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The Effect of External Versus Internal Types of Feedback and Goal Setting on Endurance Performance

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ABSTRACT

To examine the effects of different types of feedback and goals on endurance performance, a laboratory experiment was conducted with 80 physical education students 18 – 21 years of age. After a baseline trial on a submaximal test on a cycle ergometer, participants were assigned to one of four experimental conditions and performed the task again. Group 1 participants set a personal goal for lowering their heart rate and were provided with concurrent heart rate feedback. Group 2 participants set a personal goal for lowering their heart rate during the task and were provided with concurrent heart rate feedback as well as time on task feedback. Group 3 participants set a personal goal for increasing time on task and were provided with respective concurrent feedback. Group 4 participants were given the instruction "do your best" but not any feedback. The results showed that Groups 1 and 2 improved their performance significantly, with Group 1 showing the largest improvement. It seems that heart rate feedback coupled with goal setting for heart rate decrease is effective in enhancing endurance performance. Findings are discussed in terms of theoretical as well as practical implications for understanding relationships between goal setting and external or internal types of feedback.

Introduction

One of the main aims of athletes and trainers is maximizing performance. Sport psychology contributes to this endeavor by proposing, among others, the application of psychological techniques such as goal setting. The theory supporting goal setting was developed in industrial/organizational settings but research has proven the effectiveness

of this technique in different fields (Locke & Latham, 1990). Locke and Latham (1990) have reviewed an impressive number of studies that support the notion that specific, challenging goals lead to higher levels of performance than easy goals, no goals, or "do your best" goals.

Research examining goal setting in sport and exercise settings has provided less consistent evidence. Specifically, Kyllo's and Landers (1995) meta-analysis indicated that goal setting improves performance in sport by 0.34 of a standard deviation. Generally, some studies support the beneficial effects of goals on performance (eg., Burton, 1989; Hall, Weinberg & Jackson 1987; Lerner & Locke, 1995; Theodorakis, 1995; 1996), but other studies have failed to demonstrate any difference between the goal setting group and the "do your best" group (e.g., Weinberg, Bruya & Jackson, 1985; Weinberg, Bruya, Jackson, & Garland, 1986). Weinberg and Weigand (1993) attributed these findings, in part, to the provision of feedback only to participants in the goal setting condition. They argued that providing the specific goal participants with feedback while withholding feedback from participants in the do best condition constitutes a methodological flaw. Weinberg and Weigand (1993) further argued that feedback is inherent in many sport situations, thus, it's effect should be examined in conjunction with goal setting. Therefore, the present study aimed to examine the combined effect of feedback and goal setting on endurance performance.

In sport and exercise settings different types of feedback can be provided. Some types of feedback are external to the performer, such as time on task, distance, number of repetitions, or weight. However, some other types of feedback can be internal to the performer. For example, in endurance tasks, internal feedback can be given regarding the performer's biological functions such as heart rate, respiration, and systolic blood pressure. This type of internal feedback is also known as biofeedback. Although biofeedback has been shown to be very important in learning and performance in sport and exercise settings (e.g. Bar-Eli, Dreshman, Blumenstein, & Weinstein, 2002; Kavussanu, Crews, & Gill, 1998; Zaichkowsky & Fuchs, 1988), there are no studies that have examined its effectiveness in connection with goal setting.

Several studies have demonstrated that individuals can control their heart rate while performing at submaximal level if provided with concurrent feedback regarding this biological function. For example, Goldstein, Ross and Brady (1977) had participants performing several sessions of a walking task on a treadmill and instructed them to try to lower their heart rate. Half of the participants were provided with heart rate monitoring while the others were not. Participants who received heart rate feedback had a significantly lower mean heart rate as well as lower systolic blood pressure. Perski and Engel (1980) reported that when subjects who were performing an endurance task on an ergometer bicycle, were given heart rate biofeedback and were instructed to try to lower their heart rate, they were able to lower their heart rate about 20% relative to a control group. In a similar study, Perski, Tzankoff, and Engel (1985) showed that the provision of heart rate biofeedback to subjects performing on an ergometer bicycle resulted in a smaller increase in heart rate in comparison with a control group. Similarly, Lo and

Johnston (1984) reported that heart rate feedback was superior to verbal instructions for reducing heart rate in participants performing an endurance task on an ergometer bicycle.

