Limb Lateralization and the Evolution of Communication

[1]Forrester, G.S., [2]Thomas, M.S.C., [3]Annaz, D., and [4]Mareschal, D.

[1]Department of Psychology, University of Sussex; [2]Developmental Neurocognition Lab, Birkbeck, University of London; [3]Centre for Brain and Cognitive Development, Birkbeck, University of London; [4]Department of Psychology, Middlesex University

We use a novel observational method to show that both young children and gorillas use their left hand preferentially in social contexts, but use their right hands preferentially for manipulating physical objects. We discuss the evolutionary implications of such a dissociation.

Introduction

- Well documented association between right-handedness and left hemispheric brain specialization in human adults (Bradshaw & Nettleton, 1981; McManus, 2002)
- Evolutionary relationship between handedness and brain asymmetry remains elusive
- Traditional studies reveal inconsistent handedness data for apes, but demonstrate an overall lower proportion of right-handedness in apes compared with humans (Hopkins, 2006)
- Discrepancies may be the result of a lack of methodological consistency across studies
- We challenge the view that lateralized use of the limbs is unique to human evolution (e.g. Bradshaw & Rogers, 1993; Corballis, 2002) and may develop with language acquisition.
- We argue that lateralized motor preference depends, in part, upon the target of the action (animate or inanimate).
- Dissociation revealed using a new methodology that assesses the 'targets' of lateralized limb actions.

Methods

Subjects

- Four semi-free ranging gorillas (*Gorilla gorilla gorilla*) observed at Port Lympne Wild Animal Park
- Four typically developing children (36-48 months) observed in a nursery setting

Multidimensional Method (MDM)

- Four hours of naturalistic behaviour was assessed for frequency counts across each subject population.
- Video focal-follows of individual subjects based on a predetermined, counterbalanced schedule.
- Two synchronized digital video cameras captured different perspectives of naturalistic behavior.
  1) a close-up image of focal for detailed information (e.g. eye gaze, facial expression) (figure 1).
  2) a wider field of view for information regarding social context (e.g. social partner(s), proximities).
- Two synchronized videos combined to view both angles simultaneously.
- Video streams compressed and, coded offline using OBSERVATRON software (figure 2) for frequency of lateral motor preference and target of action (figures 3 and 4).
- Data stored in an SQL database.
- Chi-square analyses test the null hypothesis that there was no association between hand use and the target of manual actions.
- Handedness indices (HI) were calculated according to the formula (R-L)/(R+L). HI varies between -1 and 1, positive numbers = right-handed actions, negative numbers = predominantly left-handed actions

