Journal of Ethology (2023) 41:5–13
https://doi.org/10.1007/s10164-022-00764-z

VIDEO ARTICLE

Stone handling in geladas (*Theropithecus gelada*): implications for spontaneous drawing-like activity as a playful behavior

Virginia Pallante[1] · Achim Johann[2] · Michael A. Huffman[3] · Elisabetta Palagi[4]

Received: 26 January 2022 / Accepted: 1 October 2022 / Published online: 7 November 2022

Abstract

Stone handling (SH) is a form of solitary object play widely documented in four species of macaques and most recently also in geladas (*Theropithecus gelada*). Here, we describe the SH activity of two mother-reared captive gelada males, who combined different behavioral patterns in a sequence that occasionally led to the production of colored marks on a hard surface. Two playful techniques of different complexity emerged spontaneously in the two subjects. In the *etching and releasing technique,* the stone or pieces of it were repeatedly scraped across either a vertical or horizontal hard surface. In the *grind and finger technique,* additional patterns were recruited such as scratching the stone to produce small debris that the subjects manipulated through a thumb–index finger precision grip. Animals selected preferentially hard surfaces when their SH sessions involved patterns that potentially released color and engaged in such patterns for longer and in a repeated way. This evidence suggests the high motivation of the two males to engage in drawing-like behavior that, as it occurs for other forms of play, can be characterized by its *autotelic self-rewarding* nature. Digital video images related to the article are available at http://www.momo-p.com/showdetail-e.php?movieid=momo220922tg01a and http://www.momo-p.com/showdetail-e.php?movieid=momo220923tg01a

Keywords Self-rewarding purpose · Untrained animals · Spontaneous drawing · Etching · Releasing technique · Grind · Finger technique · *Theropithecus gelada*

Introduction

Object play is a widespread form of play consisting of a solitary or social spontaneous activity that involves manipulating inanimate objects without an apparent immediate purpose (Hall 1998; Burghardt 2015). Stone handling (SH) is a form of object play well reported in non-human primates (Nahallage et al. 2016), that has been formerly described in four species of the genus *Macaca* that show both similar and species-specific SH behaviors (*Macaca fascicularis*, Cenni et al. 2020; *Macaca fuscata*, Hiraiwa 1975; Huffman 1984; *Macaca mulatta*, Nahallage and Huffman 2008; *Macaca cyclopis*, Nahallage et al. 2016). Stone handling is readily distinguishable in form and activity context from the occasional pick up, examination, and discard of a stone or other object by a monkey or ape engaged in exploration. This playful activity consists of the manipulation of stones in a series of patterns variously organized in spatio-temporal and kinematic sequences that can be structurally complex and diversified. (Huffman 1984; Leca et al. 2007; Pellis et al. 2019). These patterns can be inter-mixed, creating unpredictable and novel situations which ultimately share a common self-rewarding nature for the player (Burghardt 2015). In a recent study, Cangiano and Palagi (2020) documented for the first time the occurrence of SH in a non-human primate species outside the genus *Macaca*, that being *Theropithecus gelada*. In the group of captive geladas under study, all age–sex classes of individuals engaged in SH. In geladas, SH is highly variable at an individual level and includes not

✉ Virginia Pallante
VPallante@nscr.nl

✉ Elisabetta Palagi
elisabetta.palagi@unipi.it

1 Netherlands Institute for the Study of Crime and Law Enforcement, Amsterdam, The Netherlands

2 NaturZoo Rheine, Rheine, Germany

3 Primate Research Institute, Kyoto University, Kyoto, Japan

4 Department of Biology, Unit of Ethology, University of Pisa, Pisa, Italy

only several patterns previously described in macaques, but also new ones that are unique to the species (Cangiano and Palagi 2020). The propensity for geladas to engage in SH can be linked to the feeding techniques of the species (Fashing et al. 2014). Gelada hands are characterized by long thumbs, a high robusticity index (finger diameter/finger length), and the highest thumb-to-digits ratio among Catarrhines. Their hand anatomy is the closest to humans of all Catarrhines (Fashing et al. 2014).

As other object play activities, drawing-like behavior has been reported to be self-rewarding in a number of animal species. This activity requires the use of a tool that is traditionally defined as a freely manipulable object, which is used to modify another object (Call 2013). Although drawing abilities have been mainly attributed to humans, several cases of drawing-like behavior have also been documented in non-human animals (great apes, Morris 1962, see also Martinet and Pelé 2021 for a review; Asian elephant, Gucwa and Ehmann 1985). During this activity, the release of colored marks occurs using specific tools and pigment combinations but also implies the development of manipulative techniques including the handling of an object to produce a colored mark and the scratching of a surface to reveal the color (Martinet and Pelé 2021). In great apes, the propensity to engage in reward-free drawing emerged from enrichment programs by simply providing artificial tools (Hanazuka et al. 2019; Pelé et al. 2021). The drawing-like behavior was also induced via active training by caregivers/researchers (Iversen and Matsuzawa 1996, 1997; Martinet et al. 2021). Although there are some anecdotal observations on the spontaneous drawing behavior in primates (e.g., capuchin monkeys, Klüver 1933), no qualitative or quantitative studies of drawing-like behavior have ever been provided.

