Maatschappij- en Gedragswetenschappen

Rapportage

Dossiernummer:	433-08-123
Titel project:	Learning about vocal structure: comparative approaches to language and song learning in humans and birds
Hoofdaanvrager:	Prof dr CJ ten Cate
Titel rapportage:	Eindverslag

Learning about vocal structure: comparative approaches to language and birdsong learning in humans and birds -- April 17-18, 2009, Leiden

The workshop was held at “Oud Poelgeest” near Leiden. We received one cancellation – from Mark Liberman due to family circumstances – but otherwise all invitees arrived the day before the workshop and attended all sessions. The workshop featured 13 great talks and many interesting discussions in the question-answers sessions, the breaks and the two reserved slots for group and plenary discussion. The program was intensive, but the workshop was characterized by an unusual cooperative atmosphere.

Striking at the workshop was the enormous diversity in backgrounds, and yet it was very successful at finding points of contact, common themes and identifying some controversies. The research presented was based on a data from subjects of different ages – neonates (e.g., Mehler), toddlers (e.g., Peperkamp, ter Haar, Levelt, Zuidema), adults (e.g., Mehler, Scharff) – and many different species – humans and other mammals (Scharff), several species of songbirds including starlings (Gentner), zebrafinches (van Heijningen,Scharff), Bengalese finches (Okanoya) and chaffinches (Lachlan), and non-songbird bird species (ten Cate). The data used was furthermore obtained using many different techniques, including non-invasive brain imaging (Mehler), invasive brain lesion/blocking studies (Okanoya,Scharff), behavioral experiments (ter Haar, Van Heijningen, Goldstein), and observational studies (ten Cate, Gentner, Levelt). In some cases observational data was analyzed using advanced computational techniques (Peperkamp, Lachlan, Zuidema).

In that great variety, a number of common themes arose. One was a very general concern with characterizing the features of human language that qualitatively distinguish it from communication in other animals. Everyone agrees that such 'design features' exist, but the details can be disputed and we had some useful interchanges at the workshop pointing out complexities in natural language phonology and bird song that should not be underestimated. Another common theme was a methodological one: the widely felt need for the creation of publicly available corpora in bird song research. Such corpora – large databases of (partially) annotated empirical observations – would allow many more and different questions about bird song structure to be addressed. Several of the participants (including Scharff and Lachlan) agreed to take up this issue, perhaps in the form of a grant proposal to the German science foundation. Many other shared interests were identified (e.g., the often neglected influence of social factors in learning, possible evidence for separate systems for statistical and rule learning). Furthermore, several possible future collaborations were fostered (e.g., Lachlan, Gentner and Zuidema intend to share data for syntactic analysis in bird song data).

One common theme stood out in particular for us: the use of the artificial language learning paradigm to address the comparative questions that were the main theme of the workshop. There was broad consensus that it's time to move beyond the “aabb vs anbn” task that has been the focus of much high profile research in recent years. But it became clear that many basic questions in artificial language learning still remain unresolved, including questions about the roles of categorization, rule learning and variable abstraction. We concluded that there is great potential here for comparative research with song birds and human infants; discussions at and after the workshop about this theme have laid the basis for our Brain & Cognition grant proposal.

Friday, April 17th 2009

9.00	-			Welcome & Introduction to the Workshop
9.00	-	9.45	Sharon Peperkamp	*Statistical inferences and linguistic biases in early phonological acquisition*
9.45	-	10.30	Jacques Mehler	*t.b.a.*
10.30	-	11.00		Tea & Coffee
11.00	-	11.45	Timothy Gentner	*Rules, patterns, sequences, memory, and female choice*
11.45	-	12.30	Mark Liberman	**cancelled**
12.30	-	14.00		Lunch
14.00	-	14.45	Caroline van Heijningen	*ABBA revisited: Can songbirds really detect syntactic structure?*
			Sita ter Haar	*Sensitivity to phonological markedness and frequency of occurrence in 9-month-old infants*
14.45	-	15.30	Claartje Levelt	*Syllable structure in early child language*
15.30	-	16.00		Tea & Coffee
16.30	-	17.30	Working groups	(invited speakers only)
17.30	-	18.00	Plenary discussion	(invited speakers only)
18.30	-	20.30	Workshop Dinner	(invited speakers only)
20.30	-		Sander van Maas (Amsterdam, Utrecht)	Evening Lecture (on the composer Messiaen)

