Door slamming: Tool-use by a captive white-handed gibbon (*Hylobates lar*)

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Gibbons often accompany their morning song bouts by spectacular locomotor displays that may include branch shaking and branch braking. These displays typically occur at the climax of the great-call, the most conspicuous and stereotyped song phrase of the female. Here I report on a captive female white-handed gibbon slamming the sliding door of her wooden sleeping box during the climax of her great-call. This special addition to her display produced a single, loud bang which acoustically accentuated the climax of the female's great-call, made her great-call sound unique, and possibly enhanced the call's effect on potential receivers (presumably female conspecifics). The female's use of a door to modify her duet contributions represents a novel behavioural variant, and one of the few cases of tool use in gibbons or small apes. Furthermore, behavioural innovations like this one may have played a role in the evolution of human music.

Introduction

Great apes have frequently been reported to use tools, both in captivity and in the wild, and these primates' propensity for tool use has been evaluated in various studies (*e.g.* Boysen *et al.*, 1999; Breuer *et al.*, 2005; Fontaine *et al.*, 1995; Köhler, 1927; McGrew, 1992; Nakamichi, 1999, 2004; Toth *et al.*, 1993; van Schaik *et al.*, 2003; Visalberghi *et al.*, 1995; Whiten *et al.*, 2001).

In contrast, tool use in gibbons has rarely been studied, and relatively few cases of tool use have been observed in the small apes (Anonymous, 1971; Baldwin and Teleki, 1976, p. 63; Beck, 1980; Cunningham, 2006; Cunningham *et al.*, 2006; Drescher and Trendelenburg, 1927; Rumbaugh, 1970). In his review of tool use in apes, McGrew (1992, p. 53) ranked gibbons "with their total of two anecdotes" among the non-tool users, together with gorillas.

One of the most interesting specialisations in gibbons are their loud morning vocalisations, commonly known as songs (Geissmann, 1993; 2000b; Haimoff, 1984; Marshall and Marshall 1977).

In many gibbon species, males produce one or several distinct types of short phrases, which often become gradually more complex (as seen, for instance, in the number of notes, the number of distinct note types or the degree of frequency modulation) as the song bout proceeds. In more or less regular intervals, females insert long, female-specific phrases, which are commonly referred to as great-calls. In most species, great-calls consist of a particularly rhythmic series of long notes uttered with increasing tempo and/or increasing peak frequency. Males usually stop vocalising at the beginning of each great-call and provide a special reply phrase (coda) at or after the climax of the great-call before resuming their more common short phrases. The combination of the female great-call and the male coda is termed a great-call sequence, and this sequence may be repeated many times during a single song bout (Geissmann, 2000b).

In addition, one or both partners often exhibit a locomotor display at the climax of the great-call, which may consist of a more or less acrobatic burst of locomotion through the crown of the tree and be accompanied by pilo-erection, branch shaking and branch braking (Deputte, 1982; Chivers, 1974, p. 238; Geissmann, 2000b; Kappeler, 1984, p. 381).

Here I report on a possible case of tool use observed in a captive female white-handed gibbon. The behaviour was typically preformed as part of her song bouts, usually as part of the locomotor display during her great-call phrases.

Animals, materials and methods

Study animals

The study animals included an adult female (*Si*) and an adult male (*Pu*) of white-handed gibbons (*Hylobates lar*). They were kept as a pair at the Zoo Seeteufel in Studen, Switzerland. They arrived at the zoo around 1971 from a private owner. Both were presumably wild-born, and reportedly adults upon arrival. Both were of the light colour phase, but the female was clearly darker and larger than the male (Fig. 1).

No conspecifics lived in the zoo, but three groups of siamangs were also kept there (Geissmann, 1986, 1999, 2000a, 2008). They were housed in the same type of cages. One of these siamang groups lived in a neighbouring cage to that of the gibbon pair.

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All groups could hear each other throughout the year. During the summer, all hylobatid groups were kept in wire-mesh outdoor cages (area x height: 25 m^2 x 2.5 m) equipped with several horizontal metal bars, ropes, and a wooden sleeping box (Fig. 2). The sleeping box had an area of about 2 m x 0.6 m and a height of about 1 m. It contained two equal-sized sleeping compartments, each with a circle-shaped entrance that could be closed with a sliding door (Fig. 3).

