自然風景の中のヘビは素早く正確に検出されるのか？ ーフリッカー変化検出課題を用いたヘビ検出の検討

Can snakes be detected more rapidly and accurately in a natural scene? A flicker paradigm task study on the Snake Detection Theory

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Abstract

Snake is a serious threat to humans for the past millions of years so that humans became extremely sensitive to snakes during the long evolution period. The present experiment shows that humans and non-human primates can detect snake pictures more quickly and accurately than those of other animals. According to Isbell's Snake Detection Theory, it is possible that snakes have promoted primate's visual system and its functional integration with the fear system during the long evolutionary history. Here we performed a flicker paradigm task to compare the accuracy and speed of detection between two types of the target stimuli, which consisted of snake pictures and lizard pictures. In order to minimize the low-level feature effect, pictures were converted into greyscale, then controlled the luminance and contrast of the stimuli using the SHINE tool box. We find that the snake target stimuli can be detected more rapidly and accurately than lizard target stimuli. Our study shows that participants were more sensitive to snake pictures during the flicker paradigm task and supports the Snake Detection Theory.

Keywords — the Snake Detection Theory, flicker paradigm, snakes, detection, evolution

1. Introduction

Snakes have preyed upon humans for millions of years. Unlike other dangerous animals such as lions, snakes can easily creep on a pretty high tree which is a big threat to primates including human beings. How to survive from snakes then becomes an important element in natural selection. In order to rapidly responses to potential danger, the detected threat is quickly and automatically conveyed to the amygdala, which is central to fear activation [1]. Thus it is possible that during the long evolutionary history, snakes have promoted primate's visual system and its functional integration with the fear system [2].

Experiments on the snake detection theory basically apply two kinds of methods. One is the electrophysiological study. In the previous EEG studies, researchers measured the event related potential (ERP) component of electroencephalogram (EEG) peaking around 225–300 ms after a stimulus onset, which can be called as Early Posterior Negativity (EPN). Participants' EPN were larger in response to snake pictures than pictures depicting other creatures such as spiders and birds [3][4]. In addition, partial pattern of snake skin pictures elicited the largest EPN amplitude compared with lizard skin and bird plumage pictures [5]. Body curvature can also enhance the EPN in response. For example, snake and worm pictures elicited larger EPN amplitude than beetle pictures [6]. However, previous studies only collected EPN data but no visualized data such as accuracy.

Another way to verify the Snake Detection Theory is visual search task. For example, participants were displayed matrices images which contained one snake image and eight lizard images as snake target condition or one lizard images and eight snake images as the lizard target condition. Participants were faster to fixate under the snake target condition even after controlled low-level features [7]. Furthermore, 3-4 years of children can detect striking posture snakes rapidly [8]. Snake-naïve monkeys also quickly found target pictures of snakes than those of innocuous objects [9][10]. But the perceptual processes of danger detection in natural scenes are still unexplored.

The previous visual search task used matrices which contain two kinds of attentional targets in one matrix. Thus the visual search task has a weakness of its procedure because the reason for the quick detection of snakes can be explained by effective detection of threat targets, by delaying disengagement, or by both [11]. Quick detection of the snake images might be achieved due to slow detection of innocuous objects in the matrix of the visual search task, because dangerous objects are particularly effective at maintaining attention or "delaying disengagement" during visual search task.

Another explanation of why dangerous animals can be rapidly detected is that dangerous animals attract attention based on their low-level features [12] [13] in the visual search task. Visual search tasks often generate the possibility of low-level perceptual confounds, so sometimes a simple feature, such as the black dots of leopard pattern, may also cause the rapid detection of dangerous animals.

2. Method

In order to have a better understanding, we use the flicker paradigm method, in which viewers are asked to detect the difference between two alternating scenes that are identical except for an added object (snake or lizard). A trail of the flicker task starts with a fiction cross, and then followed by a nature scene added with a cut target object, a blank, the nature scene without target object and another mask in orders (see Figure 1). Since one stimulus only has one target but no distracters, the result of this experiment can provide evidence for snakes' strong attentional capture compared to other animals. In the flicker paradigm, the impact structure information in the scene can be ignored [14] and the necessity for memorizing is low [15]. Also the reaction time and accuracy data can be easily recorded.

