

RESEARCH

Anticipatory Alarm Behavior in Bengalese Finches

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Abstract—The ability for short-term alarm precognition was explored in Bengalese finches. During the experimental trials, subjects were put individually for 20 minutes in a testing cage and in the last 5 minutes a 15-second video clip of a slowly crawling snake was shown to them in a TFT screen. The video clip was presented at random starting out from 20 possible randomly predetermined options. During the control trials, no snake video clip was shown to the birds. Subjects were filmed, and, in a double-blind fashion, the frequency of their display of alarm was registered 0–3, 3–6, and 6–9 seconds immediately before stimulus presentation and before the same moment of the control trial for each bird. As a second control, behavior frequency was also registered immediately before the 10-minute point after the initiation of the experimental trial. The results showed that the birds reacted to the snake video clip at least 9 seconds before presentation, the frequency of the alarm display during that period being higher than that during both controls. Females and males did not differ significantly in any of the measures.

Keywords: alarm display—Bengalese finches—birds—precognition

Introduction

There has been an upsurge of interest in human, unconscious, short-term anticipatory response, or precognition, especially since the first paper by Dean Radin on electrodermal activity and presentiments (Radin, 1997a).

Anomalous anticipatory effects using galvanic skin response as a conditioned-dependent variable were first explored with success by Vassy in the late 1960s, but reported later (Vassy, 1978). In this study, all data were obtained by human observation. In later and more exact investigations, electrodermal activity (Skin Conductance Level (SCL), which measures fast and slower-moving changes), was the unconscious response variable in experiments in which a series of randomly selected photographs (so that the incoming stimuli could not be inferred) was shown to the subjects. SCL increased more if the future

picture (next 2–3 seconds) was going to be emotional (shocking photos, such as erotic scenes and autopsies), than if it was going to be a calm one (pleasant and neutral photos of nature, landscapes, and cheerful people). Anticipation was also manifested, although at lower intensity, by an increase in heart rate and a reduction in fingertip blood volume (Radin, 1997a, 2004). Electrodermal activity was also significantly higher before presentation of the emotional pictures (as compared to that before the calm pictures) when Skin Conductance Response (SCR, which measures only fast-moving changes in electrodermal activity) was the responding variable (Bierman & Radin, 1997, 1999). The fact that participants anticipate much better the presentation of positive emotional pictures (generally erotic) than negative emotional pictures (violent and injurious) (Radin, 1997b) suggests that the emotional meaning of the future event may be important.

Another study (Globish, Hamm, Esteves, & Öhman, 1999) concerned with skin conductance took advantage of a previously published conventional study (i.e. with completely different goals) about the speed with which fear arises in animal-phobic subjects, and with a long enough period of measurement before the stimulus. Re-analysis of the raw data searching for a precognition effect (Bierman, 2000) showed a larger anticipation to occur before the erotic stimuli as compared to neutral (marginally significant) and animal (snakes or spiders) (non significant) stimuli.

To avoid the problem of idiosyncratic responses to pictorial stimuli, random audio startle stimuli and control moments of silence have been used. In this case, the effect of anticipation was revealed by a higher increase in relative skin conductance before the stimulus than before the control (Spottiswoode & May, 2003, May, Paulinyi, & Vassy, 2005).

Heart Rate (HR) was registered while subjects were asked to choose one out of four calm (non-emotional) pictures, the randomly selected picture being selected before they made their choice or after making their choice but not knowing about it. The experiment yielded very significant changes in HR before correct choices as compared to failed ones in the first situation, and still significant in the second experimental situation (Sartori, Massaccesi, Martinelli, & Tressoldi, 2004, Tressoldi, Martinelli, Massaccesi, & Sartori, 2005). The use of Heart Rate Variability (HRV, which refers to beat-to-beat alterations in HR, and is usually regarded as an indicator of cardiovascular autonomic control) during presentation of calm and emotionally arousing pictures produced still higher effects. This experiment resulted in a significantly higher heart rate deceleration occurring prior to future emotional stimuli compared to calm stimuli, starting about 4.75 seconds before stimulus presentation and showing some gender differences. Comparison of these results with those in the medical literature in relation to cardiac decelerations/accelerations suggests that the psychophysi-

ologic system processes the prestimulus information in the same way as conventional sensory input (McCraty, Atkinson, & Bradley, 2004a).