During the winter, all gibbons were housed in a building. The gibbons were moved between summer and winter cages while inside their sleeping box. The main indoor cage of the white-handed gibbons had a glass front facing the visitors' area. A second, much smaller indoor cage was located above the first one. It contained the sleeping box and was not visible to the visitors.

Terms and definitions

Tool use: In this paper, I follow the definition of tool use as proposed by St. Amant and Horton (2008, p. 1203):

> "Tool use is the exertion of control over a freely manipulable external object (the tool) with the goal of (1) altering the physical properties of another object, substance, surface or medium (the target, which may be the tool user or another organism) via a dynamic mechanical interaction, or (2) mediating the flow of information between the tool user and the environment or other organisms in the environment."

Bioacoustic terms: Gibbon song bouts consist of "phrases" and occasional "single notes". "Great-calls" are the most stereotyped and most easily identifiable phrases of gibbon song bouts and are produced by females of all gibbon species. All other phrases are termed "short phrases" here. A particularly characteristic short phrase in gibbon duet songs is the male's "coda", which is produced at or near the end of the female's great-call. The combination of a female great-call and the corresponding coda is called a "great-call sequence". The short phrases occurring between the great-call sequences are termed "interlude sequences". A typical cycle of events occurring several times in a gibbon duet song bout begins with male short phrases (often accompanied by female short phrases), followed by the onset of a female great-call. The male falls silent during the build-up phase of the great-call and adds a coda at the climax. After that, he resumes the production of short phrases (again, with or without female short phrases). The first sonogram shown in Fig. 4 illustrates some of the terms used in this paper: note, great-call, short phrase, and coda.

Data collection and equipment

Observations were carried out non-systematically in the time periods of 7–21 July 1981, 3–4 Sept. 1981, and 21–24 Nov. 1981. The gibbons were kept in their outdoor cage during the first two observation periods and in the indoor cage during the last period.

Thirty-seven duet song bouts and three isolated female solo great-calls with no male contribution were monitored during this study, and 32 of these

Fig. 1. The white-handed gibbon pair. The female sits on the left, the male on the right. Photo: Thomas Geissmann. – *Das Weisshand-Gibbon-paar: Weibchen links, Männchen rechts*.

Fig. 2. The cage of the adult white-handed gibbon pair (male above, female below) at the Seeteufel Zoo in Studen, Switzerland. Photo: Thomas Geissmann. – *Der Käfig des erwachsenen Weisshand-Gibbonpaares im Zoo Seeteufel in Studen, Schweiz. Das Männchen ist oben, das Weibchen unten sichtbar*.

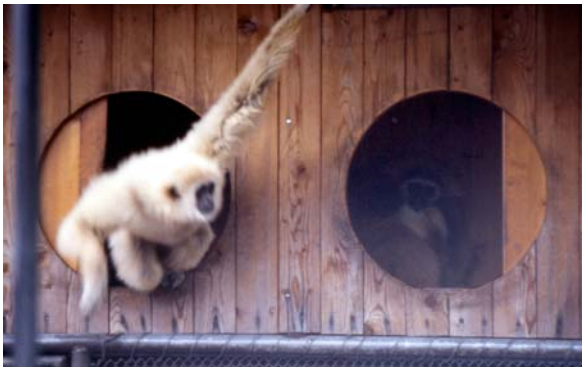

Fig. 3. The sleeping boxes of the white-handed gibbons. The male is just leaving his box, while the female can be seen sitting in her box. Photo: Thomas Geissmann. – *Die Schlafboxen der Weisshand-Gibbons. Das Männchen (links) verlässt soeben seine Box, während das Weibchen (rechts) in seiner Box sitzt*.

song bouts, or parts of them, were recorded on tape, including 52 great-call sequences. A male solo song bout was heard only once during this study (at 04:00 a.m.) and is not included in these numbers.

Tape-recordings were made with a UHER 4200 Report Stereo S and a UHER 4200 Report Stereo IC reel tape recorder (with tape speed set at 9.5 cm/s), equipped with a AKG directional microphone.

The sound material was digitised with a sample rate of 44.1 kHz and a sample size of 32 bit. Time versus frequency displays (sonagrams) of tape-recorded vocalisations were generated using the Canary software version 1.2.4 on an Apple Power Book G4. The FFT (*Fast Fourier Transformation*) size of the sonagrams was 2048 points with an overlap of 75% and a frame length of 512 points (frequency resolution = 10.77 Hz) (Charif *et al.*, 1995).