Here, we report on a spontaneous drawing-like activity using stones in two gelada males, a dominant and a follower male, who were hosted in the same colony of that studied by Cangiano and Palagi (2020). The two males combined SH patterns already described by Cangiano and Palagi (2020) with other SH patterns that have not been reported for the other subjects in the same study. The peculiarity of the SH activity of these two males is that it led to the release of color on hard surfaces where the stones were manipulated. As for the other Catarrhines, geladas are also equipped with trichromatic vision and are, therefore, able to perceive differences in colors (Surridge et al. 2003; Bergman and Beehner 2008; Hiramatsu et al. 2017).

Despite the difficulties of understanding whether a behavior is intentionally enacted, if releasing of color is an important part of a SH session, we expect animals to preferentially select hard surfaces while engaging in patterns that better afford the release of color. If these predictions will be confirmed, we can hypothesize that animals are motivated to engage in drawing-like behavior as a form of solitary, manipulative play that is self-rewarding for the subjects (see Burghardt 2015 for an extensive review).

Methods

Individuals studied

We observed two gelada males (Bako and Bernd) living in a captive colony (OMU2) at the Naturzoo (Rheine, Germany). At the time of observation, the colony was composed of one adult male (Bako, born in 2003), 5 adult females, one sub-adult male (Bernd, born in 2005), 2 sub-adult females, and 11 immature subjects. Bako and Bernd were born in captivity, mother-reared and had never received any form of human training (*Theropithecus gelada* Studbook, European Endangered species Programme, EEP). The same zoological institution hosted in an adjacent but separated enclosure a second colony (OMU1) of geladas. The two colonies were physically separated but partly in visible contact, since they occupied two adjacent enclosures. Each enclosure consisted of indoor (a room of 36 m^2) and outdoor facilities (an island of 2700 m^2 surrounded by a boundary ditch). The animals could freely move from indoors to outdoors; however, we had access to observe the animals only when they were present in the outdoor facility. Researchers and visitors had the opportunity to observe animals from a distance without interfering and modifying their behavior. Keepers limited their contact with them to provide food and to clean the enclosure. Therefore, no other direct interactions were possible between animal and human subjects.

Data collection

The two gelada colonies have been observed during the summer months for several years (2007, 2009, 2010, 2011, 2014 and 2017). However, the SH techniques described in the present report were observed exclusively during the study period of July–August in 2010 and in 2011. Although initially our data collection was not specifically focused on SH behavior, after observing the first SH drawing-like events displayed by Bako and Bernd, we started video-recording their SH activity via all-occurrences sampling (Altmann 1974). The video collection started as soon as the subject was observed touching the stone independently from the nature of the surface (*hard surface* vs *soft surface*) and ended when the subject abandoned the stone for at least 10 s (see also Cangiano and Palagi, 2020). We collected 45 videos, 40 of which included a SH session with drawing-like behaviors (Table S1, Fig. 1 http://www.momo-p.com/showdetail-e.php?movieid=momo220922tg01a, Fig. 2, http://www.momo-p.com/showdetail-e.php?movieid=momo220923tg01a), and 5 videos included a SH session with no

Fig. 1 Bernd using the *etching and releasing technique* during a drawing-like session. The production of white marks on the gray surface of the cliff is clearly visible. (http://www.momo-p.com/showdetail-e.php?movieid=momo220922tg01a)

drawing-like behaviors. With the term *hard surface*, we refer to specific locations characterized by a vertical or horizontal flat surface on the artificial cliffs, a concrete surface or other larger stones in the outdoor enclosure. With the term *soft surface* we refer to locations characterized by soil on the ground and grass that does not afford leaving marks.

In the following years of data collection, Bako and Bernd were no longer present in the colony under study, and these two SH behaviors were never observed in other individuals in subsequent years of our study.

Videos were analyzed frame-by-frame to extract all the patterns forming each SH session and the duration of the session itself. Table 1 shows the detailed description of each pattern observed. Table 1 includes both behaviors that have been described by Cangiano and Palagi (2020) and new behaviors that have observed only in Bako and Bernd's stone handling sessions. Table S1 shows the list of the sessions with their durations in seconds. We counted the number of times (bouts) and the duration of each pattern occurring in a given session. For each pattern, we took notes about the surface (*hard surface*, *soft surface*) on which the stone was manipulated. Moreover, we extracted information on the hand used to manipulate the stone (left, right, both).

Statistics

For both individuals, we evaluated the hand-preference characterizing those patterns involving a precision grip (*Removal, Precise manipulation of small debris/flakes, Rub small debris/flakes*, see Table 1 for the definitions) and those not involving a precision grip (*Carry, Drag back, Fingertips, Flip, Gather, Hold, Move stone away, Pick, Push, Rub the stone, Roll the stone, Slamming, Spinning*) using the Handedness Index (HI). The HI scores range between −1 and + 1, with negative values indicating left handedness, and positive values reflecting right handedness (Hopkins 1999; Wiper 2017).

To analyze which surface (hard or soft) animals selected to perform each pattern, we applied a Chi-square test. We ran this analysis on those SH patterns involving direct contact between the stone and the surface.

Due to the non-independence of data, the randomization paired sample t-test was used to compare the frequency of the rubbing and the time spent in reinforcing the action during the SH sessions performed on hard- and soft surfaces.

