**How do African Elephants (*Loxodonta Africana*) React to Human Voices that are Perceived to be a Threat?**

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**Abstract**

Elephants are not thought to have predators but their most predominant threat comes from humans (Soltis et al., 2014). Our interactions with Elephants have not always been amicable due to the destruction of their habitats, poaching for ivory and we are now in competition with them over resources to survive. Fatalities have been inflicted on both sides due to these encounters to the point where Elephants can now categorise humans from specific geographical locations as threats through listening, smell and observation. The current study considers if Elephants’ reactions to hearing voices of known human predators is universal, or if the two different populations, from Amboseli and Samburu, respond differently. Previous recordings of behavioural responses were provided by McComb et al. (2014) (Amboseli Elephants responding to Maasai playbacks) and Soltis et al. (2014) (Samburu Elephants responding to Samburu playbacks). The findings of this study could hint towards cultural influence on social learning. Results showed that there is potential for there to be cultural influences on fear responses but it is currently highly-unlikely. This could be due to lack of data and extraneous variables from the secondary data provided. Further study should be performed to more accurately contribute towards the current study’s aim.

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Yes Mum, Dad and Jack, this is for you.

**Introduction**

## **Animals need to be able to detect predators**

It is essential for animals in the wild to be able to accurately detect predators for survival. Different species have a variety of different techniques to enable them to detect predators and figure out the best escape route. For example, Vervet Monkeys have different calls for each of their prime predators: Leopards, Eagles and Snakes (Seyfarth, Cheney & Marler, 1980). It was established that the purpose of these calls was to alert other near-by monkeys of a predator and provide the urgency of the situation so the others could act quickly and get to safety (Seyfarth, Cheney & Marler, 1980; Manser, Seyfarth & Cheney, 2002). Seyfath, Cheney & Marler (1980) identified each call as distinguishably different to other non-alarm calls and could be differentiated between alarm-calls for what predator had been detected. This was done by recording each of the alarm-calls and playing it back to a sample of Vervet Monkeys, then looking at where the subjects gazed and the behaviours they responded with. For example, if an Eagle alarm-call was played then they would run for cover and hide in dense areas of foliage so they could not be spotted from an aerial point of view (Seyfarth, Cheney, & Marler, 1980). A current popular topic is how humans pose a threat to survival for a large number of species, primarily through the eradication of habitats and poaching.

## Poaching - How does it affect the Elephant populations?

Elephants are not known for having many predators, but their most predominant threat is humans (Soltis et al., 2014). Maisels et al. (2013) found a direct link between human activity and the decline of wild African Elephants since 2007. The main reasons for this are poaching for ivory (tusks), the destruction of habitats and engaging in fights in competition over scarce resources for survival (CITES, 2012; Maisels et al., 2013; Poole, 2018c). Poole (2018c) explains that in the ivory trade, poachers tend to target the older Elephants as they have bigger, heavier tusks that would be more valuable. The result of conflict often leaves younger Elephants and calves behind without any guidance, due to the bigger Elephants being males or matriarchs within the female herds (Poole, 2018c). Why human interference has such a detrimental effect on the wild African Elephant population can be understood when the Elephants’ social network is explained.

Elephants have a unique social structure where they can form close relationships that allow for a deeper connection that can almost be compared to human relationships (Ree, 2012). Poole (2018d) identifies the fluid fission-fusion society Elephants live in, where relationships are formed with family members, bond groups and independent males. Each female herd has a unique matriarchal hierarchy that is determined by the personality and wisdom of the elected matriarch, who is usually the largest and oldest female in the group. The role of the matriarch is the leader of the herd. She will be the individual that other herd members gravitate towards and the one that makes the important decisions. When people think of the matriarch, they often associate the term with the idea of autocracy, which can be the case in some herds, but decisions can be sorted democratically with the matriarch taking suggestions from other adults and sometimes calves (Poole, 2018d).

Poole (2018e) explained that these scenarios encourage a rich, social-learning environment for calves to be educated by their elders about all sorts of behaviours, from using their trunks to learning reproductive skills. The notion that Elephants learn fundamental life skills through social-learning is supported by The David Sheldrick Wildlife Trust as they were able to successfully release orphaned Elephants back into the wild through systematic care and interaction from humans and older Elephants (Poole, 2018e). The older Elephants were seen to pass on information about food in the local area and exhibited example behaviour on how to avoid potential dangers and calves were seen practising and performing these behaviours, which they eventually improved on over time. Poole (2018e) suggested that social-learning can take place over extended periods of time and has shown how fundamental it is for the development of a calf.

As a result of the ongoing dispute between Elephants and humans, more attention is now being paid to how animals recognise and respond to humans appropriately, being able to distinguish who is a threat and who is not. Elephants have been able to categorise humans into specific geographical locations through voice, smell and visual cues to help identify who is a source of threat (Bates et al., 2007; Soltis et al., 2014; McComb, Shannon, Sayialel & Moss., 2014). Very few studies have been performed that focus on Elephant fear responses to human voices that are identified as threats by Elephants. McComb et al. (2014) and Soltis et al. (2014) performed similar observational, fear-response playback experiments that are useful for this study’s comparative intentions. Both experiments are briefly outlined below.