Results

Duet song bouts of the white-handed gibbon (*Hylobates lar*) pair at the Seeteufel Zoo in Studen were usually very short and had an average duration (± standard deviation) of 5.6 ± 5.4 min (n = 40 song bouts, range = 0.3-30.0 min). These duet song bouts usually included 1.6 ± 1.1 great-calls (n = 32 song bouts, range = 1–5 great-calls).

The female often exhibited an unusual behaviour during her great-call phrases. This is illustrated in the sonagrams of Fig. 4. Just a few seconds before her great-call phrases, she moved to her sleeping box (while singing) and sat in it, continuing to call from there. She half shut the sliding door, which is audible on many of the tape-recordings. At the climax of her great-call, the female slammed the sliding door of the sleeping box open, jumped out of the box and performed a short locomotor display. As part of the display she usually brachiated vigorously around the cage and occasionally hit the wire-mesh with her feet.

The bang of the sliding door changed the female's great-call. It did not necessarily make the call much louder but it added a broad-band signal to the purely tonal call of the gibbon and registered on the sonagrams as a vertical line (Fig. 4).

The sliding door display was used in about 53% of the great-calls (Table 1). In the outdoor cage, the proportion of great-calls with the sliding door display was higher (71%) than in the indoor cage (30%). The difference is statistically significant (Chi-square test, $df = 1$, $p < 0.004$). The lower proportion of sliding door displays in the indoor cage probably results from the design of that cage and the gibbons' preference for spending most of their time in the large main part of the cage which has a glass front facing the visitors' area, whereas the sleeping box with the sliding doors is located in a small and relatively dark separate part of the indoor cage from which the gibbons cannot view the visitors. Therefore, much of their singing in the indoor cage occurred away from the sliding door.

Table 1. Proportion of sliding door displays in female great-calls produced in the outdoor and in the indoor cage. – *Verhältnis zwischen* great-call-*Strophen mit und ohne "Türknall-Display", sowie Vergleich dieser Verhältnisse bei Strophen, die im Aussenkäfig (Sommer) und im Innenkäfig (Winter) produziert wurden.*

Cage	Sliding door display		Total
	Present	Absent	
Outdoor (summer)	20 (71.4%)	8 (28.6%)	28
Indoor (winter)	7 (30.4%)	16 (69.6%)	23
Total	27 (52.9%)	24 (47.1%)	51

Occasionally, the female did not produce a bang although she opened the sliding door during the climax of the great-call (37% or 10 out of 27 sliding door displays). This possibly occurred because the wooden sliding door did not slide very easily or because she did not get a good grip on the door.

Between great-calls, while the female contributed short phrases to the interlude sequences, she usually went back to the sleeping box, sat inside the sleeping box and half-way closed the door, to be in position and ready to repeat her display during the next great-call. The sound of the closing door could be clearly heard preceding six of the tape-recorded great-calls. The time interval from the closing of the door until the bang of the sliding door display was 33±13 s (range 23-56 s).

In five out of 32 song bouts tape-recorded during this study, the female was heard slamming the sliding door (n = 7 slams) while producing short phrases after a great-call.

The female was only once observed using the sliding door display other than during song bouts. This occurred after the gibbons were presented with a play-back of one of their own song bouts tape-recorded on the previous day. As a result of the play-back, both gibbons became agitated. They produced soft hoots during several minutes, brachiated around their cage, and repeatedly exhibited locomotor displays during which they hit the wire mesh with their feet in the direction of the loud-speaker. The female also slammed the sliding door of her sleeping box once during this situation.

The male white-handed gibbon was not observed to include the sliding door in his displays and he rarely entered the sleeping box during the song bouts. The same applied to the three groups of siamangs that were kept at the zoo and that had access to the same type of sleeping boxes.

