1 Primates – News & Perspectives
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3 # Great apes reach momentary altered mental states by spinning
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Abstract

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16 **Among animals, humans stand out in their consummate propensity to self-induce altered states**
17 **of mind. Archaeology, history and ethnography show these activities have taken place since the**
18 **beginnings of civilization, yet their role in the emergence and evolution of the human mind itself**
19 **remains debatable. The means through which modern humans actively alter their experience of**
20 **self and reality frequently depend on psychoactive substances, but it is uncertain whether**
21 **psychedelics or other drugs were part of pre-human ancestors' ecology or culture. Moreover,**
22 **(nonhuman) great apes in captivity are currently being retired from medical research, rendering**
23 **comparative approaches thus far impracticable. Here, we circumvent this limitation by**
24 **harnessing the expanse of YouTube public data to show that apes engage in rope spinning**
25 **during solitary play. When spinning, apes achieved speeds sufficient to alter self-perception and**
26 **situational awareness, comparable to those tapped for transcendent experiences in humans (e.g.,**
27 **Sufi whirling), and the number of spinning revolutions predicted behavioural evidence for**
28 **dizziness. Thus, spinning serves as a self-sufficient means of changing body-mind**
29 **responsiveness in hominids. Proclivity towards such experiences is shared between humans and**
30 **great apes, opening an entry point for the comparative study of the mechanisms, functions, and**
31 **adaptive value of altered states of mind in human evolution.**
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Introduction

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35 Seeking altered mental states is seemingly a human universal, historically and culturally (Slingerland 2021;
36 Biwer et al. 2022). The biological and behavioural precursors of such experiences are, however, unclear
37 (MacKenna 1992; Pollan 2019), notably because it is challenging to confidently confirm whether
38 substance use was viable within the highly diversified ecological and cultural human paleo-backdrop
39 (Bergström et al. 2021). Whether altered state experiences within the hominid family shaped the
40 emergence and evolution of the modern human mind remains one of the major and most thought-
41 provoking unknowns in cognitive science.
42   Wild primates consume fermented foods with alcoholic content (reviewed in Hockings et al.
43 2015; Amato et al. 2021). These events typically depend on natural availability and opportunistic use of
44 scarce resources (Hockings et al. 2015). Though suggestive that primates may indeed experience
45 'drunkenness', consumption may be primarily driven by alcohols' high-caloric content, and thus, a side-
46 effect and "unavoidable consequence of frugivory"(Hockings et al. 2015). Primate medical research has
47 also focused on drug- and alcohol-related behaviours (Grant and Bennett 2003; Wakeford et al. 2018),
48 but these have primarily shed insight into substance addiction and abuse, where subjects are externally
49 administered such substances. Evolutionary interpretation is, thus, tenuous at best. Here, we propose
50 and explore the use of a new comparative behavioural model for the study of pro-active divergence from
51 normal waking states in human evolution: spinning.
52   Apart from sensing sound (Ghazanfar and Hauser 2001), the vertebrate inner ear monitors and
53 sensors changes in body motion, orientation, position and velocity (Lowenstein 1948). Spinning, i.e.,

rapidly rotating around ones' body-axis, mechanically disrupts inner ear homeostasis and sends nervous signals to the brain that conflict with automatic eye-movement (Nigmatullina et al. 2015). In humans, this neuronal cross-signalling prompts the perception of a whirling world, along with dizziness, light-headedness, head-rushes, vertigo, elation and other altered states of perception, mood and consciousness. Averting these symptoms when spinning at high or sustained speeds requires extensive dedicated training (e.g., professional dancers, circus performers, astronauts). More generally, in untrained neurotypical persons, spinning is pro-actively tapped for rapture (e.g., playground spinner bowls, marry-go-rounds, carousels) and collective or spiritual experiences (e.g., Sufi whirling dervishes). In autistic children and adults, spinning is also used as a self-stimulating behaviour to control ones' sensory input or intentionally block out external input (British National Autistic Society). Homology in inner ear anatomy among hominids (Quam et al. 2015; Braga et al. 2017) and relatively similar body size (amongst primates) suggests that similar spinning behaviours carry similar neurophysiological effects in great apes and humans. Thus, this poses the possibility that, by spinning, ancestral individuals, whether with or without access to psychotropic drugs, nevertheless had the natural means to self-induce altered states of proprioception and awareness.

