Effects of verbal feedback on heart rate self control

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Present study tested the effects of discrete posttrial verbal feedback information on self control of an increase and a decrease in heart rate (HR). Sixteen volunteer male subjects were divided into two groups, in which they received either verbal feedback (VF) or no feedback (NF). All subjects were asked to increase and then decrease their HR relatively to their pretrial base HR levels, keeping their respiratory activities as much stable as possible during the tasks. Results showed that subjects in VF group achieved better HR control than ones in NF group, especially, in HR decrease sessions. Respiratory activities, however, could not account for these differences of HR. Therefore, it was suggested that the subject's internal strategy influenced the HR control. The relationship between HR control and verbal feedback information as the calibrator of the amount of HR changes was discussed.

Key words: self control, heart rate, verbal feedback, biofeedback, internal strategy.

A variety of studies of heart rate (HR) changes in human subject have been described in terms of HR self control or HR biofeedback established through external sensory feedback display. Among these studies, several parameters (e.g., type of feedback stimulus, instructional effects, motivational factors, retention of feedback effect, etc.) which are considered to play an important role, have been investigated, as Blanchard and Young (1973) and Williamson and Blanchard (1979) have reviewed.

Unfortunately, only a few reports have provided the utility of verbal feedback on HR modification in the early period of operant HR conditioning researches (Ascough & Sipprelle, 1968; Cox & Sipprelle, 1971). Those authors demonstrated that the subject was able to accelerate and decelerate HR activity, which was reinforced verbally without any awareness of the stimulus-response contingencies. However, their results seem to be deficient in interpreting as evidence that their subjects have obtained voluntary HR control. Because the basic idea of operant verbal HR conditioning without knowing the desired response has diverged from the present HR self control (biofeedback) researches.

Brener (1974, 1977) has emphasized that the ability of individuals to comply with instruction to their HR activity and the awareness of their own introceptive sensory states to be performed, are major conditions for voluntary HR control. According to Brener's model, the incentive properties of feedback stimuli are based primarily upon associative processes and are determined by verbal command usually contained within the instruction. It could be considered that calibration of the amount of HR changes provided by verbal feedback discharges the commands to activate the response image presentation of introceptive sensation. That may be identical with other exteroceptive feedback stimuli that have been employed so far.

More recently, Wright, Carrol, and Newman (1977) have dealt with the effects of verbal feedback of elicited HR changes. In their study, verbal information of elicited HR changes was considered to be the necessary condition for calibration, and subjects would perform HR control in compliance with instructions included in the previous verbal labeling. They divided subjects into three groups. A group
received veridical verbal feedback of elicited HR changes during stimulation trials. But other two groups were falsely informed or received no feedback during the trials. The result showed that verbal feedback group obtained greater HR changes than other two groups in subsequent HR self control trials. Wright et al. (1977) have noted that the association between verbal labeling of elicited HR changes and introspective stimuli may be calibrated by instructions to control HR activity. But they did not discuss whether verbal feedback itself has an effect on the ability to control HR activity directly.

In the present study the authors investigated the effect of verbal feedback on HR control. We designed verbal feedback to provide HR information telling about the outcomes on HR control performances immediately after each trial. Verbal feedback information based on HR activity might provide subjects with the knowledge of results (KR) about their HR self control coming out well or not in each HR control task, although KR is retarded after each trial. According to Brener's model, it would be postulated that calibration of the amount of HR changes provided as KR with verbal feedback also allows the commands to activate the response topography associated with HR increase and decrease.

The second aspect of the present study was to investigate the subject's internal states contributing to the control of HR activity. Many previous papers suggested that subjects showed such particular mental states when they used some internal techniques as active thinking in HR speeding and passive attitude in HR slowing (Bell & Schwartz, 1975; Bouchard & Corson, 1976; Murray, 1968; Wells, 1973). This implies that learned HR decreasing should require subjectively different status from that of HR increasing. In this study self-report measurement was used in the form of a postexperimental questionnaire designed to show the affective-cognitive states of subjects during HR control tasks. An attempt was made to prove that the subjects would manifest the divergent internal responding to the different HR control direction. We hypothesized that the subjects given verbal feedback would rate higher score than those who received no feedback. If affective activities are the processes responsible for the changes in HR activity, the subjects might reveal the enhanced affective feelings in attention to attain the large magnitude of HR changes. It is possible to consider that HR controlling might facilitate the affective feeling (internal strategies) associated with HR self control and result in stronger feeling than could be achieved with no feedback condition.