Discussion

The female gibbon's use of a door as a part of her regular display at the climax of her great-calls

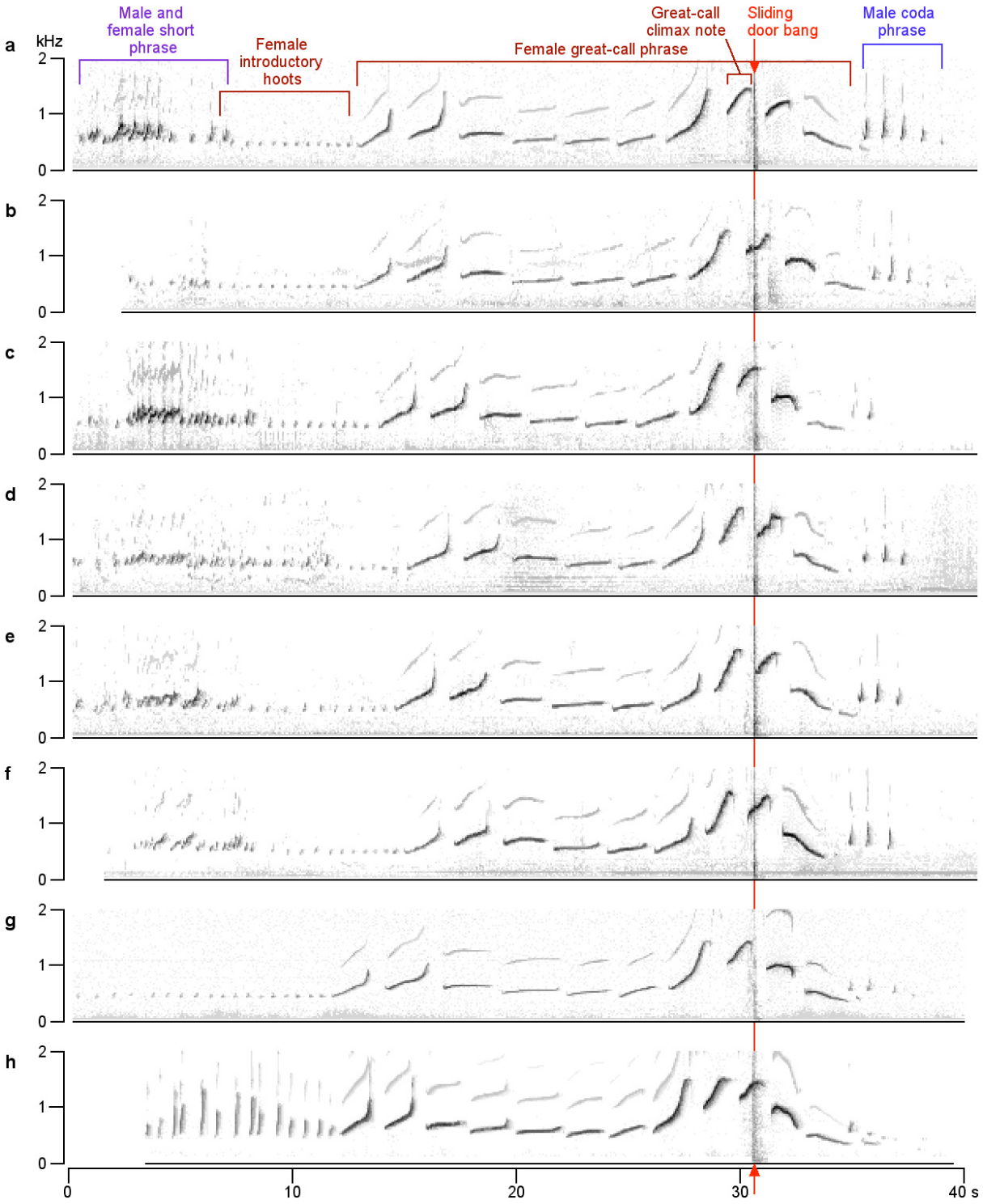

Fig. 4. Sonagrams showing short excerpts from duet song bouts by the pair of white-handed gibbons at the Seeteufel Zoo in Studen. At the climax of her great-calls (arrows), the female opens the sliding door of her sleeping box with a bang, which registers on the sonagrams as a vertical line. Sonagrams are aligned by this sound of the sliding door. Examples were tape-recorded in July (a-f) and September 1981 (g) in the outdoor cage, and in November 1981 (h) in the indoor cage. – *Sonagramme von Ausschnitten aus Duettgesängen des Weisshandgibbon-Paares im Zoo Seeteufel in Studen. Jeweils im Höhepunkt (*climax*) ihrer* great-call-*Strophe wirft das Weibchen die Schiebetür ihrer Schlafbox auf. Dieser Knall erscheint auf den Sonagrammen als vertikale Linie (Pfeil). In der Abbildung sind die Sonagramme untereinander nach diesem Knall ausgerichtet. Die Tonaufnahmen wurden im Juli (a-f) und September 1981 (g) vor dem Aussenkäfig und im November 1981 (h) vor dem Innenkäfig der Gibbons angefertigt*.

appears to be unique. I have carried out behavioural observations on all gibbon species, in captivity and in the wild, but I have not observed a comparable behaviour in other small apes.