Several important results were also obtained in a similar experimental design where data were also collected from the electrocardiogram (ECG) and the electroencephalogram (EEG). Information was obtained from the latter on cortical Event-Related Potentials (ERP, the changes of the ongoing EEG due to stimulation, especially clear as a response to unpredictable stimuli), Heartbeat-Evoked brain Potentials (HEP, in which characteristic brain waves are seen to accompany rhythmic activity of the heart), and cardiac decelerations/accelerations (derived from the ECG). The results showed that: 1) There were significant differences in prestimulus ERPs and HEPs for calm versus emotional stimuli. 2) Both the heart and the brain are involved in stimulus anticipation, the heart apparently receiving and responding to prestimulus information before the brain. 3) The frontal cortex, temporal, occipital, and parietal areas appear to be involved in the process. 4) An interaction between HEPs and ERPs is especially apparent in females (McCraty, Atkinson, & Bradley, 2004b).

The use of functional Magnetic Resonance Imaging system (fMRI) to obtain information on Blood Oxygenation Level Dependence (BOLD, magnetic signal variation related to oxygen intake and neuron activity) enables the observation of fast-changing events in the brain. This technique was used while the participants were presented erotic, violent, and calm images, and showed that the above-quoted anomalous anticipatory effects are replicated with BOLD: Anticipatory activation of the visual cortex preceding emotional stimuli was larger than the anticipatory activation preceding neutral stimuli (before the erotic stimuli in males and before the erotic and violent stimuli in females) (Bierman & Scholte, 2002).

Although there is no reason to suppose that humans are better-equipped than other animals with respect to their ability to foresee the future, the literature on precognition by non-humans is very scant. In any case, the results of the few studies are quite promising, and if the effect is definitely demonstrated in them, the biological mechanisms involved in precognition would be open to research.

In an experiment performed with earthworms, in which the response (small changes in skin impedance) to mechanical vibration was recorded, the nearly significant results were more positive the more trials were performed, and the time window in this case would extend one second before stimulation (Wildey, 2001).

The results of experiments with dogs can be interpreted as evidence for precognition. In these studies the animals showed an anticipatory behavior long before their owners returned home, the owners returning at randomly selected times and travelling in unfamiliar vehicles (Sheldrake & Smart, 1998, 2000).

Analysis of environmental variables suggests that the dogs' anticipatory behavior is significantly affected by changes in global geomagnetic flux (Radin, 2002).

Therefore, the cumulative evidence strongly suggests that short-term precognition occurs in humans and other animals. The subjects apparently can respond physiologically to an emotionally arousing stimulus seconds before it is actually experienced, as if the body's perceptual apparatus were continually scanning the future.

Since predation is a major selective force in the evolution of morphological, physiological, and behavioral characteristics of animals, the alarm response to predation is probably a good candidate among different activities when trying to detect the capacity for an anticipatory response in them. In addition, the behavior of alarm is unfailingly produced by naïve animals in the presence of danger, and is sufficiently conspicuous for reliable data collection (Alvarez, Braza, & Norzagaray, 1976, Alvarez, Sánchez, & Angulo, 2006, Alvarez, 1993, Alvarez & Sánchez, 2003). The capacity for anticipatory perception of alarm as well as potential gender differences will be explored in Bengalese finches.

Methods

All subjects (23 adult male and 24 adult female Bengalese finches *Lonchura striata* var. *domestica*) lived in unisexual adult groups of conspecifics in $1.5 \times 3 \times 2$ m aviaria near Seville, Spain, and were fed a varied diet of seeds and vegetables. The experiments were carried out between December 1, 2008, and April 30, 2009. Sex of Bengalese finches was determined from blood samples (Griffiths, Double, Orr, & Dawson, 1998).