Method

Subjects

The subjects were 16 healthy male undergraduate and graduate volunteers who were from 18 to 25 years in age (mean = 21). They had no experience with HR self control or relaxation training such as autogenic training or meditation. Each subject was randomly assigned to verbal feedback (N = 8) group and no feedback (N = 8) group.

Apparatus

Following physiological variables were recorded with a 13-channel electroencephalograph (SAN’Ei 1A52 Model). HR was measured with recording electrodes attached to subject's right and left forearms, the amplified signals were coupled to a SAN’Ei2130 Model cardiotachometer, and the cardiotachogram was recorded on a DC recorder. Respiration rate and depth were measured by means of a strain gauge transducer cemented on the belt strapped around the subject's chest. At the time, skin potential response (SPR) was measured with electrodes placed on the right palmar and ventromedial forearm. Those electrodes were separated by
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approximately 8 inches (20 cm). Occipital EEG activity was recorded through an electrode attached to the position Oz on the scalp. The subject’s left earlobe was grounded. The raw EEG signal was carried to an analyzer (SAN’EI 10A Model) and modulated to the instantaneous spectrum and the amplitude integral. Outputs of spectrum which was passed through three different band filters (i.e., theta, alpha, and beta) and the amplitude integral which was computed in each 5 s interval, were recorded in the polygraph simultaneously. When experimental contingencies were in force, subjects were presented with 500 Hz 25 dB tone (high tone) on each HR speeding task, and 250 Hz 25 dB tone (low tone) on each HR slowing task via a speaker which was coupled with an auditory stimulator (NIHON-KODEN, Model 1PS) located 1.0-in in front of them. Those tones were used as different signals for HR control task in each trial. Those signals came on at the beginning of each trial period and went off at the end of the period. Signals from SPR and EEG were not analyzed in the present report.

Procedure

Each subject was seated in reclining lounge chair in a light-proofed, sound-attenuated shield experimental chamber. Subjects were instructed about the experiment in detail while electrodes and transducers were attached. After 10-min resting baseline period, two blocks of 5 trials each were presented. In the first block the task was randomly chosen as either to increase or decrease HR and in the second block the task was the opposite of the first block. Each trial was of 1-min duration, and the intertrial interval varied arbitrarily within 1 and 3-min. Subjects were instructed that they were to be presented with high- and low-pitch tones by the stimulator. One of the tones signalled the increase task and the other signalled the decrease task. When the tone signal was presented, subjects were to control their HR in the instructed direction. Subjects were instructed that they were expected to achieve a 10% change in HR from the mean baseline HR level. Subjects in verbal feedback (VF) group were given the additional instructions that they would receive verbal information about their HR performance immediately after the each trial. That information was the average HR change obtained in the pretrial and the trial. So that the subject in VF group would be delivered verbal information consisting of: (1) pretrial HR level, (2) whether they could respond to the desired direction correctly or not, and (3) the relative change calculated by subtracting the pretrial HR level from HR performances obtained in the trial. In addition to that information, subjects were reinforced verbally in the case of the change of HR was in the desired direction or encouraged to try harder when the change was in the undesired direction. Rationale of introducing verbal reinforcement were to maintain constant effort by the subject to control HR activity. Information of pretrial HR level was delivered prior to the trial, the other two components of information of HR activity and verbal reinforcement were always provided by the experimenter’s voice via intercom after each trial. The subject in no feedback (NF) group was given no feedback. All subjects were instructed to regulate their own respiration rate by synchronizing them with the sound of metronome. The rate of paced respiration in each subject was equal to the average rate that he attained in the initial 10-min baseline rest period. The subjects were also instructed not to engage in any other bodily change in attempt to control their HR. If the subject failed to regulate respiration adequately or slipping into the sleep, the ongoing trial was terminated. The subject was instructed via intercom to pay attention, and that the trial was repeated. Those behaviors were also monitored by polygraphic recording of EEG, SPR and respiration.
At the end of the second block of trials there was 5-min rest period in which all subjects were asked to answer the questionnaire. The questionnaire was used to examine the type of internal strategies utilized by subjects in attempt to control their HR activity. The questionnaire consisted of two parts, i.e., self-reported description and rating 35 affective words. In self-reported description, the subject used his own words to describe his feeling and any internal strategy for HR controlling. In the part of rating affective words, it contained 35 affective words and required a rating along a five-point scale for subject's perceived association between affective feeling and the control task. Those affective words were selected from various feelings and states of consciousness reported in the previous studies (Engel & Chism, 1967; Engel & Hensen, 1966; Murray, 1968), and our preliminary experiment. Following this rest, another 10-min resting baseline was taken, two more blocks of five trials were run and the questionnaire was given.

