Context-Specific Vocalizations in Human Infants (Homo sapiens): Can Computer Modelling Help to Bring Further Insight into Categorical Perception?

Verena Kersken, Juan-Carlos Gómez and Klaus Zuberbühler
Centre for Social Learning and Cognitive Evolution, University of St Andrews, St Andrews, Scotland, e-mail: vk29@st-andrews.ac.uk

1 Abstract

Using a methodological approach adapted from field-studies with non-human primates, we observed the vocal behaviour of prelinguistic infants in one of their natural habitat, a nursery environment. We identified a number of vocalizations reliably triggered by specific contexts in the infants and conducted an acoustic analysis of the different call types. Our results show that prelinguistic infants produce different categories of vocalizations. Categorical production has also been observed in other primate species, for example Vervet or Diana monkeys.

Computer modelling could aid the analysis of such data by simulating the perceptual processes at work in the receiver when perceiving and categorizing a call. This would move the way we analyze calls beyond an objective description of their acoustic parameters and more towards a representation of the perceptual processes involved in categorical auditory perception.

2 Prelinguistic Vocalizations in Human Infants – Categorical Production?

Long before human infants produce their first word at about 12 months of age, they produce a variety of sounds that are communicative, for example to express pain, to request objects or actions, to protest about something unpleasant done to them and to point at interesting events or objects in their environment.

In order to examine whether the calls of human infants are functionally distinct, we observed the vocal behaviour of 30 infants between the ages of 7 and 20 months in one of their natural habitats – a nursery environment. We identified the contexts in which vocal behaviour occurred and conducted an analysis of the acoustic features of the vocalizations in five distinct contexts: protests, requests for food or actions, declarative pointing and giving objects to others. A discriminant function analysis was conducted on 10 different acoustic call variables (onset, middle and offset of fundamental frequency; mean and peak intensity, number of harmonics, duration of the call, maximum and minimum fundamental frequency and the number of elements in one call). Overall 192 calls were used for the statistical analysis. The model correctly classified 56.8% of the

calls. We conducted a Monte Carlo simulation to randomize the data by randomly assigning calls categories to the data points and fed it into the model. A chi-squared test was used to compare the overall number of correct and incorrect classifications the model produced. The results revealed a significant difference between the two data sets and that the actual data produced more correct classifications than the randomly generated set (chi squared = 26.99, df = 1, p> .0001).

The results suggest that prelinguistic infants produce non-linguistic vocal behaviour selectively in certain contexts. Although this is not a complete description of infant vocal behaviour, it nevertheless suggests some homogenous classes of vocalizations that are systematically related to their production context Consistency and context-specificity in production provides caregivers and other infants with important cues to what the infant wants or needs. These basic call types therefore function referentially in a comparable way to some vocalizations of non-human primates.

3 Context Specificity and Categorical Perception

The current study applies a methodology developed in the investigation of non-human primate vocal behaviour to human infants. Many non-human primate species produce context-specific calls. Examples include predator-specific alarm calls in Vervet (Cheney, Seyfarth and Marler 1980) and Diana Monkeys (Zuberbühler 2000), both of which have specific calls for aerial or ground predators. Other examples include calls that imply the presence of different types of food (e.g. Capuchin Monkeys: Pollick, Gouzoules and de Waal 2005; chimpanzees: Slocombe and Zuberbühler 2005).
Playback studies have demonstrated that some of these calls are meaningful to other primates and that these calls are perceived categorically (Cheney, Seyfarth and Marler 1980, Zuberbühler 2000). Categorical perception has been studied extensively in humans, particularly with regards to how we perceive spoken language and its various elements (e.g. Brauer and Friederici 2007). In categorical perception, there are psychological mechanisms at work which transform the actual perceived sound to a virtual sound that is similar to the nearest category prototype - so it can be classified into one category despite not being a perfect match (Livingston et al 1998). These mechanisms might ameliorate particular properties of the heard sound, such as a particular pitch or frequency pattern, and therefore allow the recipient to classify the sound into one particular category more readily. MAYBE TOO TEXTBOOK LIKE

4 Challenges for Computer Modelling

If categorical perception in non-human primates also works in this particular way, then the statistical analyses we are using at the moment are unable to produce meaningful results because it is not clear which parameters are relevant for the understanding and categorization of these calls. The call analyses primatologists are using measure objective parameters, such as frequencies, duration, harmonics or intensities to describe calls and

compare them against each other to identify potential differences between classes of calls. However, although this method seems valid for the objective description of calls, the choice of parameters is often arbitrary and, more importantly, might not be a valid reflection of the processes going on in the receiver.

Computer modelling could help to expand and improve the method of analysis currently used with research into primate vocal production and perception and infant prelinguistic vocalisations. Computer modelling could offer a form of data analysis that more closely resembles the actual perceptual processes that are at work in the receiver. Projects so far have mainly considered the area of language and speech perception. however rarely the non-linguistic sounds produced by non-human primates or prelinguistic infants.

Human infants are a particularly interesting example because they interact with a linguistic community and are able to understand speech, but are yet unable to produce language. It could for example identify salient features of calls and model understanding and categorisation in the receiver. Investigating call classes using model clusters could therefore be a more appropriate way of data analysis. Furthermore, the wealth of data collected in this topic can provide a rich database to model brain and perceptual processes that are working in the perceiver.

Acknowledgements

Thanks to Acorn and WonderYears Nurseries, Eric Bowman and the Leverhulme Trust

References

Brauer, J. and Friederici, A.D. (2007): "*Functional neural networks of semantic and syntactic processes in the developing brain*", Journal of Cognitive Neuroscience, Vol.19, No. 10, pp. 1609-1623

Cheney, D.L., Seyfarth, R.M. and Marler, P. (1980): "*Vervet monkey alarm calls: Semantic communication in a free-ranging primate*", Animal Behaviour, Vol. 28, pp. 1070-1094

Livingston, K.R., Andrews, J.K. and Harnard, S. (1998): "*Categorical Perception Effects Induced by Category Learning*", Journal of Experimental Psychology: Learning,Memory and Cognition, Vol. 24, No.3, pp. 732 - 753

Pollick, A.S., Gouzoules, H. and de Waal, F.M.B. (2005): "*Audience effects on food calls in captive brown capuchin monkeys, Cabus apella*", Animal Behaviour, Vol. 70, Issue 6, pp. 1273-1281

Slocombe, K.E. and Zuberbühler , K. (2005): "*Functionally Referential Communication in a Chimpanzee*", Current Biology, Vol. 15, Issue 19, pp. 1779-1784

Zuberbühler, K. (2000): "*Referential Labelling in Diana Monkeys*", Animal Behaviour, Vol. 59, Issue 5, pp. 917-927