Chick-computer interaction using sounds

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1 Objective

Interne of things (IoT) has been well developed and widely used in human society. Even in farm animal management, IoT has been introduced to monitor the condition of farm animals automatically. The farmers now understand the locations and behaviors of animals on their own mobile phones [1]. On the other hands, the automatic technology to control the behaviors and emotions of animals has been poorly developed.

Our final goal is the interaction between animals and computers and the development of completely automated management of animals. To archive it, it is essential to develop the two novel technologies for controlling as well as understanding of animals' emotion and to coordinate them.

The maternal care is widely observed in animal kingdoms. In domesticated chickens, the brooding behaviour of hens (mother chicken) induce the behavioural development of chicks, and the chicks brooded by hens shows dramatically low fearfulness in novel environment [2]. The persistent effect of maternal care is also observed after removing hens from chicks [3]. However, it is almost impossible to introduce the actual hens into farms where the thousands to tens of thousands of chicks are kept in a large area.

Here we show the chick-computer interaction using sounds. We first analyzed the sound communication between chicks and hen. Then we recreated the interaction with chicks using sounds in a computer. Finally, we evaluated the effect of chick-computer interactions on behaviour and also brain by genome-wide gene expression analysis using RNA-sequencing.

2 Materials and Methods

3.1 Sound communication between chick and hen

The chicks (commercial breed) and hens (silky fowls; high broodiness) were used. The chicks were introduced after hens showed broodiness, and the sounds between chicks and hens were recorded. A total of 2,038 sound spectrograms were obtained using a sound analysis software (Audacity). The sounds were classified and analyzed by time series analysis and transition analysis.

3.2 Chick-computer interaction

First, we developed a software "Chick Call Detector" (CCD): The calls of chicks were automatically classified into pleasure-call at positive emotional state and distress-call at negative emotional state based on the slope of sound frequency, and then the sound files of food-calls of hens were played back in real time at the timing when the distress-calls of chicks were detected. The CCD system was consisted of importing the sound of chicks from microphone into PC, processing by CCD in PC, and exporting of food-call sound from speaker via audio interface. To evaluate the system, the chicks were divided into the following three groups: control (no sound), yoked control (random presentation of food-call), and treatment (presentation of food-call using CCD). The fearfulness of chicks was measured by behavioral test against the novel object used in Welfare Quality protocol [4].

3.3 Gene expression in brain

The total RNA was extracted from the brains of chicks in the above three treatments. The RNA was sequenced by next generation sequencer (DNBSEQ, BGI) with 150-bp paired-end reads. The sequenced reads were aligned on chicken reference genome (Gallus gallus7, release-106, whiteleghorn layer) using HISAT2 and the aligned reads were counted and statistically analyzed using Cuffdiff. The pathway analysis using the differentially expressed genes (DEGs) were also performed.

3 Results and Discussion

3.1 Sound communication between chick and hen

When hens showed maternal care to chicks, the calls of chicks were mainly classified into distress- and pleasure-call and only food-call was found in hens (Figure 1a). Also, we found in time series analysis that hens showed food-call when chick showed distress-call, and after the chick calls were changed from distress-call to pleasure-call, hens stopped the food-call (Figure 1b). The results indicated that the food-call of hens suppressed the distress-call and induced the pleasure-call of chicks.

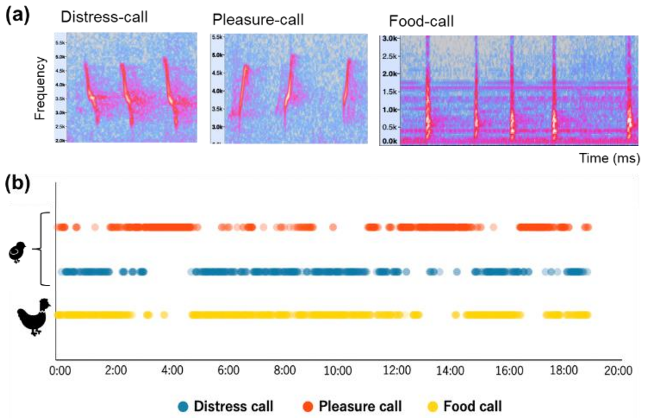

Figure 1: (a) The sound spectrogram of chick (distress- and pleasure-call) and hens (food-call). (**b**) The change of sound communications between chick and hen.