Methods

To test and provide a proof-of-concept for the assumption that spinning induces altered mental states in great apes and potentially did so as well in human ancestors, we searched YouTube (Google Inc.) for publicly posted and publicly available videos of great apes spinning. We used image-based measures to quantify rotational speeds and rotational duration (see Suppl. Methods). We focused on rope spinning (Byrne et al. 2017), which in our sample mainly occurred as solitary play without evident causes or goals beyond the act itself. Ropes – or rope-like items like vines – likely enable apes to achieve faster free rotations and longer rotation lengths, allowing us to explore the physiological and motoric limits that great apes can experience autonomously. Because the ear and eye anatomy underlying the neurophysiology of spinning are fundamentally the same across body sizes of the same species, we had no prior expectations about differences in rotational speed, rotational length or their respective effects between, for instance, adolescents versus adults or males versus females.

We then compared ape spinning speed with expert human spinning in different dance and traditional styles, namely, self-revolving pirouettes performed by professional ballet and Ukrainian Hopak dancers, Sufi whirling dervishes and circus artists in suspended spinning rope acts. These acts require extensive training and dedicated practice to supress the neurophysiological effects associated with rapid and/or prolonged spinning that untrained individuals would normally suffer. In the case of Sufi whirling dervishes, spinning is deliberately used to induce states of mystic experience and spiritual trance. Accordingly, we used these world traditions as baseline for rotational speeds that can be confidently assumed to significantly disrupt the normal waking state in humans and, by means of biological and behavioural homology and similar body size, in great apes.

Results

We uncovered 40 videos containing 132 bouts of rope spinning by great apes, composed of a total of 709 revolutions (Fig. 1A, B; see videos in Suppl. Methods). These included orangutans from at least 7 different sites (plus 4 unidentified sites), gorillas from at least 7 sites, including 2 wild (plus 3 unidentified), chimpanzees from 2, and bonobos from 4. Great apes spun on average for 5.4 revolutions per bout, for an average of 3.3 consecutive spinning bouts, and at an average rotational velocity of 1.43 revolutions/second (rps). The longest bout was 28 revolutions; the fastest sustained rotational speed (for 5 spins) was 3.3 rps; and the fastest single revolution was at 5 rps, clearly indicating that spinning was not an "erratic" behaviour.
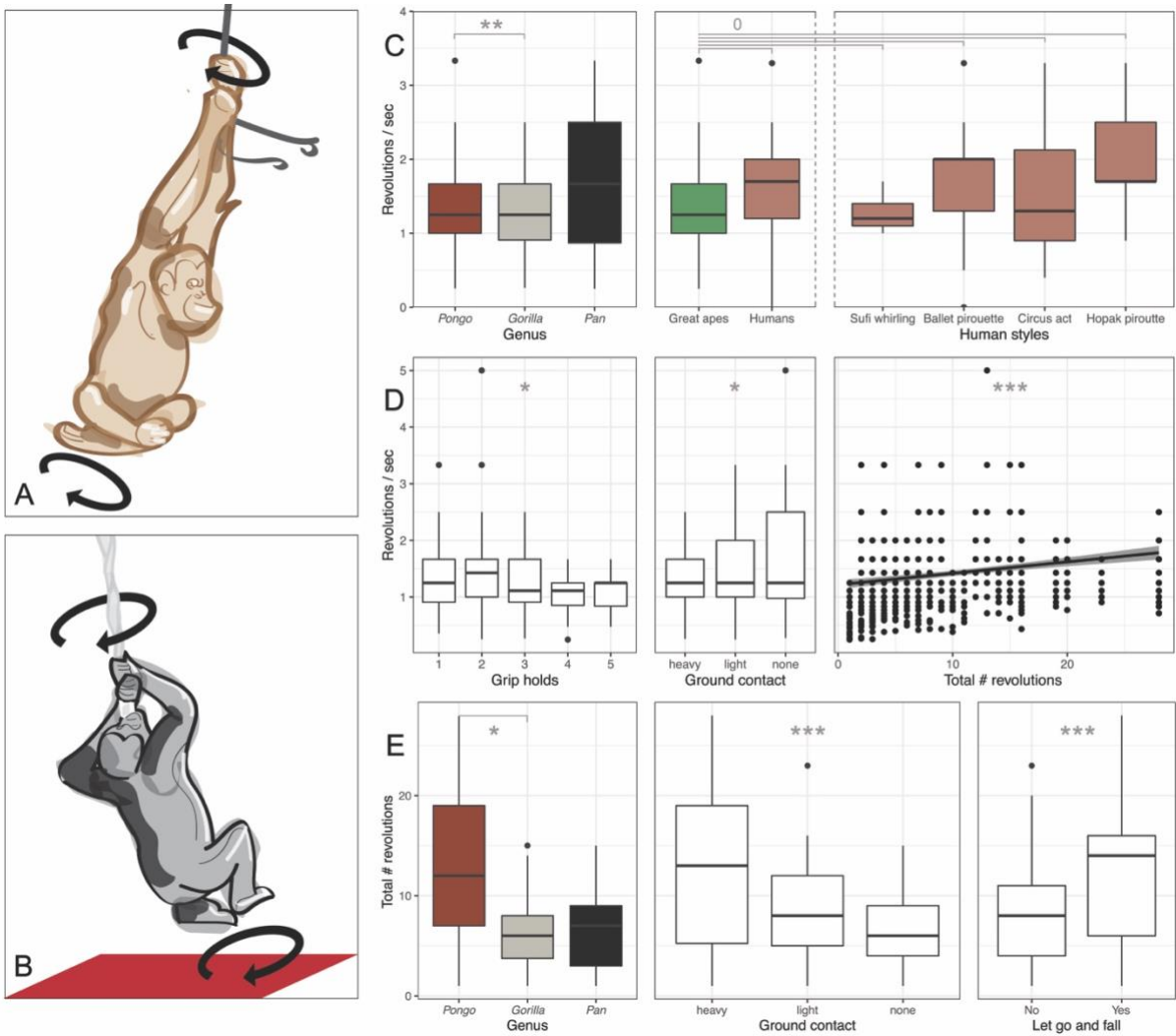
Fig 1. Great ape spinning compared. A and B: Exemplar cases of spinning by an orangutan (A) and a gorilla (B). C: Comparison of rotational speed between great ape genera, between apes and human, and between apes and traditional human styles. D: Behavioural correlates of rotational speed between great apes. E: Variation revolution number between great apes and behavioural correlates. Box plots represent median and 25–75% interquartile range; whiskers represent lowest/highest value within 1.5 times interquartile range below/above; data points represent outliers. Graphic representations based on raw data; denoted differences based on model estimates. *: significant effects at $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$, 0: no significant differences.