### McComb et al. (2014)

McComb et al. (2014) took interest in how wild animals were able to identify their predators and plan an escape route according to the predator’s known method of attack. However, McComb et al. (2014) noted that the identification of threats from humans to Elephants is much more complex as there are varying degrees, from non-harmful tourists to local, known poachers. Elephants are known to have incredibly high cognitive skill, to the point that they can distinguish if an individual is a threat from smell (Bates et al., 2007). It is known that the human voice can communicate an individual’s age and sex but McComb et al. (2014) wanted to test if Amboseli Elephants can distinguish human threats through voices, among other identifications like cars. For the purpose of this study, the primary focus will be on the Maasai tribe voices used as stimuli, as they are known to be in conflict with wild Elephants over local resources. McComb et al. (2014) used 48 known family groups from the Amboseli Elephant Research Project and measured their behavioural reactions to vocal playbacks (Poole, 2018b). The voices used were Maasai vs. Kamba men, Maasai men vs. Maasai women, resynthesised voices (Maasai male-female and Maasai female-male), and Maasai men vs. Maasai boys. Maasai men are the individuals that most commonly fight Elephants, whereas females and children do not. Results showed that Elephants reacted most strongly by exhibiting behaviours, as described in *Appendix A*¸ to Maasai men than to any other stimulus, even if it was resynthesised to sound female but not the other way around. Elephants can distinguish resynthesised voices as the original sex because they use a different cue structure than humans to detect the sex. It was also reported that the Elephants were less likely to investigate and become stealthier in response to the human stimuli than had it been a lion posing a threat. McComb et al. (2014) concluded that predator distinction could be a skill learned in early development or socially learnt through the cues from older Elephants.

### Soltis et al. (2014)

The other similar study being used was interested in the vocalisations Elephants have been known to make in response to different threats. They investigated whether calls for human threats and Bee threats could be distinguished. Like the Maasai tribe, as described in McComb et al.’s (2014) summary above, the Samburu tribe have been known to come into conflict with Elephants over resources which sadly too can end in fatalities on both sides. Soltis et al. (2014) used a sample of 14 Elephant families known from the Samburu Research Project and looked at the behavioural and vocal responses to the stimuli. Results showed that wild African Elephants do use referential vocalisations to warn others of predators. They found that both the Samburu and Bee stimulus elicited vigilance and flight behaviours but head-shaking only occurred for Bees. The calls could also be distinguished by humans via auditory cues, as the Samburu stimulus made a change in F1 and F2 formants and had the strongest fundamental frequency, but the Bee stimulus only affected the F2 formant. Results suggested that the alarm calls and behaviour could also depict the urgency of the situation through specific acoustic characteristics (Soltis et al., 2014).

**Current Study**

The current study considers if Elephants’ reactions to hearing voices of known human predators is universal, or if the two different populations, from Amboseli and Samburu, respond differently.

This will be achieved by using two sets of secondary data obtained from McComb et al. (2014), who studied Amboseli subjects and Soltis et al. (2014), who studied Samburu subjects. From the videos, specified behaviours were observed that had been identified as alert responses to the stimuli (as defined by McComb et al., 2014). Groups of behaviours that were thought to be most likely influenced by cultural transmission were statistically analysed to see if there was a significant distance in the behaviours observed between the two populations and the difference in behaviour from the matriarch of the observed herd and the first reactor to the human vocal playback.

It was predetermined that a similar recording system to McComb et al. (2014) would be used to enable a clear recording of behaviour. The null hypothesis (H0) was that there would be no observable differences in reaction to the human voice playbacks between the two Elephant populations. From this, six hypotheses were chosen that were thought to be the most indicative of whether the behaviour was culturally related and had been socially passed down by older generations.

1. Whether the first reactor was the matriarch.
2. The reactor’s latency to retreat in relation to the human vocal playback.
3. Whether the reactors retreated.
   1. If they did, were there any significant differences in the direction of retreat, formation of retreat and how fast they retreated?
4. Whether specified behaviour, that was identified as being “alert”, was observed.
   1. Is “when” the behaviour occurs in relation to playback indicative of cultural behaviours?
5. If bunching occurred, when was it the most intense?
6. Where the matriarch was positioned during retreat in relation to the group.

Any differences found in how they respond *could* suggest these reactions were learned socially and therefore reveal a cultural difference in response to the playbacks. However, it should be noted that there could also be lots of other reasons why different populations respond differently to the playbacks.