3.2 Chick-computer interaction

When recreated the sound communications between chick and hen using CCD, the latency time until eating in novel object test was shorter in yoked control than control ($P < 0.01$; Figure 2a, c). The latency time was also shorter in CCD treatment (Figure 2b) than yoked control ($P < 0.01$; Figure 2c). The results indicated that the fearfulness could be reduced using recorded food-call of hens. Interestingly, more reduction of fearfulness was found in interactive presentations of food-call based on chick call than random presentations.

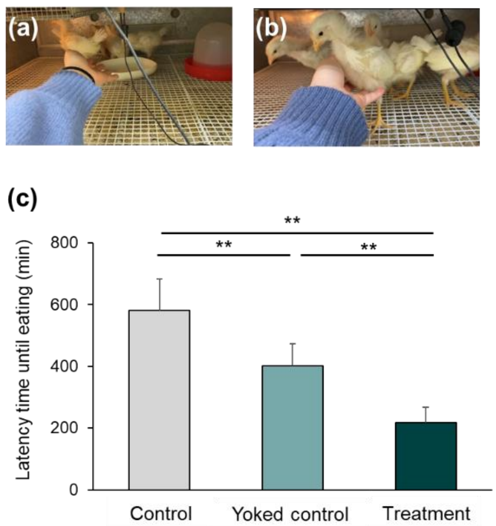

Figure 2: (a, b) The fearfulness of chicks was dramatically reduced in CCD treatment (b) than control (a). **(c)** The latency time until eating in novel object test was lower in the order of treatment, yoked control and control (all $^{**}P < 0.01$).

3.3 Gene expression in brain

The RNA-seq analysis identified the DEGs between the two comparison groups: control *vs.* yoked control and control *vs.* treatment (Figure 3a). To identify the candidate genes, we combined the results from the two comparisons and identified 58 DEGs (Figure 3b). Of the DEGs, *AANAT*, *ASMT*, *OTX2* and *NRTN* were found. *AANAT* and *ASMT* were functional genes to produce the serotonin and melatonin, which has important role for reduction of fearfulness. Also, *NRTN* and *OTX2* were functional with dopaminergic neuron, which is key role to relate the stimulus with reward. Therefore, the results suggested that induction of interactive communication and reduction of fearfulness were occurred in brain of chicks.

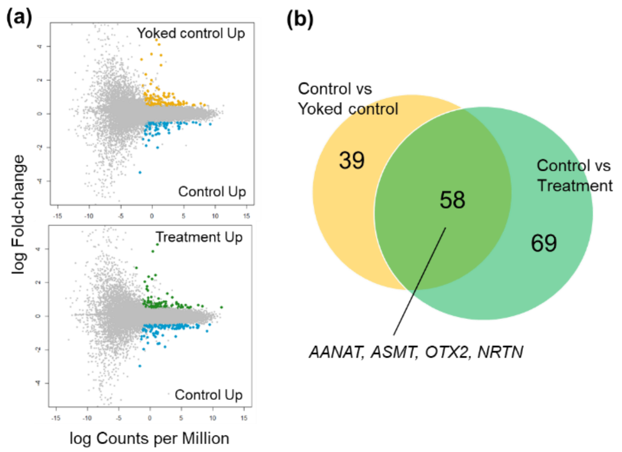

Figure 3: (a) The MA plot compared the gene expression. **(b)** The ben diagram combined the DEGs of two comparison groups.

3.4 General discussion and future plans

We have also developed the hen-imitated robots (mother chicken-imitated robots). In the meeting, we will show the robots and would like to discuss about adaptive motion for chicks.

References

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