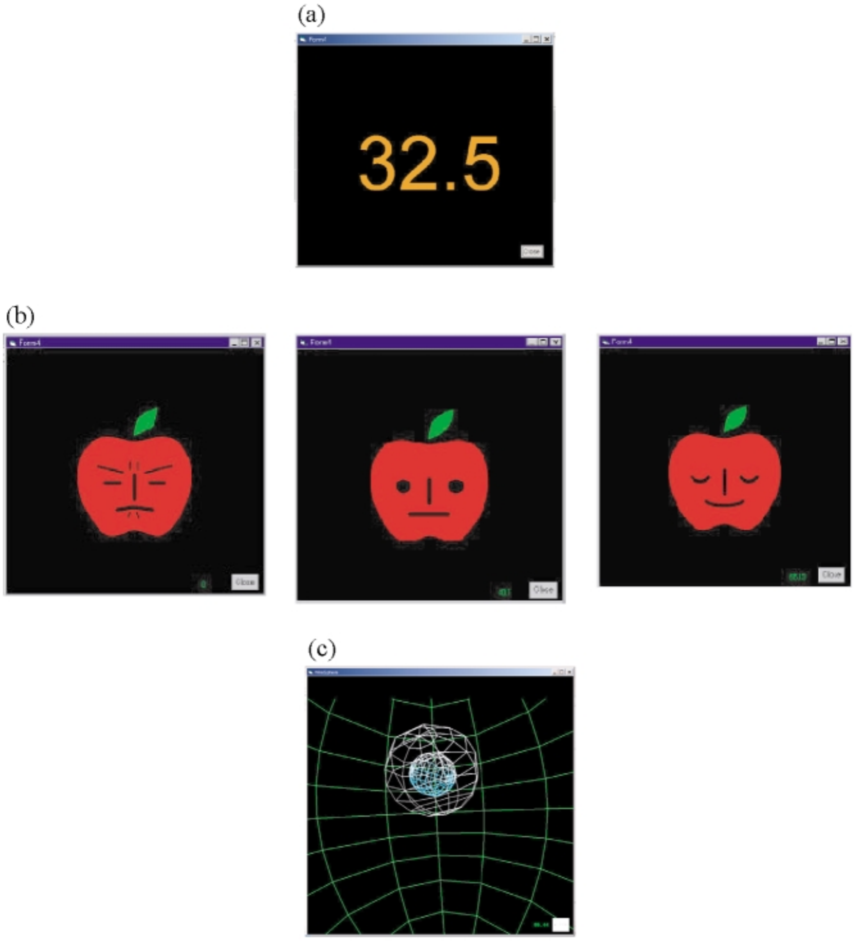

Fig. 3. Images displayed to participants. (a) Numeric character representing HF power; Numeric. (b) Apple representing HF power with facial expression; Apple. (c) Wire-frame sphere; Sphere1 (Speed of animated motion is according to the HF power); Sphere2 (Speed of animated motion is in inverse proportion to HF power).

linear prediction model of time series:

$$r(t) = \sum_{k=1}^{p} a(k) r(t-k) + Z(t) \tag{6}$$

where $r(t)$ is the time series of R-R intervals, $a(k)$ is the linear prediction coefficient, p is the order of the autoregressive process, and $Z(t)$ is the prediction error, which is the white noise. The optimal order of the autoregressive process is selected as the minimized the final prediction error (FPE) described below:

$$\mathrm{FPE}(k) = Z_{sd}^2 \frac{N+k}{N-k}. \tag{7}$$

Z_{sd}^2 is the variance of $Z(t)$ and N is the number of data.

The power spectral density function ($P_{AR}(f)$) is described in Eq. (8).

$$P_{AR}(f) = \frac{Z_{sd}^2}{\left|1 - \sum_{k=1}^{p} a(k) \exp(-j2\pi f k)\right|^2}. \tag{8}$$

In this equation f is the frequency.

Wavelet transform is one of the popular time-frequency analysis methods. This method is useful for the analysis of non-stationary time series. Wavelet transform provides a flexible time-frequency window according to observing frequency. Gabor transform is one of the wavelet transforms. The power spectral density function derived from the Gabor transform is described in below:

$$P_{wt}(f) = \left| \sum_{t=1}^{N} \frac{\exp\left(-\frac{(t-b)^2}{4f}\right)}{2\sqrt{\pi f}} \exp(-j2\pi f t \Delta t) \right|^2. \tag{9}$$

Gaussian function localizes the Fourier transform of f around $t = b$ in the Gabor transform.

Next, 170 measured R-R interval time series with 3-minute long were analyzed. The area of the power spectral density function with 0.15 to 0.4 [Hz] is defined as the HF power in FFT and AR methods. A time window with 20 [sec] width is used to calculate power by the wavelet transform. The average of the powers derived from the moving window 1 [sec] interval is defined as the HF power in the wavelet transform.

The correlation coefficients of the proposed method and other methods are shown in Table 1. A large correlation coefficient is presented in the AR model and in the wavelet transform. The accuracy of estimation of the HF power is the same as with the conventional methods.