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Investigating extant non-human primates to infer fossil primate manual abilities: An interdisciplinary approach utilizing behaviour, morphology and modelling evidence

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Humans are considered to have unique manual abilities in the animal kingdom. However, we still do not know what the extent of manual abilities in primates is, nor how they evolved. What makes humans unique? The present study investigates the manipulative abilities of Hominids, using an interdisciplinary framework combining behavioural, morphological, functional, and biomechanical approaches. Behavioural strategies were quantified across captive great apes and humans during the same complex tool use task. A three-dimensional geometric morphometric (3DGM) approach was also used to investigate surface shape variation and co-variation at the base of the thumb. This was combined with a musculo-skeletal model to better interpret the behavioural results and to test the putative biomechanical constraints imposed by Hominid hand proportions during tool use. The behavioural and functional results demonstrate that each species uses different techniques. More complex manual abilities, such as in-hand movements, were observed in African great apes and humans to the exclusion of Pongo. However, humans show distinct manual dexterity and perform faster the task than great apes. The different behavioural demands of each species habitat may explain this variability, as well as their concurrent variability in manual morphology. Results of 3DGM show that shape variability at the base of the thumb seems to be linked with the in-hand movements used by each species. Results of the musculo-skeletal model show that certain grips are more challenging for some species, particularly orangutans, such that they require stronger muscle forces to perform these grips in a given range of motion. This integrative approach clearly shows that the different manipulative abilities of Hominids cannot simply be a consequence of the different thumb morphologies but also of the different mechanical constraints related to the overall hand proportions. These results highlight and discuss the difficulties of inferring manual abilities in fossil taxa from morphology, without

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taking into account the overall morphology of the hand and its possible link with biomechanical constraints.

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