**Methods**

***Materials***

A total of 28 videos were used to compare behaviours of Elephants from two sites in Kenya: 14 videos from Amboseli National Park (McComb et al., 2014) and 14 videos from Samburu and Buffalo National Reserves (Soltis et al., 2014). All 14 videos provided by Soltis et al. (2014) were used but McComb et al. (2014) provided 28 videos so it was decided to only use 14 so there was an equal amount of material for each of the sites. A mixture of seven strong and seven weak samples were taken randomly from the McComb et al. (2014) sample to ensure it was representative of the population.

McComb et al. (2014) also provided a spreadsheet of all the videos coding and the behaviour recording sheets to help corroborate our findings.

**Procedure**

Secondary analysis of data from video footage was used, previously obtained through observational field studies of wild African Elephants reacting to voice playbacks of local humans who are known to attack Elephants, Samburu (Soltis et al., 2014) and Maasai (McComb et al., 2014). Each video had a playback Excel sheet where observations of behaviours were described and length of occurrence. The reactions to the voice playbacks were focused on the first reactor and the matriarch. If the matriarch was the first reactor then only her behaviour was recorded. If it was not clear who the matriarch was, then only the first reactor was recorded. In the rare case where all reactions were not captured at the same time, then a general observation of who was seen to react first was noted. All videos were then coded into a spreadsheet by the definitions provided below and in *Appendix A.* The complete observation data spreadsheet and behaviour recording sheets provided by McComb et al. (2014) for their videos were used to corroborate results to ensure nothing was missed and the behaviours were being coded appropriately.

**Definitions**

Definitions used to categorise behaviours were taken from McComb et al., (2014) except for *Foot Raise* which was implemented for this specific study. Specific categories and scales are provided in *Appendix A.*

## Statistical Analysis

Multiple hypotheses and tests were run to test if there were cultural differences in Elephants’ fear responses to known local human predators. These hypotheses were chosen by looking at the collected observational data and choosing factors that were most likely to denote fear responses that could be influenced by cultural differences.

The first hypothesis tested whether the first responder was the matriarch by comparing the Amboseli population to the Samburu population. A Fisher’s Exact test was run due the abnormal distribution of the data.

The second hypothesis compared the matriarch’s and first reactor’s latency to retreat between both populations. The aim was to see who tended to retreat faster and see if there was a cultural influence on this behaviour. A Mann-Whitney U test was run to see if there was a statistically significant difference between the responder’s and the two populations.

The third hypothesis compared whether the matriarchs and / or first reactors retreated and if this was specific to the populations. A Fisher’s Exact test was run due to the non-normal distribution of data.

This was then taken further by seeing if there was a difference in whether they retreated in the same direction or not, the position in which the group retreated (broad front or in a single line) and how fast they retreated (running or walking). A Chi-square test was performed to compare the populations for each of the sub-categories.

The fourth hypothesis looked at the differences of the occurrence of different specific behaviours. These behaviours included *Smell*, *Head Movement*, *Listening*, *Calls* and *Foot Raises.* These behaviours were each recorded for the number of times observed before, 10 seconds during and after playback. This meant any changes in occurrences of behaviours could be seen and shown to be an affect from the human voice playback heard.

*Smelling*, *Calling* and *Foot Raises* had Fisher’s Exacts tests run on them to compare which population tended to perform each of the behaviours more. It was not possible to run this test on *Listening* and *Head Movement* as they were seen to be a constant.

Then, a repeated measures ANOVA was run on each of the behaviours to show when each behaviour was performed more and whether it was in relation to the voice playback.

The fifth hypothesis was to compare the populations by their bunching intensity before, immediately as playback had begun to play, 30 seconds after and 60 seconds after playback had started. A Mann-Whitney U test was carried out comparing each of the four conditions.

The sixth hypothesis tested whether the position of the matriarch in relation to the group during retreat was specific to a population. A Chi-square test was run to compare whether the matriarch occurred in the front, middle or back of the group during retreat.

**Results**

All matriarch results are be listed below but due to the similarity of first reactor results, they have been moved to *Appendix C.*

## Matriarch was the First Responder

A Fisher’s Exact test was run and found a non-significant result, as seen in *Figure 1*, Fisher’s Exact: (1) = .62, *p* = .695. It was found that Samburu matriarchs were more likely to be the first reactor, meaning that they were more aware and reactive to their surroundings and the other Elephants tended to follow their lead.

*Figure 1*. Frequency of when the matriarch was also the first reactor in each population.

**Latency to Retreat**

To determine if there was a difference in how long it took for a responder to react, we considered the latency to retreat after first hearing the voice playback. Matriarch latency to retreat was assumed to take longer in Amboseli (*Mdn* = 18 seconds) than in Samburu (*Mdn* = 11 seconds) but was found to be statistically non-significant, *U* = 21.00, (*Z* = -.13), *p* = .896, r = -.03 (Field, 2005).

Meanwhile the first reactor’s latency to retreat was assumed to be quicker in Amboseli (*Mdn* = 9.00) than in Samburu (*Mdn* = 9.00) but again, was found to be non-significant, *U* = 17.50 (*Z* = -.27), *p* = .788, r = -.07 (Field, 2005).