Participants

Fourteen male students and 14 female students who studied in Nagoya University participated in this study from January through April 2018. They were all of Asian heritage and right handed. Their age ranged from 18 to 28 years, with a mean age of 22.61 years ($SD = 2.81$).

Stimuli

A trial consisted of two series of pictures : ①the background picture itself or ② the background picture added with a cut object. Twenty-eight background pictures of natural scenes were taken in Nagoya University and Chayagasaka Park. Neither human beings nor artificial objects should appear on the pictures. The background pictures were adjusted into grey scale and cut into 2000 * 1500 pixels in GIMP software. Then the pictures were processed using the SHINE toolbox (default settings; Willenbockel et al., 2010) in MATLAB to minimize low-level confounds. The SHINE toolbox first matches the contrast of the images and then matches the luminance histograms. The target objects which contain 14 lizards and 14 snakes taken all around the world were downloaded from internet (because lizard and snake are both reptiles and share the similar body-shape). The objects themselves were cut by GIMP and adjusted into grayscale, then shrank into approximately 1% of the background picture (216 * 156 ~ 126 * 268) to match the background scenes. The mean luminance of these targets were also matched in GIMP. The cut snake picture and the cut lizard picture were added to the same background respectively for counterbalance, so there will be 14 snake target stimuli and 14 lizard target stimuli for condition A and 14 lizard target stimuli and 14 snake target stimuli for condition B. Half of the participants did the 28 trails of condition A, and the others did the condition B task. Participants were asked to detect the difference in the flicker paradigm task and they would not be told that the differences were consisted of lizard or snake directly at the beginning of the experiment.

Procedure

One trail (see Figure 1) consisted with ① fixation cross; the loop of ② background picture (last for 250 ms), black mask (last for 250 ms), background picture with object (last for 250 ms) and another black mask (last for 250 ms). One loop consists of one second and considered to be one cycle. Once they figure out the changes, they press the "0" button and then they are displayed by ④ the background picture which were divided into 25 parts (a 5×5 matrix) by red lines so that participant can point at the changes precisely. One block consisted of 28 trails. If participants did not find the target, the cycle was repeated 15 times and recorded as a miss.

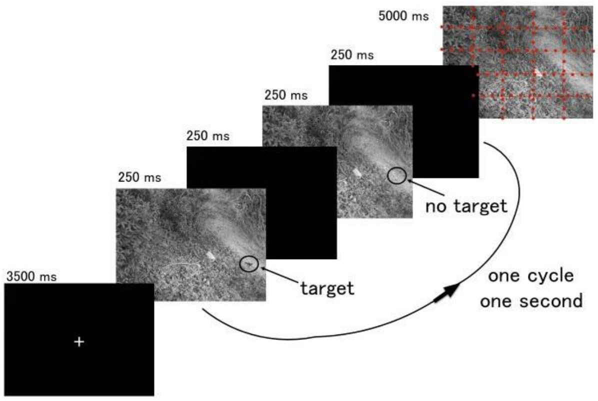

Figure 1 A flicker paradigm task procedure

Background pictures with object (snakes or lizards) are used as independent variable, and as the dependent variable, accuracy, reaction time and cycle number of responding are recorded and analyzed.

3. Results

As for the results, snake targets were detected more often and more correctly than lizard targets.

Accuracy

The correctly detected targets (see Figure 2) in lizard trails were much less than snake trails (hit rates, 56% lizard vs. 78% snake). In the meanwhile, participants made less error mistakes in snake trails than lizard trails (false-alarm rates, 3% lizard vs. 2% snake). Missing the change is also a severe case, and in our experiment 41% of lizard targets were missed (miss rates) vs. 20% of targets to snake trails. We did not set correct rejection situation this time. The signal detection theory was used to analyze the accuracy rate and the results showed snake advantage in accuracy remains strong (d' = 1.78 lizard vs. 2.43 snake, $F(1, 27) = 40.42$, $p<.01$).

