A Practice-Specificity-Based Model of Arousal for Achieving Peak Performance

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ABSTRACT. The authors propose a practice-specificity-based model of arousal for achieving peak performance. The study included 37 healthy male physical education students whom they randomly assigned to a high-arousal \((n = 19)\) or low-arousal group \((n = 18)\). To manipulate participants’ level of arousal, the authors used motivational techniques. They used heart rate and the Sport Competition Anxiety Test (R. Martens, 1977) to measure the level of arousal that participants achieved. At the determined and given arousal state, the 2 groups performed the task (basketball free throws) for 18 sessions. Both groups performed a retention test at the 2 arousal levels immediately after the last exercise session, in the posttest, and after 10 days. Results showed that both groups learned the task similarly and achieved their peak performance at their experienced arousal level. When tested at an arousal level that differed from the one that they experienced throughout practice sessions, participants’ performance had deteriorated significantly. Performance of the task seemed to have integrated with the arousal level of the participants during the task learning. The findings of this study suggest a practice-specificity-based explanation for achieving peak performance.

Keywords: motor learning, peak performance, practice specificity

Investigators have viewed arousal as an important contributor to levels of athletic performance (Hanin, 1999; Weinberg & Gould, 1999). Investigators have generally referred to arousal as an energized state generated from the onset of a performance. Performers can experience it both physiologically (e.g., increase in heart rate and adrenaline levels) and psychologically (e.g., feelings of apprehension, tension, and worry). Arousal level can range from highly energized states to very low states (Hardy, 1996).

Motor behavior specialists and exercise psychologists have taken the lead in researching peak performance to help performers in sports achieve peak performances more often and with greater consistency. They have tried to identify ideal performance states and to develop athletes’ psychological skills (Harmison, 2006; Schmidt & Wrisberg, 2000). In addition, they share many theoretical methods and models to help sports performers achieve their optimal performances. The specificity of practice hypothesis is one of those theoretical methods (Henry, 1958/1968; Proteau, Marteniuk, & Levesque, 1992).

According to the specificity of practice hypothesis, practice conditions that mimic retention conditions facilitate maximal retention performance of a task. Researchers’ explanations for the learning benefits of practice specificity typically involve the similarities of skill context or processing requirements. Experiencing a task in a practice context that matches the test conditions as closely as possible should lead participants to perform better in retention (Maslovat, Chua, Lee, & Franks, 2004).

Proteau, Marteniuk, Girouard, and Dugas (1987), who studied the role of vision in learning, provided empirical support for the practice-specificity effect in motor behavior. Proteau et al. (1992) proposed in the specificity of practice hypothesis that motor learning is specific to the available sources of afferent information that individuals use to guide their movement during practice. Studies of aiming skills have also supported that hypothesis. Proteau et al. (1987; Proteau et al., 1992) conducted a series of studies whose results support the specificity of practice hypothesis. They were mainly interested in the role played by visual information in the control of aiming movements, and they always used a transfer paradigm.
Proteau et al. (1987) examined the accuracy of an aiming movement performed for 200 or 2,000 trials under either a full-vision condition or a target-only condition. Following acquisition, all four groups performed under target-only conditions. The results of the study showed that full-vision practice leads to notably greater errors in performance than does practice in the target-only condition. Furthermore, Proteau et al. (1987) found that the performance decrement was more profound for the 2,000-trial condition than for the 200-trial condition. Those results reflected participants’ development of a sensory-specific movement representation with practice and demonstrated that the researchers’ withdrawal of sensory information previously available during acquisition disrupted performers’ ability to accurately point to the target object. That finding is typically predicted in the specificity of practice hypothesis (Krigolson, Gyn, Tremblay, & Heath, 2006). Therefore, for the aiming task, optimal performance is attributable to the availability of the source or sources of afferent information that participants use during practice to ensure optimal accuracy.

Proteau et al. (1992) examined the effect of adding vision to a group who had practiced under target-only conditions. Their results showed that the addition of vision degraded performance significantly. The studies of Proteau et al. (1987; Proteau et al., 1992) involved sensorimotor specificity. However, there are other types of specificity, including context specificity and processing specificity (Schmidt & Lee, 1999).

In a study related to context specificity (Wright & Shea, 1991), participants worked on learning specific patterns of key-pressing movements. The experimenters provided an incidental auditory stimulus for each pattern. In retention, participants were tested with either the same auditory stimulus or a different stimulus. Their performance in retention was maximal when the same auditory stimulus was present, leading to the conclusion that the stimulus served as an associated cue that triggered the desired response (Wright & Shea).

The specificity of practice hypothesis has not obtained support from investigations of gross motor skills such as power lifting (Bennett & Davids, 1995) and beam walking (Robertson, Collins, Elliott, & Starkes, 1994).