Zaichkowsky and Fuchs (1988) reviewed a number of studies that used biofeedback in order to enable subjects to control their heart rate and respiration during exercise. They concluded that "… cardiac and pulmonary functions have been shown to be under volitional control during various exercise regimens of different submaximal intensities" (p. 403).

Another type of feedback for endurance tasks regards the time individuals sustain their effort. This type of feedback falls within the types of feedback usually termed "knowledge of results". It has been a consistent finding of sport psychology research that knowledge of results facilitate enhanced performance (Schmidt, 1991). However, there are no studies that have compared the effects of these two types of feedback (biofeedback and external feedback) on endurance performance. Hence, such information would be valuable to practitioners in the field of sport psychology.

A respective question arises as to the most appropriate type of goals for enhancing endurance performance. One can set goals for sustaining effort for a longer period of time and judge the achievement of this goal by examining time on task. Yet, another individual may set goals for reducing his heart rate or control his breathing rate while performing and judge the achievement of this goal by means of appropriate biofeedback. However, there is a lack of research regarding which of these two types of goals are better for endurance performance.

In fact, goal setting research in sport has relied exclusively on performance goals such as duration of a submaximal muscle contraction (Hall, Weinberg & Jackson,1987), or number of sit-up (Lerner & Locke, 1995; Weinberg et al., 1985, 1986). On the other hand, as it has been shown that internal functions such as cardiac and pulmonary ones can be under volitional control (Zaichowsky & Fuchs, 1988) sport psychology research may examine the effect of goal setting on respective internal functions and the subsequent effect on performance.

Thus, the purpose of the present study was to compare the effect of performance goals coupled with respective concurrent feedback and goals for controlling internal functions, coupled with respective biofeedback on endurance performance. Two types of feedback were provided: concurrent feedback of heart rate and concurrent feedback of performance in terms of time. Also, two types of goals were set: goals for lowering heart rate and goals for increasing endurance performance in terms of time. Due to the exploratory nature of the study, specific predictions could not be made. Rather, the aim of the study was to examine which type of goals and feedback would be most effective regarding endurance performance.

Method

Participants

The participants of the study were 80 female physical education students 18-21 years of age (*M*= 20.1) from a large physical education department. Five participants did not appear for the second trial and this resulted in a total of 75 participants. Informed consent was obtained from all the participants.

Task

A submaximal endurance test on a cycle ergometer was utilized. The test (Astrand & Rodahl, 1977) involved an incremental resistance starting from 60 Watt (1 kg X 60 rpm) increased by 30 Watt every 3 minutes. Preliminary testing of this protocol indicated that it allowed for aerobic adaptation to take place before the anaerobic phase began even when performance was relatively poor. To assist subjects in retaining the requisite pedal rate, a metronome was used coupled by a digital index on the bicycle's screen. A cycle ergometer (Monark 815) was used for the test. The test was terminated when heart rate reached 170 beats per minute. Telemetric heart-rate monitoring was utilized (Polar Sport Tester). The monitored data were analyzed via the software of POLAR which provides average values, minimum and maximum values, and distribution of heart rate every ten beats.

Special care was taken in order to standardize the test conditions as much as possible. Prior to the testing each participant performed a 3 minute warm up period at 30 Watt. Seat height was adjusted prior to each testing session so the ankle of the knee joint was 150o at the distal extremity of the pedal push. During the first phase of the test, subjects were instructed to do their best. The second phase of testing took place seven days later. The same cycle ergometer was used and the same temperature as in the first trial was secured in the test room. Participants were instructed to refrain from vigorous physical activity for 24 hours prior to the testing.

Procedure

All the participants were tested individually. Upon arrival at the test room they were informed about the test ("a submaximal endurance test”), and they gave informed consent for their participation by signing a respective document. The test protocol was then carried out and in the end of the test an appointment was scheduled for the second testing which took place approximately one week later. After the first trial participants were randomly assigned by lot to one of the four experimental conditions.

The experimental manipulation took place during the second trial. Prior to this trial Group 1 participants set, in written and verbally, specific personal goals for lowering their heart rate average. During performance, they were shown a card presenting their heart rate scores for every minute of the first trial as well as the target heart rate for every minute according to the goal they had set. They were also provided with concurrent

feedback regarding their heart rate by means of a digital instrument, connected to the POLAR sportester and placed in front of them.