Results

In 2010 and 2011, the dominant adult male Bako and the sub-adult male Bernd were observed to spontaneously produce colored marks from material rubbed on substrates in their outdoor enclosure. During a solitary drawing session, the first phase was characterized by the selection of suitable material; i.e., stones that could release the color (Supplementary Material S1; Fig. 2, 00:19–00:24, http://www.momo-p.com/showdetail-e.php?movieid=momo220923tg01a). The males first picked up a white stone or a large red brick present in the enclosure that was left over from recent construction activities inside the enclosure. Next, they carried the material to specific locations characterized by a vertical or horizontal flat surface on the artificial cliffs (Figure S1), a concrete surface or other larger stones (Figure S2). Although the areas covered by *soft surfaces*, not suitable to afford leaving marks

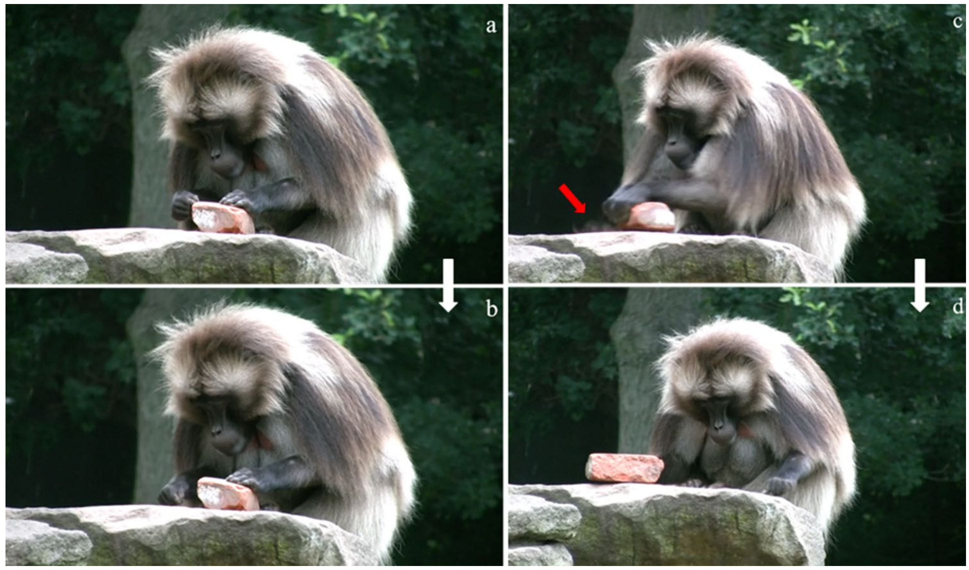

Fig. 2 Bako alternating *etching and releasing technique* (**a**, **b**) and *grind and finger techniques* (**c**, **d**) during a "drawing-like session". **a** removing small pieces from the stone; **b** rubbing the pieces of stone on the hard surface; **c** rubbing the brick and producing powder and large debris (red arrow); **d** moving the produced material around the surface by performing fingertips. (http://www.momo-p.com/showdetail-e.php?movieid=momo220923tg01a)

Table 1 Ethogram and definitions of the motor patterns recorded (alphabetical order) during the etching and releasing technique (ERT) and grind and finger technique (GFT)

Behaviours	Definition
Airplane	Lifting a stone with two hands over the head while standing up. This up and down movement is often repeated
Bite/lick/sniff	Licking, biting, and sniffing a stone
Carry	Carrying a stone from one place to another of the enclosure with one or both hands
Drag back	Dragging a stone while walking back
Fingertips*	Moving the fingertips on a surface covered with powder or debris. The pattern mainly involves the index finger, although sometimes it can be performed with all the fingers
Flip	Turn a stone (often associated with drag back)
Gather	Gather stones into a pile in front of oneself
Hold	Hold and/or block the stone with one hand
Move stone away*	This pattern consists in a single gesture aimed at pushing the stone away more distant from the surface where it was previously manipulated, increasing the area available to perform further SH patterns with different stones on the same surface
Pick	Picking up a stone with the whole hand or both hands
Precise manipulation of small debris/flakes*	Picking up/manipulating/holding small flakes/debris present on a surface by opposing the thumb and the index finger (precision grip)
Push	Move forward the stone by pushing it
Removal*	Removing small pieces from the main stone using the index finger or by using both the thumb and the index finger (precision grip)
Rub small debris/flakes*	Rubbing small flakes and debris on a surface by holding them between the thumb and the index finger (precision grip)
Rub the stone	Rubbing a stone on a surface. The movement involves the whole hand or both hands (power grip)
Roll the stone	Rolling a stone on a surface. The movement involved the whole hand or both hands
Scattering	Scattering small stones piled on the ground with repeated movements involving fingers or the whole hand
Sitting on the stone	Go up to and sit on the stone
Slamming*	Slamming a stone on a surface. Powder production. Always including both hands
Spinning	Spinning the stone on a surface in both clockwise and counterclockwise

Some definitions are extracted from Cangiano and Palagi 2020 and the new patterns are reported with an *

(e.g., soil on the ground, grass), were much larger than those suitable to allow drawing-like techniques, animals selected the spots characterized by a concrete surface or large stones in 71% of recorded cases. Despite the preferences for *hard-surface* locations, we never observed the two individuals defending these spots.