Results

Heart Rate Data

The numbers of heart beats coming out of the EKG record in the latter half of 30-s pretrial period that was assigned as precontrol base level and in the 1-min trial period were enumerated, and then HR score was computed for the each period. As additional measurement for comparing the outcomes in VF and NF groups, the trial that showed HR changes of greater than +3 beats in the expected direction contrasting to precontrol period was defined as high HR gaining trial, and the frequency was counted for the all subjects. Figure 1 shows the change of HR control performance during both increase and decrease tasks in VF and NF groups. It presents the mean HR changes from precontrol level. As Fig. 1 illustrates, the differentiation of the HR changes between increase and decrease tasks occurred in VF group, but not in NF groups. That is, VF group shows more HR increase ($\bar{x} = +3.8$ bpm, +3.4 bpm) than NF group ($\bar{x} = +1.5$ bpm, +1.6 bpm) during block I and block II. Further more, VF group revealed better HR control tasks ($\bar{x} = -1.8$ bpm, $-2.1$ bpm) than NF group ($\bar{x} = -0.6$ bpm, +0.7 bpm) during decrease block I and II. The overall analysis by two 2 (VF, NF) × 2 (increase, decrease) × 2 (block I, block II) ANOVA were conducted on the HR scores for both precontrol and trial periods. The analysis revealed that the mean difference of HR control tasks between the increase and decrease trials was significant, $F(1/14) = 37.19, \ p < .01$. The feedback condition × control task interaction, as inspected in Fig. 1, might
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stem from the effect that within the HR increase condition subjects given VF had higher HR changes than NF subjects whereas the reverse was observed within the HR decrease tasks. Analyses of HR scores obtained in the precontrol period showed no significance between groups and also between control tasks, respectively, $F(1/14)=0.41, F(1/4)=2.92, p's>.05$. As the second analysis, four $2 \times 5$ ANOVA with feedback and five repeated trials were also conducted for each HR control block. Although there was no significant difference with trial effect and interaction effect of feedback $\times$ trials in each control task, main effects of feedback condition were significant in all blocks; that is, with increase block I, $F(1/14)=4.947$, with increase block II, $F(1/14)=3.685, p's<.05$; with decrease block I, $F(1/14)=15.979$, with decrease block II, $F(1/14)=16.898, p's<.01$. Superiority of the outcomes in VF subjects was also confirmed by comparing the frequencies of high HR gaining trials between VF and NF groups, as Fig. 2 shows. Significant differences were found between groups in both control tasks with block I and II combined, respectively: for increase task, $\chi^2=9.233, df=1, p<.01$; for decrease task, $\chi^2=25.71, df=1, p<.01$.

Respiration Data

Respiration rate and depth were calculated from the chart of the polygraph record. Respiration rate (RR) was obtained by counting the frequency of breaths, over 15 s precontrol period and 1-min trial periods. The transformed average percentage of RR was scored from dividing the number of RR in the each trial period by mean RR (cycle/min) in each precontrol period. Breathing depth was measured by calculating the peak amplitude values of inhalation-exhalation cycle during each 1-min trial and then divided into three categories; shallow, medium, and deep. A shallow pattern was defined as a decrease of more than 25%.

Fig. 2. Comparison of the frequencies of trials with high gaining HR changes between VF and NF groups during increase and decrease tasks.

Fig. 3. Mean percentage of respiration rate with respect to the precontrol rates of VF and NF groups for HR increase and decrease tasks.
and a deep one was an increase of more than 25% over the initial level which was obtained from 10-min rest period. A medium depth was also defined as less than 25% change in each direction from the depth of breathing comparing to the initial rest level.

Figure 3 illustrates the overall outcome of the transformed average percentage of RR compared between VF and NF condition during increase and decrease blocks. The overall analysis by a 2 (VF, NF) × 2 (increase HR, decrease HR) × 2 (block 1, block II) ANOVA was conducted on the transformed RR score. The analysis showed no statistically significant difference between the feedback variables and the control tasks, respectively, $F(1/14)=1.71$, $F(1/14)=1.75$, $p$'s>.05. Figure 4 presents the comparison of the number of trials showing deep, medium, and shallow breathing depth during HR increase and decrease blocks in both VF and NF groups. Both groups showed a slight tendency for deep breathing associated with HR increase tasks and showed fairly constant breathing for HR decrease tasks. Those differences between control tasks were found to be significant ($\chi^2=41.866$, $df=2$, $p<.01$), but no significant difference was found between feedback conditions ($\chi^2=3.914$, $df=2$, $p>.05$). Those results indicated that the difference in HR control between groups was unrelated to those breathing patterns.