Saturday, April 18th 2009

9.00	-	9.45	Carel ten Cate	*Song structure variability between species: a comparative approach*
9.45	-	10.30	Kazuo Okanoya	*Finite-state song syntax in Bengalese finches*
10.30	-	11.00		Tea & Coffee
11.00	-	11.45	Rob Lachlan	*The evolution of population-wide patterns of song structure: linking structure to song learning*
11.45	-	12.30	Constance Scharff	*FoxP2 as a molecular window into speech and language*
12.30	-	14.00		Lunch
14.00	-	14.45	Michael H. Goldstein	*Social and statistical mechanisms of vocal learning in songbirds, human infants, and other computers*
14.45	-	15.30	Willem Zuidema	*Crunching numbers on singing birds - Making inferences about rules underlying language and bird song*
15.30	-	16.00		Tea & Coffee
16.30	-	17.30	Working groups	(invited speakers only)
17.30	-	18.00	Plenary discussion	(invited speakers only)
18.30	-		Closing & Dinner	

Populaire samenvatting

Taal is een eigenschap die mensen van andere diersoorten onderscheid. Toch komt ook taal voort uit eigenschappen die al in voorouderlijke soorten aanwezig geweest moeten zijn. Ook in niet-verwante diergroepen vinden we taalachtige eigenschappen. Een vaak genoemd voorbeeld daarvan is de zang van zangvogels. Net als taal is die zang complex van structuur en wordt die op jonge leeftijd door een leerproces verworven. In deze workshop kwamen onderzoekers van vogelzang en taalontwikkeling samen om zich te buigen over de vragen of de gelijkenissen tussen zang en taal meer zijn dan alleen een oppervlakkige overeenkomst; wat de belangrijkste problemen zijn waarin vergelijkend onderzoek inzichten kan leveren; en welke methoden daartoe het meest geëigend zijn. Een belangrijk onderwerp was de vraag in hoeverre de betrokken leerprocessen statistisch of regelgestuurd zijn. Dit werd als een belangrijk onderwerp voor toekomstig onderzoek gezien.

Research proposal

Op basis van de workshop werd door ten Cate, Levelt en Zuidema de (voor)aanvraag '*Segments and rules: the comparative biology of language learning.*' bij het NWO programma Brain and Cognition ingediend. Deze aanvraag (dossiernr 433-09-216) is inmiddels geselecteerd om verder uitgewerkt te worden.

Segments and rules: the comparative biology of language learning

Institutional environment
1-Leiden University Centre of Linguistics (LUCL)
2-Institute of Biology Leiden University (IBL)
Collaboration: Institute for Logic, Language and Computation (ILLC), UvA

Research group

Prof. Dr Carel ten Cate	IBL & Leiden Institute for Brain and Cognition (LIBC)	*Animal behaviour; birdsong (development).*
Dr. Clara Levelt	LUCL & LIBC	*Infant speech perception; phonological acquisition.*
Dr. Willem Zuidema	ILLC & Cognitive Science Centre Amsterdam (CSCA)	*Computational linguistics; formal grammar; statistical learning.*

Introduction
Language distinguishes humans from other animals. Yet, many components of the language faculty are shared with, or have precursors in, animals[1]. Finding out which aspects are human- or language-specific is the focus of an increasing number of comparative 'biolinguistic' studies, which provide important insights in the functioning, development and evolution of the language faculty. *Our proposal addresses an especially promising area for comparative research: the mechanisms used by young infants and songbirds to detect structure in streams of speech and other sounds. We will also examine the ability to learn and generalize the rules underlying such structure, and whether this is a language specific or a more general cognitive ability.*

Contribution to the B&C programme
Biolinguistic research is interdisciplinary by its very nature. Progress in understanding the mechanisms involved in language learning, and their relation to other cognitive processes, requires the integration of theoretical approaches, techniques and expertise from many domains. Such comparative work is still in its infancy, and a project like this can make a substantial contribution. We bring together expertise from three fields – developmental linguistics, behavioural biology and computational linguistics – in an innovative way to examine the controversial question whether vocal learning in infants requires higher level and domain specific processes, or involves more general and/or lower level cognitive processes, also employed by nonhuman animals. Answers to these questions will also lead to new perspectives on developmental language disorders and their treatment.