Among the SH patterns involving a direct contact between the stone and the surface, *Fingertips, Flip, Rub small debris/flakes* and *Rub a stone* were more frequently performed on the hard- than on the soft surface. Moreover, *Drag back, Rub small debris/flakes,* and *Slamming* were always performed on a concrete surface or large stone (for the statistical results see Fig. 3 legend). Since rubbing was the pattern performed most frequently, we focused on it for the subsequent analyses. Bako and Bernd both spent a larger amount of time in rubbing the stone on a hard- compared to soft surface (*Rub the stone on hard surface* vs *Rub the stone on soft surface,* paired t-sample test: $t = -5.483$, $n = 35$ sessions, $p < 0.0001$). When the rubbing was performed on a hard surface, the bouts were repeated and reiterated more frequently (*rub the stone on hard surface* vs *rub the stone on soft surface*, paired t-sample test: $t = -5.525$, $n = 35$ sessions, $p < 0.0001$, Fig. 4).

When it was possible to follow the session from its beginning, before engaging in *rubbing* on hard surface, animals always carried the stones from other spots of the enclosure (ranging from 1 to 10 m of distance).

As for the hand preference in manipulating the stones according to the presence/absence of a precision grip motor execution, the analysis revealed a left hand preference for Bako ($HI_{precision} = -0.126 \pm 0.20$ SE; $HI_{nonprecision} = -0.057 \pm 0.25$ SE), while Bernd showed a right hand preference in the case of precision grip hand patterns ($HI_{precision} = 0.165 \pm 0.21$ SE) and a left hand preference for non-precision grip hand patterns ($HI_{nonprecision} = -0.059 \pm 0.16$ SE).

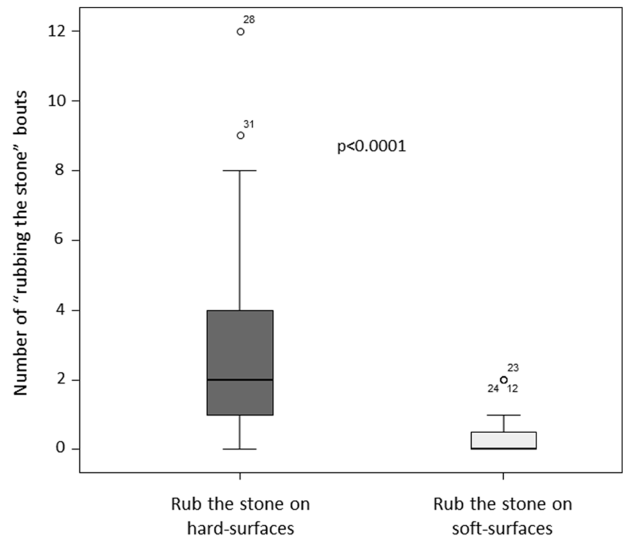

Fig. 4 Boxplot showing the number of "rub the stone" bouts characterizing each SH session performed on hard- (gray bar) and soft surface (white bar)

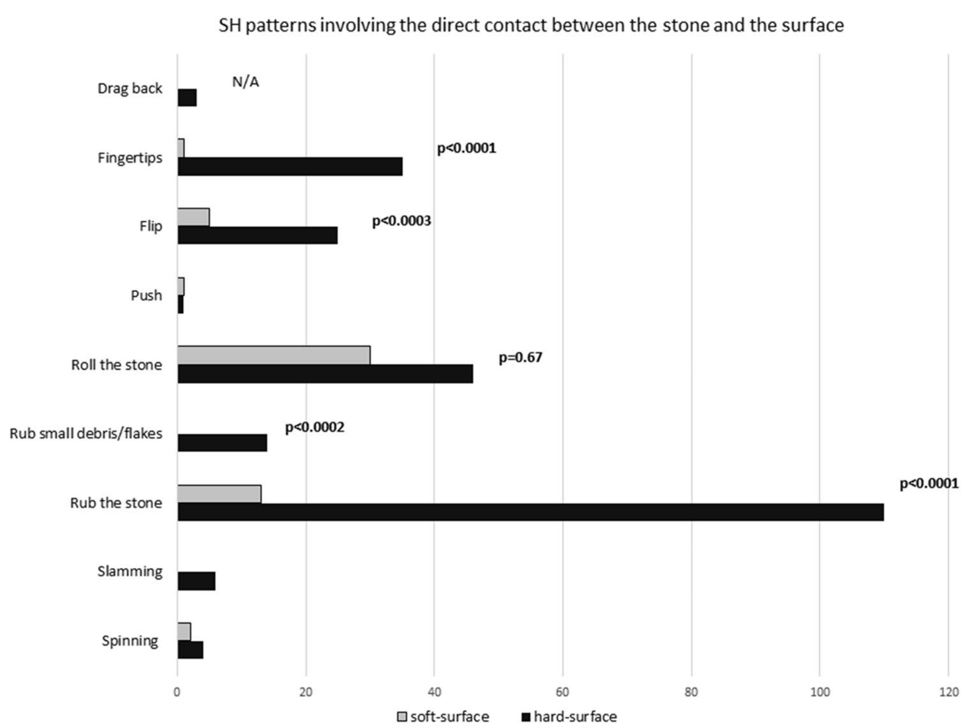

Fig. 3 Number of times each SH pattern has been performed against a soft surface (gray bars) or a hard surface (black bars) ($df = 1$). Only the patterns involving direct contact between the stone and the surface are shown. Chi-square *fingertips* = 32.11; Chi-square *flip* = 13.33; Chi-square *roll the stone* = 3.37; Chi-square *rub small debris/flakes* = 14.00; Chi-square *rub the stone* = 76.49. The p values are reported in the graph. N/A = number of cases that did not allow calculation of the Chi-square test (expected values < 5)