**Affective Data**

Table 1 summarized the response associated with the HR control task from the postexperimental questionnaire for both VF and NF groups. All words rated 3 points or more on 5-point scale were selected from the list of 35 affective words. From the self-report description, it was revealed that when subjects tried to increase their HR, they utilized more volitional and emotional thinkings as an internal strategy in order to attain the HR controlling. Conversely, when they attempted to decrease their HR activity, they kept themselves calm and relaxed as much as possible. It is really interesting that there was no overlap of selected words between increase and decrease tasks. All subjects reported that during HR raising they would “try to estimate their HR or think about something exciting”. On the other hand, during HR lowering they tried not to concentrate their attention on the inside of themselves (“leaving out any concentration or letting mind go blank”). Hence the subjective accompaniments of bidirectional HR control tasks were completely opposite. Those results suggested

![Figure 4. Comparison of the respiratory depths of VF and NF groups during HR increase and decrease tasks.](image-url)
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Table 1
Summary of words from self-report affective scale

<table>
<thead>
<tr>
<th>Heart rate increase</th>
<th>Heart rate decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irritated</td>
<td>Refreshed</td>
</tr>
<tr>
<td>Tense</td>
<td>Interested</td>
</tr>
<tr>
<td>Alert</td>
<td>Comfortable</td>
</tr>
<tr>
<td>Angry</td>
<td>Calm</td>
</tr>
<tr>
<td>Afraid</td>
<td>Drowsy</td>
</tr>
<tr>
<td>Annoyed</td>
<td>Relaxed</td>
</tr>
<tr>
<td>Scared</td>
<td>Pleasant</td>
</tr>
<tr>
<td>Weary</td>
<td>Attention is Distracted</td>
</tr>
<tr>
<td>Discouraged</td>
<td>Settled</td>
</tr>
<tr>
<td>Anxious</td>
<td>Engaged in Thought</td>
</tr>
<tr>
<td>Enthusiastic</td>
<td></td>
</tr>
</tbody>
</table>

Table 2
Comparison of summed overall affective scores in VF and NF groups

<table>
<thead>
<tr>
<th></th>
<th>VF group</th>
<th>NF group</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD)</td>
<td>67.0 (6.68)</td>
<td>49.9 (4.45)</td>
<td>6.71***</td>
</tr>
<tr>
<td>Increase task</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decrease task</td>
<td>65.0 (3.07)</td>
<td>46.3 (3.81)</td>
<td>10.84***</td>
</tr>
</tbody>
</table>

Note: t-values are statistically significant at .001 level, with df=14.

that 35 affective words could be divided into two groups in which 18 words connote emotionally arousal feelings, or in which 17 words imply the tranquil states. The difference corresponded to the direction of HR control tasks. There were no cases to assign the tranquil 17 words in HR increase and to rate emotionally arousal 18 words in HR decrease. So that, it was better to analyze those dimensions separately. To compare the strength of affective feeling between groups, individual scores of 18 words assigned in HR increase task, or of 17 words in the decrease task were separately summed up as overall affective scores in each subject.

As a result, VF subjects produced greater mean scores than subjects in NF for both HR controlling tasks. Those differences were statistically reliable between groups in the increase and decrease tasks, respectively (Table 2). This supported our hypothesis that the subject would manifest the divergent affective responding to different HR control tasks and also that VF subjects would rate higher score than that of NF subjects.

Discussion

Results obtained in this study indicate that verbal feedback providing HR information has a positive effect on the self control of HR activity. VF subjects were able to control their HR activity better as compared with NF subjects. Subjects receiving the posttrial verbal feedback showed better performance than NF Subjects for HR decrease tasks, although less differences were found for increase tasks. The magnitude of HR changes obtained here was, however, quite small. Data in the present experiment showed that subjects obtained the mean HR changes of only +3 bpm (increase tasks) and −2 bpm (decrease tasks) in even VF condition. Many other studies have reported that subjects are able to produce HR changes of greater change than +5 bpm (Bouchard & Granger, 1977; Colgan, 1977; Gatchel, 1976). However, the large magnitude of HR changes in those studies should be cautious of confiding in that their data may result in artificially higher changes due to adaptation effects (e.g., Bouchard & Granger, 1977; Williamson & Branchard, 1979). In this paper, 15 s precontrol HR level was employed as the computing basis of mean HR changes, in stead of using the initial resting HR level. It should be noted that we could find the large magnitude of HR changes if HR difference score were computed based on the initial resting HR level. That is, mean HR changes for each block should be: $\bar{x} = +6.1$ bpm, $+5.8$ bpm in increase blocks for VF, $\bar{x} = 5.0$ bpm, $4.3$ bpm for NF; $\bar{x} = -4.0$ bpm, $-4.3$ bpm in decrease blocks for VF,
\[ x = -2.6 \text{ bpm}, -2.9 \text{ bpm} \text{ for NF, respectively}. \] Therefore, results obtained here should be considered to reveal "actual gain of HR changes" on HR control performance.