Aims and research questions
A key cognitive property of human infants is their ability to extract words, and learn about underlying regularities, from a continuous stream of speech. The seminal study of Saffran et al.[2], demonstrated that 8-month old infants can use statistical regularities in the transitions between syllables to segment a monotonous stream of speech sounds into 'words'. Later studies revealed the ability of infants to use prosodic and acoustic-phonetic cues to divide the speech stream[3], or showed an interaction between statistical and prosodic cues[4]. Infants can also generalize consistent patterns in the input to abstract structures, such as distinguishing sequences of consonant-vowel combinations following an AAB pattern (e.g. wiwidi) from those with an ABB pattern (e.g. wididi)[5].

While such findings are intriguing, their interpretation is contentious. One topic concerns the level of abstraction underlying these abilities (e.g., whether they qualify as 'algebraic rules'), another whether they are based on a specialized language faculty or on more general cognitive mechanisms. Critical questions are whether: (1) the abilities shown by infants are also present in nonhuman animals; (2) nonlinguistic stimuli are processed differently from linguistic ones.

Animal experiments have almost exclusively used a nonhuman primate, the cotton-top tamarin. These experiments showed that tamarins and infants share abilities such as discriminating AAB from ABB[6], but differ in others (e.g. distinguishing ABAB from AABB structures[7,8]). However, the conclusions that can be drawn from these experiments are still very limited. Tamarins have simple vocalizations and, like other non-human primates, lack the ability for vocal learning; therefore success or failure in speech segmentation or rule learning tasks is possibly not linked to having language, but to vocal learning or having complex vocalizations. Also, the perceptual processing may differ between sounds of the own and of other species. On the infant side, a recent study[9] showed that infants could distinguish ABA from ABB patterns when the elements consisted of pictures of animals, suggesting that the ability is not specific to language. However, not all types of non-linguistic elements are suitable for learning sequences[10] and, there is a lack of studies that systematically compare the processing of speech sounds and linguistic structures with that of other stimuli.

Altogether, this calls for more comparative research and for the use of a wider range of sounds and structures in experiments. Arguably the best, but so far hardly used, model species for such comparative research are songbirds. Songbirds have complex learned vocalizations, and linguists and biologists increasingly consider birdsong the best comparative model for language. We recently demonstrated that while tamarins failed to distinguish AABB from ABAB structures, zebra finches - the most widely used songbird model - can do so[11]. In another study[12] we demonstrated that zebra finches categorize speech sounds based on phonemic contrasts in a similar manner to humans. Also, young zebra finches segment song input during vocal learning[13], making them excellent suited for a comparative study.

We will address the following questions in two PhD-projects, one on infants, the other on zebra finches: *What are the perceptual cues used by human infants and zebra finches to segment a stream of acoustic input? Do infants and zebra finches learn to detect the underlying patterns of regularities in acoustic input and do they represent this at a similar level of abstraction? Do infants and zebra finches show differences when processing conspecific, allospecific or arbitrary acoustic stimuli?*

Infants and zebra finches will be tested in similar experiments, using similar stimuli and testing methods. Infants will be tested in Levelt's 'babylab', using different types of habituation/dishabituation designs to examine whether babies perceive particular verbal stimuli as novel or familiar. Ten Cate's lab has extensive experience with testing the perceptual preferences and vocal discrimination of zebra finches. Stimuli will be constructed using CV speech syllables, zebra finch songs and tone items. We will use stimuli that allow for testing the importance of statistical regularities, phonological cues, stress and others, to detect patterns in acoustic input. We will also examine whether and what type of regularities infants and zebra finches can detect in the acoustic input (Zuidema's expertise).

Crossing boundaries

We are based in three different faculties and two universities, but build upon productive collaborations that crossed boundaries: Levelt and ten Cate in a study on the role of biases in early language learning in infants and song learning in zebra finches (competitive LIBC -PhD grant); ten Cate and Zuidema in a NWO-Cognition pilot project comparing syntax between birdsong and language. We jointly organized a recent international workshop *'Learning about*

vocal structure: comparative approaches to language and song learning in humans and birds', which identified the subject of this proposal as a key area for future study. The project will also involve international collaboration.