**Retreat**

The third test run was to see if whether the matriarch retreated or not was specific to their population (Fisher’s Exact: (1) = 6.68, *p* = .018), as it was for first reactors (Fisher’s Exact:(1) = 6.30, *p* = .033). *Figure 2* shows the comparative differences in number of retreats depending on where they are from. It was found that matriarchs and first responders in Samburu were much more likely to retreat than those in Amboseli.

*Figure 2.* Number of retreats according to the population the responders belonged to.

To consider this further, a comparison of populations was taken depending on if they retreated in the same direction, the formation in which the group retreated and whether they were running or walking.

A Chi-square test was performed to see if there was a significant interaction between the families following the same direction as the matriarch in retreat to the population they belonged to. The relation found between these variables was significant, Fisher’s Exact: (1) = 11.34, *p* = .001. Significant relations were also found between the responder’s position in retreat and population, *X2* (2) = 12.68, *p* = .002, and between whether they were running or walking and population, *X2* (2) = 12.93, *p* = .002. This shows that if the matriarch retreated, Samburu Elephants were more likely to follow the matriarch’s lead, in a single line whilst running than Amboseli Elephants.

## Behaviours

The fourth hypotheses chosen was to look at whether the behaviours observed that are denoted to alert behaviours (*Listening, Head Movement, Smelling, Calling* and *Foot Raising*) varied by population. The third hypotheses chosen was to look at whether the behaviours observed that are denoted to alert behaviours (*Listening, Head Movement, Smelling, Calling* and *Foot Raising*) varied by population. To consider whether alert behaviours and responses differed between the two populations, we compared the frequency of *Listening, Head Movement, Smelling, Calling* and *Foot Raising* behaviour (as exhibited by the matriarch and or the first reactor) before, during the playback, in the first 10 seconds of playback and after.

### Listening

Listening occurred in all observed matriarch cases but one, *Storms* from theSamburu population, because it was not clear who the matriarch was. Consequently, a Chi-square test could not be run due to listening being a constant variable. To see if there was a relationship between listening behaviours and the frequency they were observed in relation to the playback, a repeated measures ANOVA was conducted[[1]](#footnote-1).

Mauchley’s test indicated that the assumption of sphericity had been violated, *X2* (2) = 21.83, *p* = .544. This appeared to be the case for all tests to follow and can be seen in *Appendix B*. The descriptive statistics for the three conditions, *before, 10 seconds* and *after* are displayed in *Table 1.* There was an approaching significant main effect of when the listening behaviour was observed disregarding the differences in populations, *F* (1.09, 14.15) = 3.81, *p* = .068. Although, when population interaction is included, the occurrence of the listening behaviour becomes strongly non-significant, *F* (1.09, 14.15) = 2.18, *p* = .161.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Stimuli** | | **N** | **Mean** | **Std. Deviation** |
| **Before** | Amboseli | 12 | .50 | 1.000 |
|  | Samburu | 3 | 1.00 | 1.732 |
| **10 Seconds** | Amboseli | 12 | 1.25 | .754 |
|  | Samburu | 3 | 1.67 | .577 |
| **After** | Amboseli | 12 | 6.08 | 5.265 |
|  | Samburu | 3 | 2.00 | 1.000 |

*Table 1.* N (no. of valid videos per condition), mean, and standard deviation for frequency of listening behaviour observed in matriarchs for the three-time conditions, respective of their populations.

### Head Movement

A Chi-square was not able to be performed as head movement was seen to be a constant for all cases. The next step was to see if there was an interaction between the head movements observed and the three-time conditions for playback. To do this, a repeated measures ANOVA was performed. Below in *Table 2*, the mean and standard deviation are reported for each of the three time-conditions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Stimuli** | | **N** | **Mean** | **Std. Deviation** |
| **Before** | Amboseli | 12 | 1.17 | 1.467 |
|  | Samburu | 3 | 2.00 | 1.732 |
| **10 Seconds** | Amboseli | 12 | 1.50 | 1.168 |
|  | Samburu | 3 | 2.00 | 1.000 |
| **After** | Amboseli | 12 | 7.75 | 7.399 |
|  | Samburu | 3 | 3.00 | 1.732 |

*Table 2.* N (no. of valid videos per condition), mean, and standard deviation for frequency of head movement behaviour observed in matriarchs for the three-time conditions, respective of their populations.

The number of head raises by matriarchs observed, within the three-timed conditions, was found to be non-significant, *F* (1.10, 14.30) = 3.01, *p* = .102. When looking at the interaction of population with the observed behaviours in the timed conditions, the significance level drops further, *F* (1.10, 14.30) = 1.61, *p* = .228.

### Smelling

A Fisher’s Exact test was run to compare the number of observed investigate smelling behaviour was dependent on the population it was performed by. The result was found to be non-significant, showing that observed smelling behaviour was independent, as seen in *Figure 3*, Fisher’s Exact: (1) = .05, *p* = 1.000. A repeated measures ANOVA was conducted to see if there was an interaction between observed investigative smelling and when the behaviour occurred in relation to playback. In *Table 3*, the mean and standard deviation are reported for each of the three time-conditions.