Another source for limiting the magnitude of HR changes obtained here may refer to the fact that the somatic activity was inhibited by employing respiration control as the intervening procedure. Manuk (1976) has reported that application of pacing procedure effectively reduce the intervention of respiratory artifact. His result showed, however, that subjects who were given the pacing procedure caught only very small HR changes. On the other hand, Holmes, Solomon, and Buchsbaum (1979) have reported that their subjects are able to achieve the large changes in HR increase by voluntary respiration management. Those findings imply that respiratory involvement may contribute to producing the large magnitude of HR changes, especially, in HR acceleration. Of course, it does not indicate that our HR data was entirely free from the respiratory artifact. Results showed the fact that the change of respiration pattern was found between the control tasks even under the respiration pacing, but that feedback condition did not produce the difference of respiration. Figure 4 reveals that HR increase tasks were followed by an increase in breathing depth and a shallow breathing observed in HR decrease task. Those results coincide with the result of Sroufe (1971) in which changes in breathing depth and rate were closely related to HR activity. It should be noted, however, that performance on HR control for VF subjects was better than for NF subjects, in spite of the fact that there was no significant difference in the respiratory activity between VF and NF groups. This evidence suggests that HR self control is primarily due to the feedback effect rather than the intervention of respiratory components.

Subjective data supported many previous views that divergent strategies are carried out for the bidirectional HR controlling requirement (Engel & Chism, 1967; Engel & Hensen, 1966; Murray, 1968). However, some papers have questioned the validity of post hoc analysis of postexperimental questionnaire for determining the cognitive strategies, since the responses are often idiosyncratic and do not connect to HR changes directly (Blanchard, Scott, Young, & Edmunson, 1974; White, Holmes, & Bennett, 1977). In this study, however, rather than attempting to detect a particular cognitive mediator which controlled HR changes, affective changes that occurred while attempting to produce HR change were measured. Because the ongoing internal states of subjects must be changing during HR controlling every moment, it would be quite difficult to identify the specific cognitive mediator to control the HR activity. The authors considered that it will be of benefit to study the common affective states which are concomitant with the HR control task. From this idea, we hypothesized that HR controlling might facilitate the affective feeling, which imply the general internal strategies associated with HR self control, and result in stronger feeling than could be achieved with no feedback condition. Looking upon the results of Wright et al. (1977), it would be easy to consider that verbal labeling the elicited HR changes make the subject aware of his ongoing affective states and enhanced them. Actually, VF subjects showed greater scores of affective data than NF subjects both HR control tasks. The results of this study supported the above idea. In addition, affective data should be considered in light of the VF procedure applied in this study. VF subjects might have the advantage of focusing on the internal states without interruption by continuous feedback which might hinder the subject's efforts to scan the internal states associated with HR changes, especially in the HR increase. Colgan (1977)
showed that subject's perception about the feedback contingency was dependent upon the feedback modality. According to Brener's model (1977), current result suggests that the concentration on internal processes for VF subjects might promote the awareness of the relationship between changes in HR activity and subjective internal states.

Finally, the utility and the property of VF procedure applied here must be discussed. VF may imply a type of binary (or discrete) feedback in that the subjects were not provided with the proportional and analogue feedback information. However, the authors view VF procedure as a type of semantic feedback which carries much modulated information than a simple binary (discrete) feedback. Because VF subjects received the criterion for HR control performance and were feedback three bit of information about their HR performance: [(1) pretrial HR level, (2) whether they could respond to the desired direction correctly or not, and (3) the relative HR change that is calculated by subtracting the pretrial HR level from HR performance in trial], they were able to organize their own perspectives about HR control. Unfortunately, the relative efficacy of VF compared to other type of feedback could not be discussed here due to the lack of direct comparison with other feedback modalities.

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