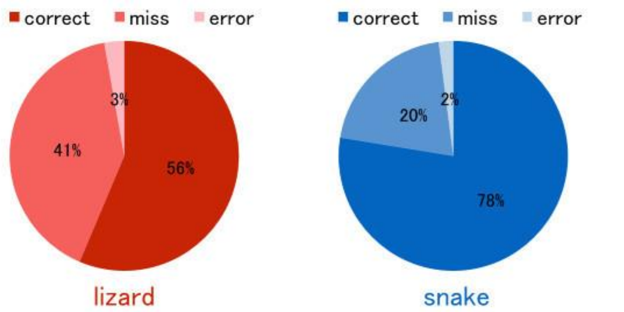

Figure 2 Proportion of detected changes

Reaction time

The reaction time of hit trials were analyzed. The higher accuracy in detecting snakes did not affect the expense of speed. Half snake targets can be detected at the sixth cycle while half of the lizard targets cannot be figured out until the ninth cycle (see Figure 3). We analyzed our data using a 2×15 ANOVA, which revealed the main effect of cycle ($F(14, 378) = 407.63$, $p<.01$), the main effect of target ($F(1, 27) = 76.33$, $p<.01$) and the significant interaction of cycle and target ($F(14, 378) = 10.87$, $p<.01$) The cumulative proportion of detected changes data resulted in a significant main effect for target type. The significant difference between lizard and snake targets showed up at the second cycle and last till the end (Fs $(1, 27) \geq 30.41$, ps$<.01$).

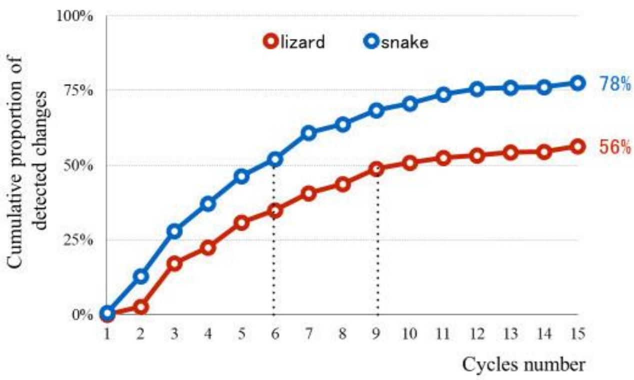

Figure 3 Cumulative proportion of detected changes

We used the Wilcoxon's signed rank test to analyze the reaction time (RT) of detected targets and the average RT of snake targets are magically shorter than lizard targets (see Figure 4, RT Mlizard = 5399, *SD* 1296 vs. RT *M* snake = 4902, *SD* 921; $Z = -1.98$, $p = 0.0476$).

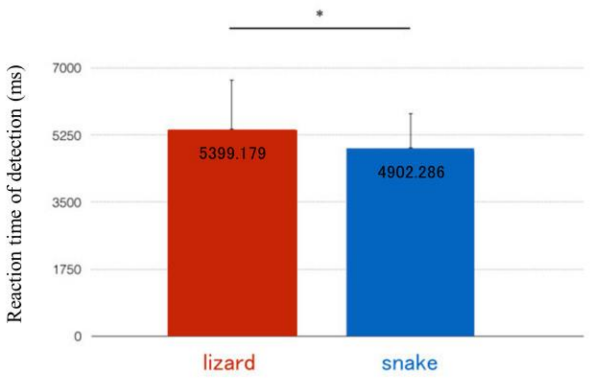

Figure 4 Mean reaction time to detect the target accurately

4. Discussion

The present study demonstrated that snake can be detected accurately and quickly than lizards. These results are consistent with previous studies and supporting the snake detection theory. Unlike these previous studies, we did not put distractor and target in the same stimuli and excluded the delaying engagement effect. The flicker paradigm requires participants to detect the changes in a new stimulus in the context. For example, in our experiment, participants were asked to point at the changes in the background picture with redline. Therefore, there is no need to compare directly between simultaneously presented stimuli and it may "more directly assess attention captures" and be "less susceptible to visual confounds" than the visual search paradigm [15]. Also, we adjusted the stimuli into greyscale and controlled the luminance and contrast to minimize the low-level feature effect. Therefore, our study supports the idea that the quick snake detection in the visual search task is caused by speeded detection of thereat targets (engagement). In addition, the present study showed that humans detected snakes more accurately under discernible condition. So far only one study reported that snakes are detected more accurately [17].