The almost complete limitation of the female's door slamming behaviour to the song bout and to the climax of the great-call in particular suggests that her use of the door is functionally goal-directed and that the female may be consciously looking for the effect of this behaviour.

The only other use of the door slamming display occurred once in response to a play-back of a gibbon diet song. The play-back probably simulated the presence of a competitive second pair or even territorial intruders. The female's use of the door slamming display in response to the play-back may be functionally related to her displays in the duet song, which is also believed to be a signal directed at neighbouring groups and potential competitors (e.g. Geissmann, 2000b).

The door slamming of the gibbon female can be categorized as tool use according to the definition proposed by St. Amant and Horton (2008): The gibbon (tool user) controls a freely manipulable object (sliding door) as a tool to mediate the information perceived by potential competitors.

The case described in this study bears some similarity to observations of a wild male chimpanzee from the Gombe study site (Goodall, 1979, 1986; Kummer and Goodall, 1985; van Lawick-Goodall, 1965, p. 812f; 1971, p. 109f). In the early sixties there were occasionally a few empty four gallon paraffin cans lying about Jane Goodall's camp. "Mike", a low-ranking male, reportedly elevated his position to alpha rank within a four-month period by conducting a noisy display bellowing ferociously, rolling empty paraffin cans he found in the camp and banging them together as he came. "Goliath was the first alpha male that I knew. He lost his dominance in 1964 to Mike. A small male, Mike embellished his charging displays by banging empty kerosene cans and so intimidated the other males with the racket that in just a few months he bluffed his way to the top. We never saw him actually fight any of the other males, not even Goliath" (Goodall, 1979). According to Laland (cited in Milius, 1999), the case of the chimpanzee banging empty kerosene cans together is considered one of the textbook examples of behavioural innovations observed in animals.

The formal similarity between the gibbon example described in this study and the chimpanzee example reported by Goodall is obvious. In both cases, an ape puts extra whump in a threat display by banging objects together.

But the similarity may go deeper than pure analogy. Based on the detailed description provided by van Lawick-Goodall (1971, p. 109f), the display by chimpanzee "Mike" can be identified clearly as a "pant-hoot", which is homologous (i.e. phylogenetic equivalent) to the song of the gibbons in general and the great-call of gibbon females in particular (Geissmann, 2000b). Chimpanzee pant-hoots, gibbon song vocalizations, as well as the loud calls of other apes and Old World monkeys, and human singing are typically accompanied by locomotor displays and have been suggested to be homologous features that can be traced back to a behavioural pattern already present in the common ancestor of the catarrhine primates. This behaviour is originally believed to serve the purpose of displaying and possibly reinforcing the unity of a social group towards other groups (Geissmann, 2000b).

The human equivalent of the locomotor display (dancing) is often accentuated by tools (e.g. musical instruments in general and percussion instruments in particular). The locomotor displays of non-human primates (including gibbons) are often acoustically enhanced by branch-shaking, branch-breaking, or other movements through thick foliage (see review in Geissmann, 2000b). For instance, the locomotor display at the climax of chimpanzee pant-hoots may include dragging or flailing branches, throwing rocks or other loose material, slapping the ground with hands, stomping with feet, hitting or stamping at a tree (drumming display), seizing branches and swaying them vigorously from side to side, or showing exaggerated leaps or brachiation in a tree (Goodall, 1986). In captive primates (including gibbons), loud call displays are often accompanied by non-vocal acoustic signals such as banging the cage. None of these behaviours have been identified as tool use, although it may be worthwhile to consider them as potential starting points for tools use. Like the chimpanzee "Mike", the gibbon female of this study appears to use a tool to modify or accentuate the sound of loud calls. Events like these may have played a role in the evolution of human music.