References

1- Hauser, M.D., *et al.* (2002a). *Science* 298, 1569-1579.
2- Saffran, J.R. *et al.* (1996), *Science* 274(5294), 1926-1928.
3- Johnson, E. (2008). *JASA*, 123, EL 144-El 148.
4- Shukla, M., *et al*. (2006). *Cognitive Psychology*, 54, 1-32.
5- Marcus, G. F., *et al.* (1999). *Science*, 283, 77-80.
6- Hauser, M.D., *et al.* (2002b). *Cognition* 86, B15-B22.
7- Fitch, W.T. & Hauser, M.D. (2004) *Science* 303: 377-380.
8- Newport, E. L., *et al*. (2004). *Cognitive Psychology* 49, 85-117.
9- Saffran, J.R., *et al.*(2006). *Cognition* 105, 669-680.
10-Marcus, G., *et al.* (2004). 29th Boston University Conference on Language Development.
11-Van Heijningen, C.A.A., de Visser, J., Zuidema, W. & ten Cate, C. (in prep.), Can songbirds really discriminate between different syntax structures? A case study on zebra finches. *To be submitted (PNAS).*
12-Ohms. V.R., Gill, A., van Heijningen, C.A.A., Beckers, G.J.L. & ten Cate, C. True phonemic perception is not unique to humans. (*Submitted).*
13-Williams, H.J. & Staples, K. (1992). *J. Comp. Psychol.* 106; 278-286.

Budget

	Personnel	Material costs
Infant project	PhD student: € 202.655	€ 35.000 (running costs baby lab; equipment; student assistance)
Zebra finch project	PhD student: € 202.655	€ 40.000 (birds and care; experimental cages; equipment)

CVs

Carel ten Cate: PhD - RUG (1984); postdoctoral fellowships - University of Cambridge (UK), UU; KNAW Senior Research Fellow (RUG). Professor of Animal Behaviour (UL) since 1992. Recipient of several awards for studies on bird behaviour. Head of a research group examining (vocal) communication in animals. Supervised/supervises several theses on bird vocalizations (most on competitive funding), including zebra finch song development. In recent years he initiated comparative studies on birdsong and language, mostly collaborating with linguists (Verhagen, Levelt, Zuidema). NIAS-fellow in 2007, project: Comparative aspects of animal vocal communication and language.

Clara Levelt: PhD in linguistics (UL, 1994). Visiting scholar (Rutgers University); research fellow (MPI, Nijmegen); post-doc VU; returning to UL in 2000. Visiting professor (Brown University 2005-2006). Currently associate professor. NWO-Vidi grant (2006) for a project on the development of the speech production mechanism. Set up a baby-lab to study infants' early lexical representations. In 2007 two more grants. LIBC grant (with CtC) for a PhD project on vocal learning by human infants and zebra-finches. NWO program grant (with Prof. Marc van Oostendorp) for a study on phonological features.

Willem Zuidema: studied Artificial Intelligence (UU); Sony Computer Science Laboratory-Paris (2000); AI-Lab of the Free University Brussels (2000-2002). PhD University of Edinburgh (2005). Since 2004 postdoctoral researcher at the ILLC, on models of language learning and evolution. Member of the CSCA; teaches in the MSc *Brain & Cognitive Science*. NWO-Veni fellowship (2007) for the project *Discovering Grammar* to study the cognitive mechanisms underlying sequence learning in humans and other species, using techniques from machine learning and computational linguistics. Collaborated with CtC in a 9-month Cognition pilot project.

Key Publications:

Borensztajn, G., Zuidema, W. & Bod, R. (2009), Children's grammars grow more abstract with age - Evidence from an automatic procedure for identifying the productive units of language. *Topics Cogn. Science* 1(1):175-188

Fikkert, P. & Levelt C. (2008). How does Place fall into place; The lexicon and emergent constraints in children's developing grammars. In: Dresher, E. & K. Rice (Eds.) *Contrast in Phonology*. Berlin: Mouton.

Holveck, M-J, Castro AC, Lachlan RF, ten Cate C., Riebel K (2008): Accuracy of song syntax learning and singing consistency signal early condition in zebra finches. *Behavioral Ecology* 19, 1267-1281.

Levelt, C. (2008). Phonology and phonetics in the development of schwa in Dutch child language. *Lingua* 118, 9, 1344 – 1361.

Verzijden, M.R., Etman, E., van Heijningen, C., van der Linden, M. & ten Cate, C. (2007), Song discrimination learning in zebra finches produces highly divergent responses to novel songs. *Proc. Roy. Soc., London B.* 274: 295-301.

Planned deliverables

Publications in high impact journals, two theses. Ongoing work at the baby lab and on bird song is regularly covered and disseminated to a wider audience by newspapers, radio and television.