Figure 1

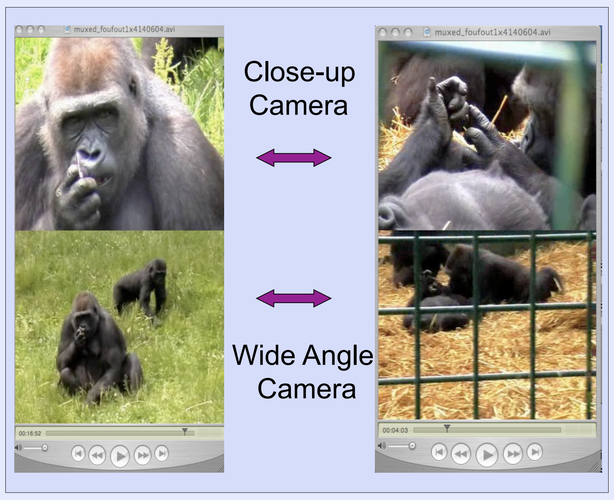


Figure 2

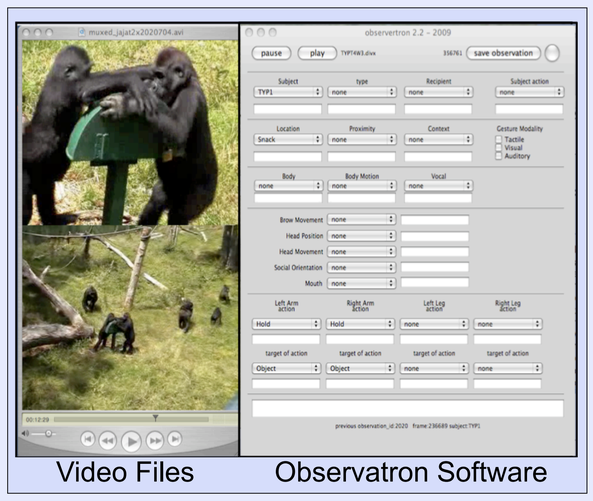


Figure 3

Figure 4

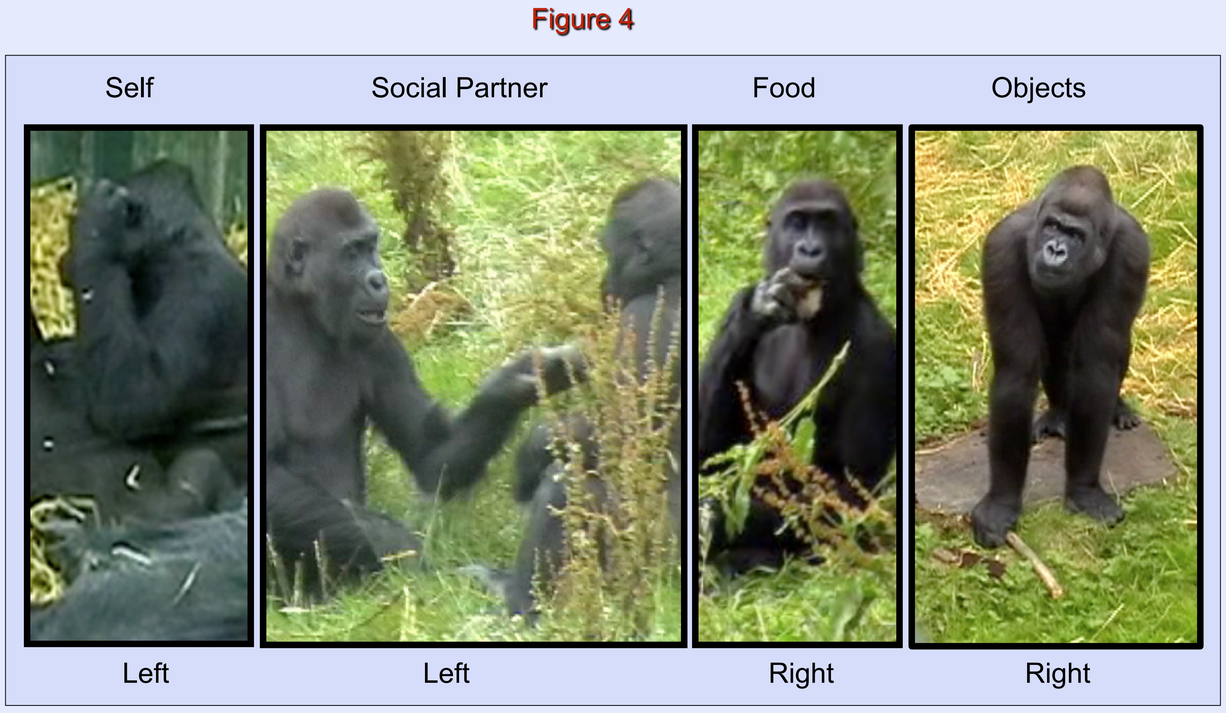


Figure 5

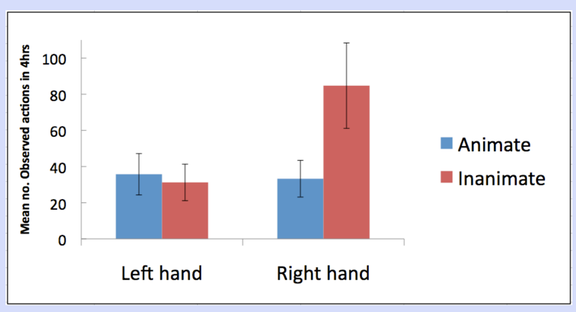
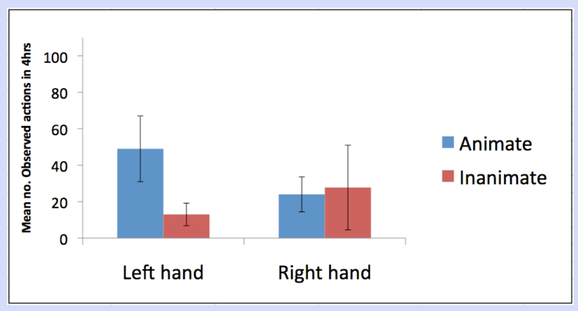