Group 2 participants were requested to set specific personal goals both for lowering their heart rate average and for performance improvement in terms of time. They were also presented the card showing their heart rate during the first trial and the target heart rate for every minute in the second trial according to their goal. While performing, they were given concurrent feedback both for time elapsed and for their heart rate. A stopwatch and the heart rate digital instrument were placed in front of them.

Group 3 participants set goals only for performance improvement in terms of time and were given respective concurrent feedback while performing. Only the stopwatch was placed in front of them. Finally, Group 4 served as a control group in a no goals - no feedback condition. Participants of this group were asked to "do their best" and were not provided with feedback while performing.

Measures

Performance. The recorded point of time at which the participant reached 170 beats per minute served as a measure of performance.

Heart rate average. Telemetric heart rate monitoring was utilized (Polar Sport Tester). The monitored data was analyzed via the software of POLAR which provides for average values, minimum and maximum values and distribution of heart rate every ten beats. For the purposes of the present study we monitored heart rate every 5 seconds.

Post experimental manipulation check

Upon the conclusion of the second trial, three open-ended questions were asked to the participants: whether they had tried to achieve their goals and if yes, what specific strategy they used. Also they were asked if the type of feedback used in each condition was helpful and beneficial to them.

Results

Two separate analyses of variance showed that the four groups did not differ significantly either on performance on trial 1, $F(3,74)=.12$, $p > .05$, or on mean heart rate on trial 1, $F(3,74) =1.46$, $p > .05$, thus confirming the random assignment of participants to groups.

Table 1 presents descriptive statistics for the four groups across the two trials. In order to examine whether the performance of the four groups differed according to the experimental manipulation a 4 (Groups) X 2 (Trials) MANOVA with repeated measures on the second factor was conducted on the two performance scores. The effect of group was not significant, $F(1,71)=.17$, $p > .05$. The trials effect was significant, $F(1,71)=18.26$, $p < .001$, indicating an overall improvement of the four groups. The Group X Trial

interaction was also significant, F (3,71)=3.66, $p < .05$, indicating differential improvement across trials. In order to compare the improvement of the four groups, the Scheffe multiple comparisons test was utilized on the improvement scores which were calculated by subtracting performance in trial 1 by performance in trial 2. The Scheffe test showed that the improvement of group 1 was significant different from the improvement of group 3.

Table 1. Descriptive statistics for the four groups

		Trial 1				Trial 2			
		Performance (sec)		Mean heart rate (bpm)		Performance (sec)		Mean heart rate (bpm)	
Group	*N*	*M*	*sd*	*M*	*sd*	*M*	*sd*	*M*	*sd*
1	20	653.70	165.77	150.96	9.24	739.45	143.70	146.23	9.24
2	17	680.40	148.30	144.02	10.45	728.24	141.91	149.58	17.70
3	20	662.95	169.18	145.50	11.31	674.60	182.81	148.55	10.74
4	18	681.17	200.38	147.86	9.81	695.33	184.28	146.64	9.73

To examine whether the experimental manipulation affected heart rate during performance, a 4 (Group) X 2 (Trials) MANOVA with repeated measures on the second factor was performed on the mean heart rate scores. Neither the trials effect, nor the Group X Trial interaction was significant.

Post experimental manipulation check questions

Ninety-two percent of the participants of the three experimental groups, reported that they had accepted their goals and had tried hard to reach them. However, the manipulation check data suggested that only participants of the first group felt they could exercise some control to their heart rate patterns. It was revealed that 75% of the participants in this group found it helpful and beneficial, whereas 50% of the participants of the second group reported that trying to focus to the heart rate and time on task feedback at the same time created anxiety and confusion. Furthermore 30% of the participants of the third group reported that focusing to the stopwatch created anxiety.

Discussion

The aim of this study was to examine the effectiveness of different types of feedback and goals on endurance performance. Two types of feedback were provided: performance feedback

and heart rate feedback. Respective personal goals were also set by the participants. It was found that participants who were provided with heart rate feedback and set goals for reducing heart rate, increased their performance significantly. Participants that were given concurrent performance feedback and set performance goals did not improve their performance. Also, participants that set performance goals and were given concurrent performance feedback and concurrent heart rate feedback did not improve their performance. The performance of the control group that performed in the "do your best condition" without feedback did not improve either.

