated with lexical access may interfere with the syntactic processing required to learn the verb.

A preferential looking study tested 22-month-old infants' (N=36) ability to map a novel verb onto an event category. Infants were assigned to one of three conditions (Noun Phrase, Pronoun and No-word), each including two phases: a familiarization phase, and a test phase.

Familiarization: Infants were presented with three videos of a familiar object undergoing a particular motion (e.g., a flower spinning). Infants in the NP and Pronoun conditions heard a novel intransitive verb used to describe these scenes ("The flower/it is blicking."). In the no word condition, infants heard neutral speech ("What's happening here?")

Test: All Infants were simultaneously presented with 1) an object from the familiar category undergoing a novel action (a flower waving), and 2) the same object undergoing a new instance of the familiar action (a flower spinning). After 2 seconds, infants in the two verb conditions heard the novel verb ("Which one is blicking? Find the one that's blicking."). Infants in the no-word condition heard neutral speech.

Results: We measured visual attention to the two videos during the test phase, focusing our attention on the 2 seconds immediately preceding and following each use of the verb. A 2x3 ANOVA revealed a significant interaction between time frame (before vs. after novel verb) and condition ($p < .05$): infants in the pronoun condition showed a significant increase in looking time to the familiar action immediately after the test word, whereas infants in the other two conditions showed a significant decrease in looking time during this period. In sum, only infants in the pronoun condition learned the novel verb, indicating that lexical processing of known words can interfere with verb-learning, despite the potential semantic contribution from lexical content. This result suggests that, for learners, the informativeness of a cue needs to be weighed against the processing cost associated with using that information.

**References**

Gillette, J. H. Gleitman, L.R. Gleitman & A. Lederer (1999) Human simulations of vocabulary learning. Cognition.

**A Peek at the Past: A Glimpse into the Future**

Helen Smith Cairns (Queens College & Graduate Center, CUNY)

hcairns@ix.netcom.com

Over 40 years ago Roger Brown attached microphones to Adam, Eve, and Sarah and the field of language acquisition was born. In the following four decades theoretical questions have expanded exponentially, as have the empirical methods to respond to them. These developments demonstrate that our discipline is intellectually vibrant and scientifically healthy. This paper, which is to wrap-up the workshop, will examine the cutting-edge work presented here in the theoretical and historical context of the study of language development in children. The future of our discipline lies with the people who are at this conference, their students and colleagues. We will speculate, based on what they had to say, about what may lie ahead.