Video description

We recorded variability in the drawing-like behavior modalities that we identified as two different techniques. Bernd was observed to use only the *etching and releasing technique* (ERT) ($N=22$ sessions, Fig. 1, http://www.momo-p.com/showdetail-e.php?movieid=momo220922tg01a), while Bako performed this ($N=6$ sessions) and the more complex *grind and finger technique* (GFT) ($N=12$ sessions, Fig. 2). With the *etching and releasing technique* (ERT), the entire stone or pieces of it were repeatedly scraped across either a vertical or horizontal hard surface. According to the size of the stone, this activity involved both uni-manual and bi-manual actions to produce salient marks on the surface. With this technique, Bernd used the entire stone to produce colored marks (Supplementary Material S1; Fig. 1, 00:05–00:13, http://www.momo-p.com/showdetail-e.php?movieid=momo220922tg01a).

Here, we provide the description of a session documenting a ET sequence performed by Bernd from Fig. 1 (see Table 1 for the detailed definitions of the item described here):

Bernd sits on a stone in a recess of the cliff in the enclosure. He holds a stone in his left hand, rolling it on an upper hard surface without paying much attention to it (*roll the stone*). He suddenly grabs the stone with both hands and starts rubbing it on the sloped gray hard surface where he sits (*rub the stone*), following a movement from up to down and producing highly visible white marks on it. His eyes are now focused on the marks produced. His vigorous rubbing is visible by the movement of his body, walking backwards to prolong the rub on the available surface. After 9 s (00:14 in the video), he moves to a nearby ledge on the cliff, carrying the stone with him (*carry*). Sitting again, he alternates rubbing and rolling the white stone on a surface at his eye level but he is soon distracted by some screams coming from the group below. At 00:29 in the video, he moves to a third ledge on the cliff, carrying again the stone in his hand. He sits and starts another rubbing session with both hands. The dark surface of the cliff highlights the white marks released by the stone. This time, the stone is moved not only up and down, but also laterally. While the right hand alternates rubbing with rolling actions, the left hand performs two movements. First, he removes small pieces from the side of the stone (*removal*) and, after a few seconds, he scatters *(scattering)* those pieces over the surface where the stone was rubbed. After the scattering phase, Bernd leaves the stone falling from the ledge, looking down at it from above.

The main characteristic of the *etching and releasing technique* (ERT) consists of applying the color by rubbing the white stone onto a hard surface.

Bako has been observed to sometimes detach small pieces from a larger stone, grasping the small pieces between his thumb and index finger while scraping them across a horizontal surface (precision grip, Fig. 2, 02:20–02:28, http://www.momo-p.com/showdetail-e.php?movieid=momo220923tg01a). In the *grind and finger technique* many motor patterns were recruited, including rubbing, rolling, and scratching the stone to produce small debris (Table 1). When Bako appeared to be satisfied with the amount of debris obtained, he used his thumb and index finger of either the left or right hand and rubbed the debris on the hard surface (Supplementary Material S1; Fig. 2, 00:55–01:09, http://www.momo-p.com/showdetail-e.php?movieid=momo220923tg01a). Phases of the *grind and finger technique* could be alternated with phases of *etching and releasing technique* resulting in a more complex sequence of actions (Supplementary Material S1; Fig. 2, 02:00–03:04, http://www.momo-p.com/showdetail-e.php?movieid=momo220923tg01a).

Here, we provide the description of a session performed by Bako from Fig. 2, http://www.momo-p.com/showdetail-e.php?movieid=momo220923tg01a (see Table 1 for the detailed definitions of the item described here):

On a quiet summer evening, Bako is handling some of the several stones lying on the ground of the enclosure. He moves from one to the other, briefly rolling (*roll the stone*) or carrying them around (*carry*). After manipulating a couple of them, he selects a red brick (*pick*) and jumps up onto the artificial cliff in the middle of the enclosure. He sits on one of the largest ledges and starts to roll the brick on the cliff's gray hard surface (*roll the stone*) and, with eyes focused on the tool as he moves it back and forth with both of his hands. After 15 s, he stops moving it, removes some small parts from it (*removal*), and places them on the hard surface where he was rolling and rubbing the larger piece (*rub the stone*). He resumes the initial movement for an additional 10 s, first keeping an eye on his companions below and then vigorously increasing the rolling and *slamming* of the brick, that visibly produces red powder which is indicated by the red arrow in Fig. 2c. It is at this point that he pushes the brick to the side (*move stone away*) and with fine movements of the thumb and index finger of the right hand starts to seemingly trace out "patterns" on the surface with the powder (*fingertips*), his eyes focused on it. Five seconds later, rolling the brick starts again for an additional 10 s, followed by the apparent drawing out of patterns on the surface. In one of the subsequent sessions, he introduces a new behavior. He actively removes pieces from the surface of the brick (*removal*). This time these small pieces are held between the thumb and the index finger (*precise manipulation of small debris/flakes*) and rubbed on the lighter colored surface of the cliff (*rub small debris/flakes*). The alternation of the two movements—brick rolling/rubbing and moving the fingers on the powder/small debris covering the surface of the ledge—continues for a couple of minutes. In the end, Bako becomes distracted, loses his balance and falls from the ledge onto the next one below. He immediately reaches out for the brick that was left above, accidentally dropping it on the ground, thus terminating the SH session. The cliff's horizontal surface where the behavior occurred was too high to be video recorded, so the observers were unfortunately not able to see the marks Bako produced. Nonetheless, this behavior explains the presence we noticed of visible red marks on the surfaces of about ten other ledges on the cliff, making us confident that such 'drawings' were made by the alpha male (Figure S1).