*Figure 3.* Number of observed investigative smelling behaviour by matriarchs in each population.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Stimuli** | | **N** | **Mean** | **Std. Deviation** |
| **Before** | Amboseli | 12 | .08 | .289 |
|  | Samburu | 4 | .00 | .000 |
| **10 Seconds** | Amboseli | 12 | .25 | .452 |
|  | Samburu | 4 | .25 | .500 |
| **After** | Amboseli | 12 | 1.83 | 3.380 |
|  | Samburu | 4 | .25 | .500 |

*Table 3.* N (no. of valid videos per condition), mean, and standard deviation for frequency of investigative smelling behaviour observed in matriarchs for the three-time conditions, respective of their populations.

There was not a significant difference between the investigative smelling behaviours observed and the time-conditions they were seen in, *F* (1.05, 14.75) = 1.17, *p* = .301. A non-significant interaction was found between when smelling was observed and the population they were seen in, *F* (1.05, 14.75) = .83, *p* = .382.

### Calling

A similar procedure to the *Smelling* analysis was followed. A Fisher’s Exact test was run and found calling was not dependent on the population it was performed by, as shown in *Figure 4,* Fisher’s Exact: (1) = .00, *p* = 1.000. A repeated measures ANOVA could not be run as a call was only observed once in each population.

*Figure 4*.Number of observed calls by matriarchs in each population.

### Foot Raising

A Fisher’s Exact was run and found that the occurrence of foot raising by matriarchs was not dependent on the population they belonged to, Fisher’s Exact: (1) = 2.33, *p* = .222. *Figure 5* shows that no foot raising was observed in the Amboseli sample but was in Samburu. A repeated measures ANOVA could not be performed due to the lack of data.

*Figure 5*. Number of observed foot raises performed by matriarchs in each population.

## Bunching

The first condition was *Before* playback had begun. Amboseli (*Mdn* = .00) and Samburu (*Mdn* = 2.00) was found to significantly differ in bunching intensity with a large effect size, *U* = 25.00 (*Z* = -3.54), *p* < .001, r = -.68, (Field, 2005).

Secondly, *Immediately* after playback, Amboseli (*Mdn* = 1.00) and Samburu (*Mdn* = 2.00) did not significantly differ, *U* = 67.50 (*Z* = -1.47), *p* = .142, r = -.28 (Field, 2005).

In the third condition, *30 seconds* after playback, Amboseli (*Mdn* = 1.50) and Samburu (*Mdn* = 2.00) did not significantly differ, *U* = 87.00 (*Z* = -.53), *p* = .597, r = -.10 (Field, 2005).

Finally, in the fourth condition, *60 seconds* after playback, Amboseli (*Mdn* = 1.00) and Samburu (*Mdn* = 2.00) also did not significantly differ, *U* = 69.50 (*Z* = -.43), *p* = .667, r = -.09 (Field, 2005).

## Matriarch’s Position

A Chi-square was conducted and found a non-significant result, meaning that where the matriarch was positioned did not dependent on the population they belonged to, *X2* (2) = 5.31, *p* = .070. However, it must be noted the Chi-square test had four cells with an expected count less than five, making the results less reliable. As *Figure 6* shows, there was an observed difference in positioning between Amboseli being predominantly more in the back whereas Samburu more in the front.

*Figure 6.* Frequency of where the matriarch was in relation to the group when retreating, in each population.

# Discussion

Although most of the results were found to be non-significant, there were a few interesting statistically significant results that show the potential for culturally different behavioural responses to fear in wild African Elephants.

The Amboseli Elephants were seen to not retreat as much as those in the Samburu population, regardless of the position that the individual held in the herd’s social hierarchy. The investigative tests into how the subjects retreated were found to be significantly different in whether they retreated in the same direction or not, the formation of the group retreating (broad front or single line) and the speed of retreat (running or walking). Samburu Elephants were more likely to retreat and follow the matriarch, behind in a single line whilst running. These findings *could* be attributed to cultural differences, but it could also be because of the different environments each of the populations were filmed in.

Amboseli Elephants tended to be seen travelling across a vast amount of uncovered, open land in McComb et al.’s (2014) videos, where their only option was to bunch toward the matriarch. Soltis et al.’s (2014) Samburu Elephants had thick foliage and trees to retreat into and hide behind. The only way to differentiate these results to see if it is a culturally passed down behaviour is to film each of the different populations in the alternative environments and see if the results remain the same.

Moreover, in the Samburu videos, provided by Soltis et al. (2014), the speaker playing the Samburu stimulus was placed much closer to the observed herds (15-30m from the nearest Elephant) than those in McComb et al.’s (2014) Amboseli herds (50m from the nearest Elephant). Soltis et al. (2014) mentioned that the close set-up was meant to induce the sudden surprise presence of Samburu tribesmen, but Elephants have an acute sense of hearing and strong sense of smell, so in a natural environment, Samburu tribesmen are unlikely to get so close without being detected (Poole, 2018a). This could be a reason as to why the Samburu subjects retreated more frequently than Amboseli subjects, and were seen to exhibit an “emergency getaway” with faster retreats with the matriarch or first reactor in the front to lead them.