Figure 6



Results

- Typical developing children (figure 5):
  - HI (inanimate) = .461, indicating a strong right-hand preference
  - HI (animate) = -.036, indicating a slight left-hand preference

$\chi^2(1, N = 740) = 45.27, p < .0001$

- Western lowland gorillas (figure 6):
  - HI (inanimate) = .361, indicating a strong right-hand preference
  - HI (animate) = -.342, indicating a strong left-hand preference

$\chi^2(1, N = 455) = 50.92, p < .0001$

Discussion

- Results indicated a pattern of preference for hand use based on encounters with animate objects (left limb) or inanimate objects (right limb) for both gorilla and child subject populations.
- Absolute differences exist in the levels of handedness and in the rates of the types of behaviours performed by the two populations.
- Patterns found for target of action for both child and ape populations challenges the view that lateralized limb use is unique to human evolution.
- Data fit well with the hemispheric speciality represented by functions for language (left hemisphere) and social emotion (right hemisphere) in humans (Hellige 2001).
- Data lend support to developing hypothesis that human language evolved, in part, from a primitive dissociation (animate, inanimate) shared by a common human/ape ancestor (Forrester & Leavens, under revision).
- Hierarchical structure found in right-handed manipulations required for activities such as tool use and food preparation may have prepared the left-hemisphere with neural architecture necessary for evolution of language (Weiss & Newport 2006) .
- The impact of results will bear upon how handedness can be used as an early-marker of cognitive development in children, and aid in early detection of children 'at-risk' for language-related impairments or social impairments (e.g. autism).
- Comparative, quantitative studies of animal behavior under a common experimental framework (e.g. Multidimensional Method) encourages a reassessment of how we evaluate handedness in primates.

References

Bradshaw, J. L. & Nettleton, N. C. (1981). The nature of hemispheric specialization in man. -Behavioral and Brain Sciences, 4: 51-91.
McManus, I. C. (2002). Right hand, left hand: The origins of asymmetry in brains, bodies, atoms and cultures. (Nicolson, ed.) -London/Cambridge: Harvard University Press/Cambridge, MA.
Hopkins, W. D. (2006). Comparative and familial analysis of handedness in great apes. -Psychological Bulletin. 132(4): 538-559.
Bradshaw, J. L., & Rogers, L., eds (1993). The evolution of lateral asymmetries, language, tool-use and intellect. -San Diego, Academic Press.
Corballis, M. C., ed (2002). From hand to mouth: The origins of language. -Princeton, NJ, Princeton University Press.
Hellige, J. B. (1993). Unity of thought and action: Varieties of interaction between the left and right hemispheres. -Current Directions in Psychological Science. 2: 21-25.
Forrester, G.S., Leavens, D.A. (under revision) Differences in manual laterality during emotive behaviour and object manipulation. -Folia Primatologica.
Weiss, D. J. & Newport, E. L. (2006). Mechanisms underlying language acquisition: Benefits from a comparative approach. -Infancy, 9(2): 241-257.

Acknowledgements

This work was funded in part by the European Commission NEST-Pathfinder grant 029088 (ANALOGY)
Thank you to the following individuals and institutions: The John Aspinall Foundation Director, Amos Courage; Head Gorilla Keeper, Phil Ridges; Livingstone Primary School's Kingfisher Director, Janie Knappett; Joint Software's Neil Forrester; Research Assistant, Roberta Herrick; University of Sussex Department of Psychology; Birkbeck College, University of London, School of Psychology