The term *grind and finger technique* can include: removing small pieces (Fig. 2a), rubbing small debris with the thumb and index fingers (precision grip, Fig. 2b), producing powder from a colored brick (Fig. 2c), and moving the fingertips on a surface covered by powder (Fig. 2c). Since in the videos it was not always possible to clearly see the marks produced, after video-recording the observers verified the presence of the marks on the hard surface located in different spots. For the exact description of the movements performed by Bako during the whole sequence see Supplementary Material S1.

In two cases, we observed Bernd first looking at Bako engaging in a GFT session and after a few seconds starting an ERT session.

Discussion

In this paper, we described how two SH techniques involved not only the simple manipulation of the stones but also specific patterns that potentially afford the release of colored marks on surfaces, a behavior that in other non-human primate species has been defined as 'drawing' (MacDonald 2014; Martinet and Pelé 2021). Different from several cases of drawing reported in the literature, the drawing-like activity described here does not derive from any specific training given by caregivers, but rather it is the spontaneous outcome of the subjects' propensity to handle stones (Cangiano and Palagi 2020). Due to the numerous different patterns recruited for the activities, the two 'drawing-like' techniques represent different degrees of complexity performed by Bernd (*etching and releasing technique*) and Bako (*grind and finger technique*) that also showed a slight difference of hand preference in manipulating the stones. These observations are in line with previous findings of SH in geladas and macaques, with adults engaging in more complex and demanding manipulative patterns compared to immature subjects (Nahallage and Huffman 2007; Cangiano and Palagi 2020).

The attention devoted by Bako to the selection of the brick (Fig. 2, 00:19–00:24, http://www.momo-p.com/showdetail-e.php?movieid=momo220923tg01a), the production of material, pushing aside the stone to apparently increase the available hard surface and the removal of the powder from the surface by his fingers (Fig. 2, 00:55–01:09 and 02:00–03:04, http://www.momo-p.com/showdetail-e.php?movieid=momo220923tg01a) led us to hypothesize the presence of a context specific action sequence that, in other primates, have been sufficient to fulfill the criteria used to categorize such a behavior as drawing (Martinet and Pelé 2021).

Although we cannot conclude that the two gelada males engaged in these 'drawing-like' techniques to intentionally produce the colored marks, we found that animals highly selected preferred hard surfaces when their SH sessions involved patterns that potentially released color (Fig. 3). *Rub the stone*, the most frequent pattern characterizing the drawing-like sessions, not only lasted longer but it was also formed by reiterated bouts when performed on a hard surface (Fig. 4). These results reveal the high motivation of our subjects to engage in drawing-like behavior, thus suggesting the presence of a self-rewarding component of the activity. As it occurs for other forms of play, the emergence of a spontaneous, innovative, and complex form of behavior is clear evidence of the *autotelic self-rewarding* nature of play (i.e., play for its own sake) (Huffman 1984; Burghardt 2015; Pellis and Burghardt 2017).

Together with the self-rewarding nature characterizing SH behavior, past and recent studies have documented just how different SH patterns may actually acquire new functions under different social contexts (Huffman and Quiatt 1986; Leca et al. 2008; Tan 2017; Cenni et al. 2020, 2022). In long-tailed macaques (*Macaca fascicularis*), two SH patterns usually characterized as playful actions have been co-opted into self-directed tool-assisted masturbating behaviors (Cenni et al. 2022). This functional shift has been possible through a process of affordance learning, mediated by the exploration and the discovery of new spatio-temporal relations of the objects (Lockman 2000). Although speculative, our hypothesis is that a similar process could lead to the development of the stone manipulative techniques associated to drawing behavior. The release of marks by accidentally performing SH on a surface of contrasting color may act as a self-rewarding stimulus for the performer that reinforces the motivation to explore possible additional functions in the use of the stone, ultimately leading to the drawing activity. As for the previous cases of functional shift, the self-rewarding mechanism characterizing the manipulation of stones in playful context would be maintained and enhanced in the new context where the stones are used, thus fostering the acquisition of the potential multiple functions that the object may provide (i.e., creativity). Although the activity of Bako and Bernd provides only limited evidence for such transition, we hope that our observations would be the starting point for future studies on drawing activity in animals.