It was expected to see differences between the Amboseli and Samburu subjects in the behaviours they performed when hearing the respective human threat playback, but all the behaviours that were considered to denote alertness were found to be statistically non-significant. An explanation for this could stem from the observational videos not being specifically shot for this study but for previous studies by McComb et al. (2014) and Soltis et al. (2014), thus resulting in the lack of appropriate data. It could be that there are culturally specific behaviours exhibited during a fear response, but the videos that were used for this study did not capture the elements that were needed. In the future, there is hope to perform an improved version of this study with first-hand evidence to directly test the hypotheses this study proposed.

Another question raised, specifically for Elephant calling, is ‘do Elephants reduce noise production when encountering a human predator?’ Soltis et al. (2014) found that Samburu Elephants gave distinct different calls for humans and Bees. It is worth investigating to find out if Elephants, when encountered by human predators, are likely to use more behavioural, referential signalling rather than vocal referential signalling to avoid drawing attention to themselves.

Difference in bunching intensity before playback between Amboseli Elephants and Samburu Elephants was found to be statistically significant. Again, this could be due to the environmental differences as most of the videos from Soltis et al. (2014) showed herds of Elephants relaxing under the shade of trees and shrubs, feeding, closely bunched together. Whereas, Amboseli Elephants were seen to be more spread out due to the open-land and often scarcity of plants to feed on. It would be interesting to see if Amboseli Elephants still spread out to feed even if they were in a similar environment to the Samburu subjects. This way, it could be determined whether the difference in bunching before playback is due to environmental differences or a cultural difference.

An approaching statistical significance was found between populations as to where the matriarch resided in relation to the group during retreat after playback had been played. It was noted in the results section that there were multiple cells that had a lower count than required which made the test slightly unreliable. This means that had there been consistent data, there is the potential for a trend to be found in where the matriarch is positioned when retreating.

In theory, this study had the correct tools at its disposal to investigate whether there was a cultural difference in behavioural fear responses in wild African Elephants in response to the subjects’ native local humans who are known to engage in conflict with Elephants. One of the primary differences between populations that could be preventing the current study to obtain accurate data is the age difference between each of the projects. The Amboseli population has been observed since 1972 by The Amboseli Elephant Research Project whereas the Samburu Elephant Project has only been running for 15 years. The location of the latter project is admittedly heavily poached and it has been found to be much harder to track Elephants and poachers, hence the current pioneering in Elephant protection and anti-poaching campaigns (Poole, 2018b; Save the Elephants, 2018). Accurate data would be difficult to obtain for the Samburu population, especially for this study that is focused on cultural transmission, because of the heavy poaching. This leaves a lot of orphaned Elephants that would not have the opportunity to socially learn behaviours from elders, meaning there is not much culture left to study and if there is it is hard to find.

To better prepare for future experiments, a review of the methods and materials of the current study has been carried out so improvements can be made to provide reliable and valid results. As previously mentioned, the secondary data used to test the hypotheses were not produced with the current study in mind. The first problem encountered was the different structures of the videos being used. In McComb et al.’ (2014) videos, there was a commentary given, pointing out key figures in each of the groups and narrative of the behaviours that were seen in that moment. Each of the Elephant herds observed had an observational sheet that was corroborated evidence of what different behaviours observers saw in the video, by the definitions provided in *Appendix A*, giving an accurate account of the behaviours seen. Whereas, Soltis et al. (2014) explained that there is a two-minute observation pre-playback, a four-minute observation during playback and a two-minute post-playback but no commentary or narrative were provided within the videos themselves or through external sources. This made it difficult to identify who was the matriarch in the groups and which subjects were part of the group being observed, as the camera would sometimes begin recording different groups or did not show all the Elephants in the area that could have been part of the groups. This also included the quality of filming used for each of the sample videos. For example, in McComb et al.’ (2014) Amboseli videos were often filmed from a distance or had obstructions in the way, like Elephant grass, which made it difficult to identify any potential behaviours. Whereas, Soltis et al. (2014) were able to film extremely closely but were not able to accurately show which of the subjects were intended to be filmed.

Furthermore, Soltis et al. (2014) specifically recorded two-minutes post-playback, meaning it was not possible to see how long it took for the observed groups in the Samburu set to relax, as defined by the definitions provided by McComb et al. (2014). This further adds to the reasoning why secondary evidence was not the ideal sample set to test the hypotheses from this study on. This reason contributes to the hope in the future that primary evidence can be recorded to discover if African Elephants do exhibit cultural differences in fear responses of known local human predators.