Estrildine finches, among them the Bengalese finch, are potentially good subjects for this kind of study, since they are easily maintained in captivity (Vriends & Heming-Vriends, 2002) and show a very distinct behavior of alarm in the presence of potential predators (mainly tail-flicking, wing-flapping, and alarm calls) (Goodwin, 1982, Lombardi & Curio, 1985a, 1985b, Zann, 1996, Marler, 2004).

Starting between 7:30 and 10:30 UT, the subjects (one at a time) were taken from their groups and put in the $70 \times 35 \times 35$ cm testing cage with transparent glass at both ends (Figure 1), where they were out of sight from other birds. Through a wide-open window the subjects could see the area with vegetation outside the aviarium, since being visually enclosed apparently reduces their expression of alarm (Lombardi & Curio, 1985a). During the experimental trials, after a period of time of 15 minutes, a video clip of 15 seconds duration of a slowly crawling horseshoe whip snake *Coluber hippocrepis* was shown in a TFT screen located at one end of the testing cage. The video clip was shown at random by a true random number generator (Orion Electronics), starting with

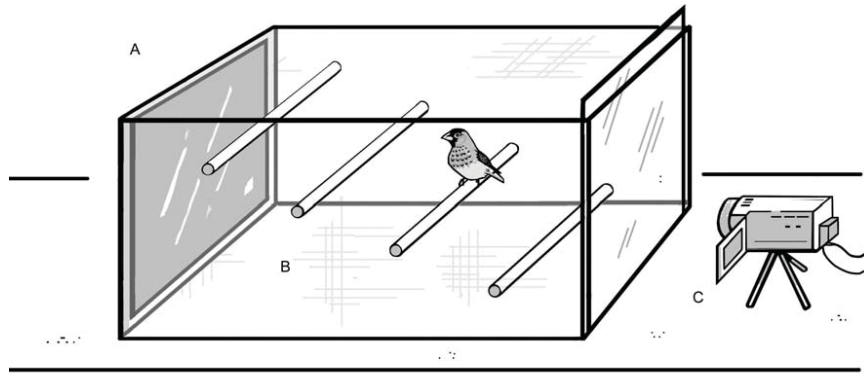


Figure 1. Testing situation. A) TFT screen, B) testing cage, C) video camera.

one of 20 possible options (unknown to the observer during the tests, and also randomly determined, Table 1) in the five minutes following the 15-minute period. The computer was located in an adjacent room and was connected to the TFT screen by a long cable.

**TABLE 1
Experimental Trials**

Time of Initiation of the 15-Sec Snake Video Clip after the 15-Min Accustoming Period, of the 20 Randomly Determined Options	
1	0 min 4 sec
2	0 min 11 sec
3	0 min 19 sec
4	0 min 46 sec
5	0 min 59 sec
6	1 min 5 sec
7	1 min 7 sec
8	1 min 13 sec
9	1 min 24 sec
10	2 min 2 sec
11	2 min 20 sec
12	2 min 44 sec
13	2 min 57 sec
14	3 min 11 sec
15	3 min 13 sec
16	3 min 16 sec
17	3 min 26 sec
18	3 min 36 sec
19	3 min 37 sec
20	4 min 41 sec

Although still images have been used to elicit behavior in the Bengalese finch (Watanabe & Jian, 1993), the use of video playback is usually more effective in birds (Dawkins & Woodington, 1997, D'Eath, 1998, Fleishman, McClintock, D'Eath, Brainard, & Endler, 1998, Cuthill, Hart, Partridge, Bennett, Hunt, & Church, 2000). Then, while cathode ray tube (CRT) screens are not appropriate to present stimuli to songbirds, thin film transistor (TFT) screens have been used with great success to obtain responses toward presented video clips from Bengalese and zebra finches (Ikebuchi & Okanoya, 1999, Galloch & Bischof, 2006, 2007).