The use of tin cans during the locomotor display of chimpanzee Mike has also been identified as tool use by McGrew (1992, p. 183). The author concluded that "[…] most non-subsistence tool use is poorly known. […] The repeated use of empty paraffin tins by a challenging adult male to enhance his agonistic display was similarly fascinating but idiosyncratic (Goodall, 1971). The tins were artificially introduced and then removed when their disruptive potential was realised."

Although there is an obvious similarity between the behaviour of chimpanzee Mike and that of the white-handed gibbon of this study, there is also a difference. Whereas the male chimpanzee reportedly gained an advantage (a raise in rank) through the use of the display-modifying tool, it is unclear whether the gibbon's tool use gave her an advantage compared to other females that did not use the tool.

Two other cases of tool use to modify primate calls have been reported. They are briefly summarised as follows:

(1) Wild orang-utans at Gunung Palung National Park, West Kalimantan, Indonesia were observed to use leaves as a tool to modify their kiss-squeak calls made during agonistic displays (including branch-

shaking and -braking) directed at the observer (Peters, 2001). The leaves were held against the mouth, in a half-folded hand. The behaviour was observed in 13 out of 15 observed individuals. The use of the leaves appeared to increase the intensity of the calls and the frequency range was also changed somewhat towards the higher frequencies.

(2) In a recent study at the Serra da Capivara National Park, Piaui state, north-eastern Brazil, capuchin monkeys (*Cebus apella libidinosus*) were observed to bang stones to produce sound in an aggressive display directed at the observer (Moura, 2007). This display was observed in six wild groups, and its primary function was suggested to be a predator-deterrent behaviour.

In both studies summarized above, the absence of the particular display in other populations of orangutans and capuchins, respectively, suggests that the behaviour could be a social tradition in the population studied.

Because the captive gibbon pair of this study was wild born and had no offspring, it was impossible to investigate social tradition of the female's unique display type.

As the female gibbon re-entered the sleeping box after producing a great-call and brought the sliding door to a half-closed position, it is also tempting to speculate that it was a pre-meditative act by which she prepared her next display in advance. The available evidence is not conclusive, however. Pre-meditative behaviour is known in chimpanzees (e.g. Osvath, 2009), but is apparently not known in gibbons.

In summary, the tool use in a female gibbon reported in this paper presents a singularity, as in several other reports on gibbon cognitive abilities. Small apes are underrepresented in cognitive research (Anderson, 2006). Yet, as suggested by this study, gibbons obviously have much to offer for our understanding of cognitive evolution in humans and apes. A renewal of interest in cognition in gibbons is urgently required, because it is very likely that gibbons still have some surprises left for us.

Acknowledgements

I thank the curators and staff members of the Seeteufel Zoo in Studen for permission to study the gibbons at their facility. I am grateful to Andrea Strasser and Natasha Arora for reading and commenting on this manuscript.

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Zusammenfassung

Tür-Schmettern: Werkzeuggebrauch bei einem weiblichen Weisshandgibbon (*Hylobates lar*)

Gibbons begleiten oftmals ihre Morgengesänge mit spektakulären Bewegungsdisplays und gelegentlichem Schütteln oder Abbrechen von Ästen der Baumkronen. Diese Displays finden normalerweise im Höhepunkt des *great-calls* statt, der auffälligsten und am meisten stereotyp verlaufenden Strophe des Weibchens. In dieser Studie wird ein in einem Zoo le-

bendes Weisshandgibbon-Weibchen untersucht, welches sich zum Singen seiner *great-call*-Strophen in eine hölzerne Schlafbox setzte, die Schiebetür der Box halb zuschob und den Höhepunkt der *great-calls* damit unterstrich, dass es mit einem Knall die Schiebetür der Schlafbox aufwarf. Der Knall verlieh den tonalen Rufen dieser Strophe einen einzigartigen, geräuschhaften Akzent und dürfte die Wirkung des Rufes auf die Empfänger (vermutlich weibliche Artgenossen) verstärkt haben. Der Einsatz einer Schiebetür zur Veränderung der Rufe stellt eine neuartige Verhaltensvariante dar and einen der wenigen Fälle von Werkzeuggebrauch bei kleinen Menschenaffen. Verhaltensinnovationen wie diese dürften eine Rolle bei der Evolution menschlicher Musik gespielt haben.