In conclusion, although the results found in the present study did not indicate any significant findings, it does provide the motivation for further research to be conducted. The videos provided for this study by McComb et al. (2014) and Soltis et al. (2014) may not have been the appropriate materials to use but it was an excellent starting place to show what should and should not be done in the future. As Rendell & Whitehead (2001, p. 324) conclude in their study, there is still an unequivocal need to study the cultural transmission of behaviours not just in wild African Elephants, but among all intelligent animals to better our understanding of cultures in different species.

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# Appendix

## Appendix A – Definitions of Behavioural Categories Used in Playback (taken from McComb, Shannon, Savialel, & Moss, 2014).

*Definition of footswinging added for the purpose of this study.*

**Avg age with matriarch** – Average age of the adults within a group, including the matriarch

**Avg age no matriarch** – Average age of the adults within a group, excluding the matriarch

**Matriarch Behaviours** (listening – retreat) – Responses exhibited by the matriarch, regardless of the rest of the group.

**Other Behaviours** (listening – retreat) – Responses exhibited by other adult females within a group, does not include the matriarch.

**Group Behaviours** (listening – retreat) – Responses exhibited by any adult female within the group (matriarch included). These behaviours are shown at the end of the spreadsheet.

**Listening** – Cessation in behaviour, ears held open and interest in the playback stimuli.

**Prolonged Listening** – Clear evidence that an individual has listened for a minimum for 3 mins.

**Head Movement** – Evidence of head raising and shaking, indicative of an alert response.

**Smell** – Up or down trunk smelling following the playback in an attempt to gain further information with regards to the caller or the threat.

**Bunch** – Reduction in diameter of the group in response to a perceived threat or unfamiliar family.

**Call** – Audible rumbles that are given following the playback.

**Approach** – Distinct move towards the speaker, which requires a discernible change in direction.

**Retreat** – Distinct move away from speaker as a result of playback.

**Group move** – Distinguishes whether a group were moving (1) prior to playback or not (0).

**Bunching intensity** – Speed and time taken for reduction in diameter, (3) fast and clearly obvious brunch with a dramatic reduction in diameter (< 30s for bunching response). (2) Bunching less hurried, but group clearly move together and there is a cessation in behaviour such as feeding (1-3 mins for bunching response). (1) Very subtle bunch that may just be a reduction in overall diameter or calves moving to mothers. More often than not behaviour such as feeding will continue.

**Calves to adult F** – Movement of calves to adult females, including mothers and allo-mothers.

**Relaxation time** – Time taken for group to relax after playback and resume foraging moving etc. (0) No response (1) < 1 min to relax (2) < 3 min to relax (3) < 6 min to relax and (4) < 12 min to relax.

**Group to matriarch** – After playback do females and calves move to the matriarch (1) or not (0).

**Matriarch Pos** – Position that matriarch spends the majority of her time following playback (relative to the group). (1) front (2) middle and (3) back.

**Change in Pos** – Records whether the matriarch changed position (1) or not (0) – comparing her position prior to and after playback (relative to the group).

**Intercept** – Classified as the matriarch moving herself between the group and playback to intercept and investigate the stimuli. This has to be an active change in position and approach by the matriarch.

**Group Bunch N –** Any sign of bunching after playback, with or without the involvement of the matriarch.

**Foot Swinging -** A foot swing is often seen as a sign of anxiety in Elephants. They will typically raise one of their front legs and let it hover above the ground.

## Appendix B – Normality Tests for each appropriate test.

**Listening**

**Matriarch**

Mauchley’s test indicated that the assumption of sphericity had been violated, *X2* (2) = 21.83, *p* = .544.

**First Reactor**

Mauchley’s test indicated that the assumption of sphericity had been violated, *X2* (2) = 27.63, *p* = .532.

**Head movement**

**Matriarch**

Sphericity cannot be assumed due to Mauchly’s test being violated, *X2* (2) = 20.43, *p* = .550.

**First Reactor**

Mauchly’s test of sphericity was violated so it cannot be assumed, *X2* (2) = 18.26, *p* = .553.

**Smelling**

**Matriarch**

Mauchly’s test of sphericity was violated so it cannot be assumed, *X2* (2) = 29.68, *p* = .527.

**First Reactor**

Sphericity cannot be assumed as Mauchley’s test was violated, *X2* (2) = 24.38, *p* = .541.

## Appendix C – All First Reactor Results

### Retreat

Similar tests were run for the first reactors in each of the groups. Whether the direction of retreat was the same or not in matriarchs was also found to be significantly different in Amboseli and Samburu, Fisher’s Exact: (1) = 8.02, *p* = .013. This was also the same case for the first responder’s position in retreat, *X2* (2) = 10.22, *p* = .006, and whether they were running or walking, *X2* (2) = 8.39, *p* = .015. Similar results were found as above in the *matriarch’s* section. This shows that if the first reactor retreated, Samburu Elephants were more likely to follow the matriarch’s lead, in a single line whilst running than Amboseli Elephants. It must be mentioned that out of the 14 videos in the Samburu sample, 10 of the matriarchs were also the first reactors.