Linear mixed modelling (see Suppl. Methods) indicated that rotational velocity was proportional to revolution count (LMM ANOVA, $F(1, 102.34) = 31.101$, $p < 0.001$), with higher speeds being achieved with higher revolutions (Fig. 1D). There were rotational speed differences depending on ground contact ($F(2, 133.65) = 4.003$, $p = 0.02$) and the number of grip holds during spinning ($F(1, 136.62) = 4.783$, $p = 0.03$), with specific grips allowing longer spins (Fig. 1D), tentatively because certain positions may afford different moments of inertia. There was a significant effect of genus ($F(2, 38.92) = 7.761$, $p = 0.001$), with orangutans spinning at significantly faster speeds than gorillas ($t = -3.082$, $p = 0.004$; Fig. 1C).

For comparison, an LMM model that included humans (revolutions: $N = 1157$, $N_{bouts} = 152$, $N_{videos} = 48$) did not detect differences in rotational speed either between great apes and humans ($F(1, 41.30) = 3.355$, $p = 0.074$) or great apes and each specific tradition style ($F(4, 36.69) = 1.949$, $p = 0.123$) (Fig.1C).

Total number of revolutions in great apes was influenced by ground contact ($F(2, 700.57) = 23.516$, $p < 0.001$), with more support leveraging more revolutions (Fig. 1E). There was a strong

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trend for genus (F(2, 37.99)=3.163, p=0.054), with orangutans spinning for significantly more revolutions per bout than gorillas (t=2.312, p=0.026; Fig. 1E). Crucially, when apes spun for a higher number of revolutions, individuals were more likely to let go of the rope or let it go slack at the end of the bout (F(1, 693.25)=81.733, p<0.001), suggesting symptoms of dizziness. Closer inspection of these 43 dismounts revealed further evidence of dizziness: the animal immediately sat or laid down 30 times, moved a short distance and then sat or laid down 7 times, and only 6 times remained balanced on its feet.