During the control trial (separated 33–49 days from the experimental trial, their order being determined at random by using the true random number generator), only the same video clip background used during the experimental trials was shown to the same birds, also with a duration of 20 minutes. For 26 subjects the sequence was experimental \bar{P} control, and for 21 subjects control \bar{P} experimental.

During the whole experimental and control trial, each subject was filmed with a 25-frames-per-second video camera (a Sony DCR-SR72E), located outside the testing cage at the opposite end of the TFT screen (Figure 1), and controlled by the experimenter from a hidden location in an adjacent room.

Video analysis allows quantification of the intensity of alarm, which in the Bengalese finch is especially conspicuous. The alarm display lasts 0.1–0.2 seconds and consists first of very rapid flapping of both wings and then an abrupt sideways thrust of the whole body, and especially of the tail (Figure 2). The frequency of this behavior in 3-, 6-, and 9-second blocks immediately before the presentation of the snake stimulus was compared to that immediately before the same moment of the trials when no snake stimulus was shown, but only the same video clip background (control 1). As an additional control (control 2), the pre-stimulation frequency was compared to that occurring immediately before the 10-minute time point after the initiation of the same trial (when only the video clip background was shown). During frame-by-frame film analysis (accuracy of 0.04 seconds), I counted the frequency per 3-, 6-, and 9-second blocks in the above-indicated periods of the subjects' alarm behavior, using the VideoDubMod 1.5.10.2 computer program. To prevent subjective bias, 9-second video clips segments immediately before the stimulus and during the two controls were extracted from the recordings by another person, and the key that identified the segments was kept by a third party (the computer department of the institute). Once those video clip segments were analyzed by the author, without knowing whether each segment would correspond to a particular subject or to the stimulus or the controls, that key was provided.

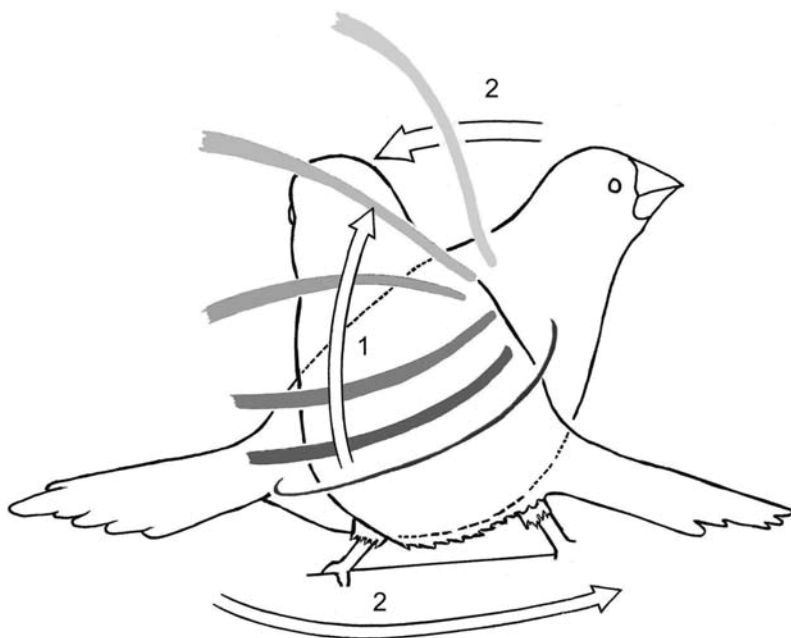


Figure 2. Acts of the alarm display of the Bengalese finch.
1) wings flapping, 2) body and tail sideways thrust.

Statistical Analysis

When separate analyses were done for males and females, nonparametric tests (Friedman ANOVA, Wilcoxon matched pairs test, Mann-Whitney U test, Siegel & Castellan, 1988, Zar, 1996) were used. When applying parametric tests, a $\log_{10}(x+1)$ transformation of behavior frequencies was carried out, and the resulting distributions did not depart from normality ($p = 0.10-0.20$, Kolmogorov-Smirnov test). The data were analysed using a repeated-measures ANOVA, in which control 1, control 2, and pre-stimulus measurements of the same experimental bird composed the replicate data. The t -test for dependent samples was used to compare pairs of distributions (Sokal & Rohlf, 1995, Zar, 1996). Data analysis was done using the STATISTICA 6.0 computer program. All reported p are two-tailed.