For the next step, we will use the same method to compare the snake targets and lizard target, in the meanwhile, collecting the EPN data to have a better understanding of the brain activity during the visual search task.

References

[1] LeDoux J., (1996) "The emotional brain: the mysterious underpinnings of emotional life", Simon and Schuster Press, New York.
[2] Isbell LA., (2006) "Snakes as agents of evolutionary change in primate brains", Journal of Human Evolution, Vol. 51, Issue 1, pp. 1-35.
[3] Van Strien J.W., Eijlers R., Franken I.H.A., & Huijding J., (2014) "Snake pictures draw more early attention than spider pictures in non-phobic women: Evidence from event-related brain potentials", Biological Psychology, Vol. 96, Issue 1, pp. 150-157.
[4] He H., Koda H., & Kawai N., (2014) "Spiders do not evoke greater early posterior negativity in the event-related potential as snakes", Neuroreport, Vol. 25, No. 13, pp. 1049-1053.
[5] Van Strien J.W., & Isbell LA., (2017) "Snake scales, partial exposure, and the Snake Detection Theory: A human event-related potentials study", Scientific Reports, Vol. 7, srep46331.
[6] Van Strien J.W., Christiaans G., Franken I.H.A., & Huijding J., (2016) "Curvilinear shapes and the snake detection hypothesis: An ERP study", Psychophysiology, Vol. 53, No. 2, pp. 252-257.
[7] Yorzinski J.L., Penkunas M.J., Platt M.L., & Coss R.G., (2014) "Dangerous animals capture and maintain attention in humans", Evolutionary Psychology, Vol. 12, No. 3, pp. 534-548.
[8] Massataka N., Hayakawa S., & Kawai N., (2010) "Human young children as well as adults demonstrate 'superior' rapid snake detection when typical striking posture is displayed by the snake", PLoS ONE, Vol.5, Issue 11, e15122.
[9] Kawai N., & Koda H., (2016) "Japanese monkeys (*Macaca fuscata*) quickly detect snakes but not spiders: Evolutionary origins of fear-relevant animals", Journal of Comparative Psychology, Vol. 130, No. 3, pp. 299-303.
[10] Shibasaki M., & Kawai N., (2009) "Rapid detection of snakes by Japanese monkeys (*Macaca fuscata*): An evolutionarily predisposed visual system", Journal of Comparative Psychology, Vol. 123, No. 2, pp. 131-135.
[11] Fox E., Russo R., & Dutton K., (2002) "Attentional basis for threat: Evidence for delayed disengagement from emotional faces", Cognition and Emotion, Vol. 16, No. 3, pp. 355-379.
[12] Öhman A., (1986) "Face the beast and fear the face: Animal and social fears as prototypes for evolutionary analyses of emotion", Psychophysiology, Vol. 23, No. 2, pp. 123-145.
[13] Simons D.J., (2000) "Attentional capture and inattentional blindness", Trends in Cognitive Sciences, Vol. 4, Issue 4, pp. 147-155.
[14] Yokosawa K., & Mitsumatsu H., (2003) "Does disruption of a scene impair change detection?", Journal of Vision, Vol. 3, No. 1, pp. 41-48.
[15] Varakin D.A., & Levin D.T., (2008) "Scene structure enhances change detection", Quarterly Journal of Experimental Psychology, Vol. 61, No. 4, pp. 543-551.
[16] Öhman A., (2007) "Has evolution primed humans to

'beware of the beast'", PNAS, Vol. 104, No. 42, pp. 16396-16397.
[17] Kawai N., & He H., (2016) "Breaking snake camouflage: Humans detect snakes more accurately than other animals under less discernible visual conditions", PLoS ONE, Vol. 11, No. 10, pp. 1-10.