These results show that heart rate feedback coupled with goal setting for heart rate decrease is effective in enhancing endurance performance. This finding parallels others supporting that runners (or race walkers) can improve their performance by using an associative attentional strategy, that is, focusing internally to the body's feedback signals (Clingman & Hillard, 1990). It is more difficult however, to come to a conclusion regarding the reason for this finding. Such difficulty stems partly from the fact that the average heart rate of the first group did not decrease significantly in the second trial while it actually increased for the second group. One possible explanation is that participants from those groups worked more economically in the second trial in terms of other indices of aerobic work such as oxygen consumption and pulmonary ventilation. The results of Caird and McKenzie (1999) attest to this notion, however, this warrants further scrutiny and empirical confirmation.

The two groups that received heart rate feedback failed to lower their heart rate significantly during trial 2 although a slight decrease was observed for group 1. These results contradict those of other biofeedback studies showing that participants could control and lower their heart rate during submaximal exercise (Caird & McKenzie, 1999; Goldstein, et al., 1977; Perski and Engel, 1980; Perski et al., 1985). There are two possible reasons for this. First, in the above studies, as well as in similar others reviewed by Zaichkowsky and Fuchs (1988), participants received biofeedback training for several sessions. On the contrary, in the present study participants were not trained to control their heart rate during exercise. Second, participants in the above studies performed an endurance task of fixed intensity. On the contrary, participants in the present study performed a task with incremental intensity. The increased demands of this task may have prohibited a decrease in heart rate in the first two groups.

Group 3 participants that set specific performance goals and received time on task feedback did not improve their performance. This finding is in contrast with those of similar studies in sport psychology who showed that specific challenging goals lead to performance improvement in strength and endurance tasks (Hall et al., 1987; Lerner & Locke, 1995). This finding can be attributed to the type of task used. In the submaximal test used in the present study, performance was not dependent on persistence in the face of fatigue which usually results from goal setting. Rather, the crucial factors for performance were aerobic capacity as well as the participants' capacity to work more economically when trying to control their heart rate. Thus, the time on task feedback and performance goals were not that relevant to the requirements of the test.

Regarding the information provided by the answers of the participants to the open ended questions after the experimental manipulation, results suggested that only participants of the first group felt that the manipulation was effective. Contrary to this, participants of the second group reported that provision of heart rate and time on task feedback created anxiety and confusion.

This condition was not successful perhaps because participants had to focus on two sources of information and to try to achieve two goals at the same time. Furthermore, participants of the third group reported that the stopwatch created anxiety. Generally speaking, only the participants of the heart rate feedback alone condition reported feelings of comfort and satisfaction. Moreover, the performance improvement in this group, verify the effectiveness and usefulness of the technique.

Although it was the first time participants tried to control their heart rate during exercise, and although specific instructions were not given, participants of all the groups reported that they used some useful strategies during this attempt. Some of them tried to create relaxing images. Also some of them reported that they focused their attention to the rhythm of the pedal and to their breathing. It seems that when individuals are asked to try to control their heart rate, during exercise they can utilize various strategies that are suitable for them.

Although the above results seem encouraging there are a number of issues that need to be addressed in future research. First, and most importantly, such experiments should be replicated out from the laboratory in field settings preferably with high level athletes as participants. This way, the results would be more valid ecologically and of greater utility to athletes, trainers and practitioners. Second, it needs to be examined whether subjects in the heart rate feedback and goals condition actually worked more economically. This would require monitoring of other physiological parameters such as systolic blood pressure and ventilation. Third, participants should undergo extensive training in heart rate control. Thus, designs with multiple trials utilizing goal setting and heart rate feedback would probably be more effective than pre-post designs as in the present study.

In sum, the present experiment examined the effect of external versus internal types of goal setting and feedback on endurance performance. Participants who set goals only for reducing heart rate and were provided with respective concurrent feedback increased their performance on an endurance task significantly more than the other groups. The other types of feedback and goal setting in this task created anxiety and confusion to the participants, and did not help them in improving their performance. Although limitations exist in the current investigation, both the qualitative and quantitative evaluations supported the effectiveness of the heart rate concurrent feedback and respective goal setting. Future empirical research is necessary to determine under what conditions internal types of feedback and goal setting will be most effective in sport.

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