Results

When the frequencies of the behavior of alarm for the three periods of 0–3, 3–6, and 6–9 seconds before stimulus presentation were compared, they were found to belong to the same population for both females ($c^2 = 0.24$, $N = 24$, $df = 2$, $p = 0.886$; Friedman ANOVA) and males ($c^2 = 1.73$, $N = 23$, $df = 2$, $p = 0.421$). Consequently, I lumped together the three periods and considered for the rest of the analysis for males and females the 0–9 seconds pre-stimulus period.

Comparisons of behavior frequencies among the pre-stimulus period and the two control periods yielded significant results for both sexes (females: $c^2 = 9.06$, $N = 24$, $df = 2$, $p < 0.018$; males: $c^2 = 12.31$, $N = 23$, $df = 2$, $p < 0.0012$; Friedman ANOVA). Post-hoc two-variable comparisons showed, also for both sexes, that behavior frequencies for the two control periods were statistically similar (females: $N = 24$, $T = 106$, $p = 0.682$; males: $N = 23$, $T = 112.5$, $p = 0.650$; Wilcoxon matched pairs test). Furthermore, and also for both sexes, the pre-stimulus period showed significantly higher behavior frequencies than for control 1 (females: $N = 24$, $T = 62$, $p < 0.036$; males: $N = 23$, $T = 29.5$, $p < 0.008$) and control 2 (females: $N = 24$, $T = 27.5$, $p < 0.002$; males: $N = 23$, $T = 35$, $p < 0.005$).

The ratio of the frequency of the alarm display during the 9 seconds preceding stimulation to 1 plus the average frequency during the two 9-second controls was considered an adequate index of individual precognition ability (IPA). When the values for the two sexes were compared, no significant difference was obtained (IPA: mean \pm SE; females: 1.59 ± 0.26 , $N = 24$; males: 1.77 ± 0.27 , $N = 23$; $U = 247$, $p = 0.537$, Mann-Whitney U test).

The frequencies of the alarm display for females and males in the 9-second blocks during the experimental and control trials are presented in Table 2.

TABLE 2
Frequency (Mean \pm SE) of Bengalese Finches' Alarm Display during the 9-Second Blocks of the Different Periods

Period	Females (N=24)	Males (N=23)
Control 1	4.88 \pm 0.82	4.57 \pm 1.01
Control 2	5.79 \pm 0.79	5.04 \pm 0.95
Pre-stimulation	9.38 \pm 0.84	8.61 \pm 1.39

The absence of male–female significance differences enables the analysis of combined information for both sexes. In this case, the normalized pre-