Our considerations on the self-rewarding nature of drawing-like behavior raise, however, a simple question. If such activity is so self-rewarding, why is it performed by only two individuals in the colony? In 2020, by reporting data on the same gelada colony, Cangiano and Palagi highlighted the high levels of individual variability in the SH performance. This was due not only to the large amount of different patterns recruited during a single SH session but also to their combination in terms of relative number and sequences. The same individual variability has been observed also in drawing-like contexts in other primate species. In a study conducted on five female orangutans (*Pongo pygmaeus*), the authors evaluated the individual differences in both modalities and frequency of drawing behavior expressed by the animals (Pelé et al. 2021). Despite caretakers regularly facilitating drawing activities by providing the apes with the necessary material (pastels and sheets) and the same opportunities to draw, the daily amount of drawings produced varied significantly between individuals. The orangutans also differed in the drawing techniques, with some holding the drawing tool between their fingers and others laying the pastel and rolling it on the sheet. The authors discussed their results in terms of a different motivation in engaging in exploratory and manipulative play, and differences in personality traits and "*states of mind*" (Pelé et al. 2021, p. 1). Despite the different material available to engage in drawing-like behavior characterizing the two studies (artificial vs natural), the data on individual variability reported by Pelé et al. (2021) in a great ape species are similar to those obtained in our study on a monkey species. Individual variability in manipulation, object play and tool use are widespread and, depending on the type of actions and contexts, there are several factors that contribute to the diversity in the performance (Call 2013; Burghardt 2015). Proximate factors can include individual life experience (Call 2013), learning mechanisms (Bandini and Tennie 2020), and the level of cognitive functional fixedness in the use of an object (Munoz-Rubke et al. 2018). The autotelic nature of SH activities together with such factors can explain the individual difference in the drawing techniques and their maintenance over time described in Bernd and Bako. Despite the descriptive nature of our report on drawing-like behavior, the observation of such rare spontaneous playful activities in geladas opens interesting scenarios. By applying the "parsimony principle" (de Waal 2012, p. 97), the possibility to explore object play variability in the light of animal personalities and motivational propensities in monkeys can help trace back the evolutionary pathways of the drawing behavior already reported in great apes and humans.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10164-022-00764-z.

Acknowledgements We wish to thank Valeria Murianni for helping in the video collection and the keepers of the Rheine Zoo for facilitating this work with animals. We thank William McGrew and Marie Pelé for the revision of earlier versions of the manuscript and two anonymous reviewers for their input.

Funding Open access funding provided by Università di Pisa within the CRUI-CARE Agreement. No funds for this study.

Declarations

Conflict of interest The authors declare no conflict of interests.

Ethical note All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. The data reported here derive from non-invasive research that is compliant with the current German law and Pisa University regulations. Thus, no permit from the Bio-Ethical Committee was needed.

References

Altmann J (1974) Observational study of behavior: sampling methods. Behaviour 49:227–266

Bandini E, Tennie C (2020) Exploring the role of individual learning in animal tool-use. PeerJ 8:e9877. https://doi.org/10.7717/peerj.9877

Bergman TJ, Beehner JC (2008) A simple method for measuring colour in wild animals: validation and use on chest patch colour in geladas (*Theropithecus gelada*). Biol J Linnean Soc 94:231–240. https://doi.org/10.1111/j.1095-8312.2008.00981.x

Burghardt GM (2015) Creativity, play, and the pace of evolution. In: Kaufman AB, Kaufman JC (eds) Animal, creativity and innovation. Elsevier Academic Press, San Diego, CA, USA, pp 129–159

Call J (2013) Three ingredients for becoming a creative tool user. In: Sanz C, Call J, Boesch C (eds) Tool use in animals: cognition and ecology. Cambridge University Press, Cambridge, UK, pp 3–20

Cangiano M, Palagi E (2020) First evidence of stone handling in geladas: from simple to more complex forms of object play. Behav Process 180:104253. https://doi.org/10.1016/j.beproc.2020.104253

Cenni C, Casarrubea M, Gunst N, Vasey PL, Pellis SM, Wandia IN, Leca JB (2020) Inferring functional patterns of tool use behavior from the temporal structure of object play sequences in a non-human primate species. Physiol Behav 222:112938. https://doi.org/10.1016/j.physbeh.2020.112938

Cenni C, Christie JB, Van der Pant Y, Gunst N, Vasey PL, Wandia IN, Leca JB (2022) Do monkeys use sex toys? Evidence of stone