### Listening

All first reactors were observed to be listening, making it a constant, so a Chi-square was not needed to be performed. To explore the hypothesis further, a repeated measures ANOVA was performed to see when listening behaviours occurred most frequently in relation to playback. All descriptive statistics for the frequency of exhibited listening behaviour during the three, time conditions, before, 10 seconds and after are displayed in *Table 1a.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Stimuli** | | **N** | **Mean** | **Std. Deviation** |
| **Before** | Amboseli | 11 | .27 | .647 |
|  | Samburu | 5 | .60 | 1.342 |
| **10 Seconds** | Amboseli | 11 | 1.55 | .688 |
|  | Samburu | 5 | 1.40 | .548 |
| **After** | Amboseli | 11 | 5.64 | 5.801 |
|  | Samburu | 5 | 1.00 | 1.000 |

*Table 1a.* N (no. of valid videos per condition), mean, and standard deviation for frequency of listening behaviour observed in first reactors for the three-time conditions, respective of their populations.

A non-significant effect was found for when the listening behaviour occurred independently of the populations, *F* (1.06, 14.89) = 3.53, *p* = .078, including when the interaction between populations was considered, *F* (1.06, 14.89) = 3.11, *p* = .097.

### Head Movement

Similarly, head movement in first reactors was found to be a constant so a Chi-square test could not be run. A repeated measures ANOVA was run to see if there was an interaction between observed head movements, the three-time conditions and if the population influenced these results. Below in *Table 2a*, the mean and standard deviation are reported for each of the three time-conditions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Stimuli** | | **N** | **Mean** | **Std. Deviation** |
| **Before** | Amboseli | 11 | .73 | .786 |
|  | Samburu | 3 | 3.67 | 4.041 |
| **10 Seconds** | Amboseli | 11 | 2.55 | 1.635 |
|  | Samburu | 3 | 2.00 | 1.000 |
| **After** | Amboseli | 11 | 7.36 | 7.311 |
|  | Samburu | 3 | 2.00 | .000 |

*Table 2a.* N (no. of valid videos per condition), mean, and standard deviation for frequency of head movement behaviour observed in first reactors for the three-time conditions, respective of their populations.

Once again, a non-significant result was found meaning there was not a significant difference between the behaviours observed and the time-conditions they were seen in, *F* (1.11, 13.26) = 1.14, *p* = .311. The result remains non-significant when looking to see if there is a relationship between the populations and the behaviours seen, *F* (1.11, 13.26) = 2.49, *p* = .137.

### Smelling

Another Chi-square test was run to see if smelling in first reactors was dependent on the population they belong to. The results found show that the behaviour is independent, meaning there is no relationship between the occurrence of smelling behaviour by first reactors to the population they respond to, as seen in *Figure 1a,* Fisher’s Exact: (1) = .00, *p* = 1.000. As always, a repeated measures ANOVA was conducted to see if there was an interaction between observed investigative smelling and when the behaviour occurred in relation to playback. *Table 3a*, shows the mean and standard deviation for each of the three time-conditions.

*Figure 1a*.Number of observed investigative smelling behaviour by first reactors in each population.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Stimuli** | | **N** | **Mean** | **Std. Deviation** |
| **Before** | Amboseli | 11 | .09 | .302 |
|  | Samburu | 5 | .00 | .000 |
| **10 Seconds** | Amboseli | 11 | .55 | .688 |
|  | Samburu | 5 | .40 | .548 |
| **After** | Amboseli | 11 | 3.00 | 3.768 |
|  | Samburu | 5 | .20 | .447 |

*Table 3a.* N (no. of valid videos per condition), mean, and standard deviation for frequency of investigative smelling behaviour observed in first reactors for the three-time conditions, respective of their populations.

No significant difference was found between the investigative smelling behaviours observed by first reactors and the time-conditions they were seen in, *F* (1.08, 15.16) = 2.73, *p* = .117. The result remained non-significant when looking between when the smelling behaviour was observed and the population they were seen in, *F* (1.08, 15.16) = 2.54, *p* = .131.

### Calling

As seen in *Calling – Matriarchs*, both cases in Amboseli and Samburu where calling occurred once in each, both first reactors were the matriarchs, meaning the results would be replicated in this case.

### Foot Raising

Similar to the matriarch condition, a Chi-square was conducted and found to be non-significant, meaning whether the first reactor was observed to foot raise did not depend on the population they were from, as seen in *Figure 2a*, Fisher’s Exact: (1) = .37, *p* = 1.000.

*Figure 2a.* Number of observed foot raises performed by first reactors in each population.

A repeated measures ANOVA could not be accurately conducted as foot raising was only observed after the playback had played.

1. A similar test will be performed on all observed behaviours to see when they most frequently occurred. The statistical results from the repeated measure ANOVAs must be taken with caution due to the non-normally distributed nature of the data. [↑](#footnote-ref-1)