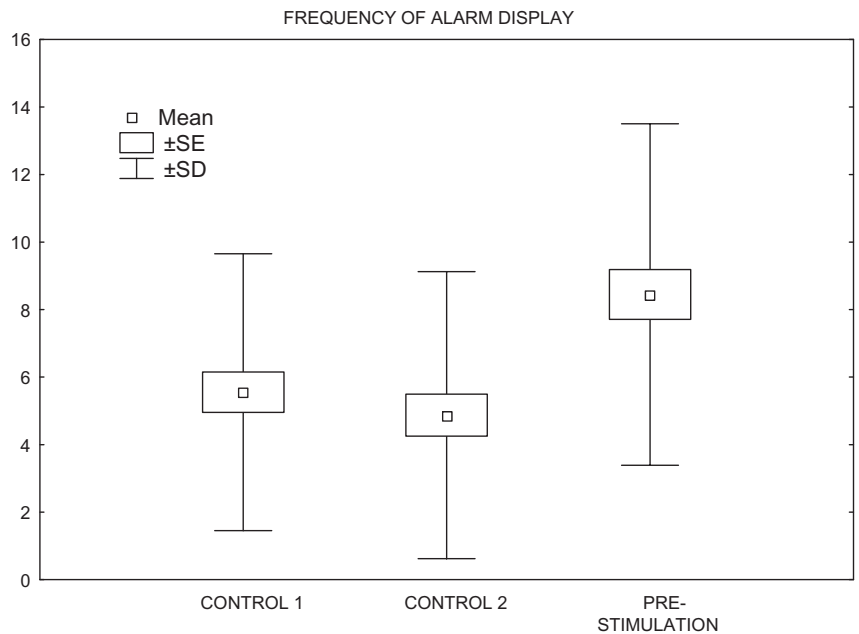


Figure 3. Frequency of the alarm display of Bengalese finches during the 9-second blocks in the two control periods and in the period immediately before stimulus presentation.

stimulation values during the three periods of 0–3, 3–6, and 6–9 seconds were also found to belong to the same population ($F_{2,92} = 0.60, p = 0.552$; repeated-measures ANOVA). Consequently the 0–9 seconds pre-stimulus period was considered for the rest of this study.

Joint analysis of the values for the pre-stimulation and the two controls periods yielded a highly significant result ($F_{2,92} = 10.12, p < 0.001$). Post-hoc two-variable comparisons showed the values for the pre-stimulation period to be significantly higher than those for control 1 and control 2 ($t = 3.56, P < 0.001, t = 4.49, p < 0.001$, respectively; $df = 46$; t -test for dependent samples). Values for both controls were not significantly different ($t = 0.93, df = 46, p = 0.357$) (see Figure 3).

Discussion

The higher frequency of the alarm display immediately before stimulation, as compared to that during the two controls, supports the idea that Bengalese finches may be able to anticipate short-term future events, also suggesting that

transtemporal perception is not limited to humans. Then, and contrary to findings in humans (Bierman & Scholte, 2002, McCraty, Atkinson, & Bradley, 2004b), no sex difference was found in Bengalese finches.

If human unconscious precognition is actually an old evolutionary mechanism in which the brain and the autonomic nervous system play a role (Bierman & Scholte, 2002, McCraty, Atkinson, & Bradley, 2004a, 2004b, Sartori, Massaccesi, Martinelli, & Tressoldi, 2004, Tressoldi, Martinelli, Massaccesi, & Sartori, 2005), and this ability has also been detected in other animals (Sheldrake & Smart, 1998, 2000, Wildey, 2001, present study), we may ask ourselves whether the different nervous systems may perform more ample functions than the classical elaboration of the information received through the ordinary sense organs (Laszlo, 2009).

Although the existence of precognition has been settled a long time back (Rhine, Smith, & Woodruff, 1938, Schmidt, 1969), the question still remains as to how it works. On the one hand, no explanation has been found so far in the deterministic framework of classical physics, as precognition seems to violate the causality principle. On the other hand, it does not fit in the unpredictable scheme of quantum physics either, suggesting that quantum theory, when applied to humans and other living systems, may not always be correct (Schmidt, 1993).

According to Bierman's (2008) psychophysical theory of Consciousness Induced Restoration of Time-Symmetry (CIRTS), the consciousness-sustaining brain can partially restore the break in time-symmetry, thus allowing for time-reversed processes like precognition. In a broad sense, the data for these Bengalese finches accommodate that hypothesis.

The ability to anticipate the presence of a predator by the Bengalese finches and other prey species would obviously increase their chances of surviving. If there would be a definite relationship between the precognitive response and the intensity or quality of the emotional event, and since the latter are expected to differ between both parties (potential predator and prey), the ongoing evolutionary arms race (Vermeij, 1987) would be asymmetrical, and perhaps to the advantage of the potential prey.

Several areas of research are more open when subjects are animals, such as selective breeding for enhanced hereditary precognition ability, exploration of physiological mechanisms involved in precognition, relationship with sex and age classes, and with social organization and personality profiles.

Although most psi studies need to be done in the controlled conditions of the laboratory, observation and experiment of animals in natural conditions should not be discarded, as they could provide hints about the natural selection and adaptive value of short-term alarm precognition.

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