tool-assisted masturbation in free-ranging long-tailed macaques. Ethology 128(9):632–646. https://doi.org/10.1111/eth.13324
de Waal FBM (2012) Empathy in primates and other mammals. In: Decety J (ed) Empathy—from bench to bedside. The MIT Press, Massachusetts, pp 87–106
Fashing PJ, Nguyen N, Venkataraman VV, Kerby JT (2014) Gelada feeding ecology in an intact ecosystem at Guassa, Ethiopia: variability over time and implications for theropith and hominin dietary evolution. Am J Phys Anthropol 155:1–16. https://doi.org/10.1002/ajpa.22559
Gucwa D, Ehmann J (1985) To whom it may concern: an investigation of the art of elephants. Norton and Company, Boston
Hall S (1998) Object play by adult animals. In: Bekoff M, Byers JA (eds) Animal play: evolutionary, comparative, and ecological perspectives. Cambridge University Press, Cambridge, UK, pp 45–60
Hanazuka Y, Kurotori H, Shimizu M, Midorikawa A (2019) The effects of the environment on the drawings of an extraordinarily productive orangutan (*Pongo pygmaeus*) artist. Front Psychol 10:2050. https://doi.org/10.3389/fpsyg.2019.02050
Hiraiwa M (1975) Pebble-collecting behavior by juvenile Japanese monkeys. Monkey 19:24–25 ((**in Japanese**))
Hiramatsu C, Melin AD, Allen WL, Dubuc C, Higham JP (2017) Experimental evidence that primate trichromacy is well suited for detecting primate social colour signals. Proc R Soc Lond B Biol Sci 284:20162458. https://doi.org/10.1098/rspb.2016.2458
Hopkins WD (1999) On the other hand: statistical issues in the assessment and interpretation of hand preference data in nonhuman primates. Int J Primatol 20(6):851–866. https://doi.org/10.1023/A:1020822401195
Huffman MA (1984) Stone-play of *Macaca fuscata* in Arashiyama B troop: transmission of a non-adaptive behavior. J Hum Evol 13:725–735. https://doi.org/10.1016/S0047-2484(84)80022-6
Huffman MA, Quiatt D (1986) Stone handling by Japanese macaques *Macaca fuscata*: implications for tool use of stone. Primates 27:427–437. https://doi.org/10.1007/BF02381887
Iversen IH, Matsuzawa T (1996) Visually guided drawing in the chimpanzee (*Pan troglodytes*). Jpn Psychol Res 38:126–135. https://doi.org/10.1111/j.1468-5884.1996.tb00017.x
Iversen IH, Matsuzawa T (1997) Model-guided line drawing in the chimpanzee (*Pan troglodytes*). Jpn Psychol Res 39:154–181. https://doi.org/10.1111/1468-5884.00051
Klüver H (1933) Behavior mechanisms in monkeys. University Chicago Press, Chicago
Leca JB, Gunst N, Huffman MA (2007) Japanese macaque cultures: inter- and intra-troop behavioral variability of stone handling patterns across 10 troops. Behaviour 144:251–281. https://doi.org/10.1163/156853907780425712
Leca JB, Nahallage CA, Gunst N, Huffman MA (2008) Stone-throwing by Japanese macaques: form and functional aspects of a group-specific behavioral tradition. J Hum Evol 55:989–998. https://doi.org/10.1016/j.jhevol.2008.06.004
Lockman JJ (2000) A perception–action perspective on tool use development. Child Dev 71:137–144. https://doi.org/10.1111/1467-8624.00127
MacDonald J (2014) Alpha: the figure in the cage. Relat beyond Anthr 2:27–43. https://doi.org/10.7358/rela-2014-002-macd
Martinet L, Pelé M (2021) Drawing in nonhuman primates: what we know and what remains to be investigated. J Comp Psychol 135:176–184. https://doi.org/10.1037/com0000251
Martinet L, Sueur C, Hirata S, Hosselet J, Matsuzawa T, Pelé M (2021) New indices to characterize drawing behavior in humans (*Homo sapiens*) and chimpanzees (*Pan troglodytes*). Sci Rep 11:1–14. https://doi.org/10.1038/s41598-021-83043-0
Morris D (1962) The biology of art: a study of the picture-making behaviour of the great apes and its relationship to human art. Methuen, London
Munoz-Rubke F, Olson D, Will R, James KH (2018) Functional fixedness in tool use: learning modality, limitations and individual differences. Acta Psychol 190:11–26. https://doi.org/10.1016/j.actpsy.2018.06.006
Nahallage CAD, Huffman MA (2007) Age-specific functions of stone handling, a solitary-object play behavior in Japanese macaques (*Macaca fuscata*). Am J Primatol 69:1–15. https://doi.org/10.1002/ajp.20348
Nahallage CAD, Huffman MA (2008) Comparison of stone handling behaviour in two macaque species: implications for the role of phylogeny and environment in primate cultural variation. Am J Primatol 70:1124–1132. https://doi.org/10.1002/ajp.20610
Nahallage CA, Leca JB, Huffman MA (2016) Stone handling, an object play behaviour in macaques: welfare and neurological health implications of a bio-culturally driven tradition. Behaviour 153:845–869. https://doi.org/10.1163/1568539X-00003361
Pelé M, Thomas G, Liénard A, Eguchi N, Shimada M, Sueur C (2021) I wanna draw like you: Inter-and intra-individual differences in orang-utan drawings. Animals 11:3202. https://doi.org/10.3390/ani11113202
Pellis SM, Burghardt GM (2017) Play and Exploration. In: Call J, Burghardt GM, Pepperberg I, Snowdon C, Zentall T (eds) APA handbook of comparative psychology (Vol 1). concepts, history, and methods (assoc eds). American Psychological Association, Washington, DC, pp 699–722
Pellis SM, Pellis VC, Pelletier A, Leca JB (2019) Is play a behavior system, and if so, what kind? Behav Proc 160:1–9. https://doi.org/10.1016/j.beproc.2018.12.011
Surridge AK, Osorio D, Mundy NI (2003) Evolution and selection of trichromatic vision in primates. Trends Ecol Evol 18:198–205. https://doi.org/10.1016/S0169-5347(03)00012-0
Tan AWY (2017) From play to proficiency: the ontogeny of stone-tool use in coastal-foraging long-tailed macaques (*Macaca fascicularis*) from a comparative perception-action perspective. J Comp Psychol 131:89114. https://doi.org/10.1037/com0000068
Wiper ML (2017) Evolutionary and mechanistic drivers of laterality: a review and new synthesis. Laterality Asymmet Body Brain Cognit 22(6):740–770. https://doi.org/10.1080/1357650x.2017.1291658