Discussion

Findings show that great apes spin at speeds that induce physiological "highs" in humans. Spinning at similar rates unescapably produces severe dizziness in untrained humans (we invite the reader to try the observed averages of rotational speed, length or bout number performed by great apes for instant validation). Notably, by comparing "recreational" spinning behaviour of apes to the professional spinning behaviour of humans, our analyses were inherently conservative. Our findings, while exploratory, provide a proof-of-concept and a new charter for the study of spinning and altered mental states between humans and great apes.

Our preliminary findings point to several directions for the future study of spinning behaviour in apes and other species. One is to investigate questions related to the evo-ecological constraints on spinning. For example, spinning differences between orangutans (mostly arboreal) vs. gorillas (mostly ground-dwelling) could suggest neurological adaptation against motion sickness or vertigo (requiring faster/more revolutions to reach dizziness in arboreal species) similar to reduction of the vestibular cerebellum observed in ballerinas and figure skaters (Nigmatullina et al. 2015). Differences in certain anatomical features between species may also help to leverage more or fewer spinning revolutions (e.g., gorillas never used foot grips, orangutans often did).

Our findings also raise interesting questions concerning whether the behaviour is performed more frequently by particular age- and sex-classes, for example, as part of play by juveniles or as part of male display. Because the behaviour in great apes appears to be idiosyncratic, performed by certain individuals rather than occurring across populations, we anticipate that answering these questions will pose an empirical challenge. If attainable, such effort could help shed new insight into the ontogeny and motivation of spinning behaviour.

More conclusive comparisons between species, as well as between age classes and sex, could be made possible with controls for the proportions in which the relevant groups occur in captivity. For example, our findings suggest that bonobos – relatively scarce in captivity compared to chimpanzees, but conversely well represented in our dataset – may be more frequent rope spinners than their sister species. Unexpectedly high rates of occurrence in a species with relatively small population numbers in captivity could be suggestive of higher predisposition towards altered states.

More data to compare captive and wild populations could also inform whether this behavior is more likely to occur in captivity, where animals might seek spinning and the ensuing state of dizziness as a way to reduce boredom. However, comparisons with wild individuals will probably be limited because recordings are rare and idiosyncratic in the wild (wild mountain gorillas are present in our data, though this was likely in part the result of nearly continuous video coverage of some gorilla groups by tourists).

Although beyond the scope of analysis here, we have observed videos of rope spinning by other primate species too, including gibbons and monkeys. Future research may seek to determine whether other primates spin as frequently as great apes and in such a way that elicits dizziness and altered mental states. Increasing phylogenetic distance will, however, reduce interpretative power based on physiological and cognitive homology with humans.

To establish clear comparative benchmarks for future ape-human comparisons, it would be relevant to determine the minimum spinning speeds and lengths necessary to induce altered states in humans, and how training affects and extends these limits. Ethnographic and anthropological studies of how children and adults use spinning and other non-pharmacological behaviours that are deliberately sought to disrupt body and situational awareness (e.g., swings, slides, rollercoasters, budgie-jumping) could provide complementary information about the role that these experiences play in our lives and, by extension, those of our ancestors over evolutionary time. Interestingly, some accredited zoos are reported to have re-used equipment from children's playgrounds as enclosure enrichment to the apes (R.

Shumaker, pers. comm.). A general adoption of the devices that make up typical children's playgrounds in great ape facilities could provide dynamic stimulation and motoric challenge, while potentially helping to reveal more comprehensively, and in a controlled fashion, how and why great apes engage in mind-altering behaviours.

Concluding remarks

Findings show that, like humans, great apes voluntarily seek and engage in altered experiences of self-perception and situational awareness. In our last common ancestors, these behaviours probably enhanced the nervous system and musculature (Byrne 2015), helping expand the range of action patterns, but also momentarily altering individuals' inner world, range and patterns of perception, emotion, and (self- and other-) awareness. Our empirical evidence gives some grounding to the intriguing possibility that the self-induced altered mental states of our ancestors could have shaped aspects of modern human behaviour and cognition, as well as mood manipulation and mental wellbeing.

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Competing interests

The authors declare no competing interests.