Investigators have applied the specificity of practice hypothesis and theories of arousal–performance relations (Apter, 1982; Hanin, 1999; Hardy & Fazey, 1987; Hull, 1943; Kerr, 1990; Martens, Vealey, & Burton, 1990; Yerkes & Dodson, 1908) to assist athletes in preparing high-performance athletes for competition. By analyzing an individual’s responses to a series of statements about how he or she feels in a competitive situation, sport and exercise psychologists have adopted and tested those theories, and the results of a few studies have supported them. Although the theories have their own appeal, however, empirical research supporting their claims is virtually nonexistent (for a review, see Gill, 2000).

Because investigators have not yet studied arousal on the basis of the specificity of practice hypothesis, and to shed more light on arousal–performance relations, in the present study our goal was to determine whether learning is specific to the arousal state that participants use to perform a perceptual-motor task (basketball free throws). To reach that goal, we required two groups of participants to train under a high-arousal or low-arousal condition. After acquisition training, they switched to the other arousal condition and then switched back to the original one. Ten days later, they performed the task at the original arousal level and then switched once more. We examined whether posttest performance and retention performance were specific to the arousal state that the participants experienced during training. The finding that arousal switching decreased performance in comparison with that at the arousal state that participants experienced in acquisition would support the specificity of practice hypothesis.

Method

Participants

We randomly sorted 37 male physical education students into high-arousal (n = 19) and low-arousal (n = 18) groups. Their mean age was 21.78 years (range = 20–25 years). The two groups had no significant differences in the task pretest score, height, weight, IQ, age, educational status, or resting heart rate. All participants were inexperienced at the experimental task, right-handed, and naive to our purpose in the experiment. Basketball was their two-credit course. The Committee for Ethical Considerations in Human Experimentation of the Sport Science Research Center, College of Physical Education and Sport Sciences, University of Teheran, Iran, assessed and approved the experimental protocol.

Experimental Task

We chose the basketball free throw as the experimental task. A free throw is an unguarded shot that a player takes from the foul line of a basketball court. The foul line is the line 15 ft from the backboard and parallel to the end line from which players shoot free throws. Basketball players’ free-throw shooting is important because it determines the final score in many games. All close games can be won or lost on the free-throw line.

Materials

We used the Sport Competition Anxiety Test (SCAT) to evaluate the cognitive arousal level of the participants. Martens (1977) developed SCAT to investigate anxiety due to competition. By analyzing an individual’s responses to a series of statements about how he or she feels in a com-
petitive situation, one can determine that person’s level of anxiety. The items on SCAT are simple. SCAT contains 15 statements about how people feel when their performances are evaluated. The test takers read the statements and decide whether they hardly ever, sometimes, or often feel a particular way when they compete in sports, games, and exercises. SCAT is a scale ranging from 10 (low competitive anxiety) to 30 (high competitive anxiety). The SCAT is reliable and valid. Many field researchers have demonstrated that it can be used to predict state anxiety in competitions (Martens, Vealey, & Burton, 1990). Because people’s anxiety is particularly high when they feel that their performance is being evaluated (Wrisberg, 1994) and competition involves performance evaluation (Gill, 2000), we chose SCAT to evaluate the cognitive arousal level of the participants.

To evaluate the physiological arousal level of participants, we measured standing participants’ heart rate with a pulse-monitor watch. Experimenters can determine the number of heartbeats per minute within 30 s by holding participants’ fingers on its sensor. Changes in heart rate are an index of arousal (Fenz, 1975, 1988; Pribram & McGuinness, 1975).

We used a basketball free-throw test (15 attempts) to measure the performances of the participants. We graded the shooter on results only: We awarded 2 points for each basket that the participant made and 1 point for an unsuccessful shot that hit the rim from above either initially or after rebounding from the backboard.

Procedure

During initial practice, we verbally instructed and showed participants how to complete the task (Schmidt & Lee, 1999). We created two arousal states. The high-arousal group exercised at a high-arousal state, whereas the low-arousal group exercised at a low-arousal state (see Table 1). We progressively used motivational techniques, including pep talks, verbal exhortation, goal setting, presence of spectators, task importance, evaluation (competition or contest), and rewards, to create the high-arousal state (Gill, 2000; Locke & Latham, 1985; Sage, 1984; Schmidt & Lee; Wrisberg, 1994; Zajonc, 1965). To create the low-arousal state, we recorded only the performance scores. Training consisted of 30 min of exercise (15 trials) three times per week for 6 weeks (18 sessions). After every three sessions of exercise, we administered SCAT and took heart rate measures to ensure that the groups were exercising and performing the task in the given arousal state. We administered SCAT after participants warmed up, and we measured their heart rate after 5 trials of practice. The duration of each session was approximately 30 min. The time breakdown was as follows: 5 min of stretching, 20 min for 15 free-throw trials, and 5 min for cooldown.

We held practice sessions in an indoor standard basketball court. Participants took the pretest after the initial instructional practice. They underwent acquisition (progression) tests during 18 sessions of practice. They performed the posttest immediately after the 18th session of practice, and they performed the retention test after 10 days of no practice. The two groups performed the posttest and the retention test in both high- and low-arousal states, which enabled us to assess the degree to which the optimal performance depended on the experienced arousal state (see Table 1).

We considered each group’s mean score on the 18th practice session as its optimal (peak) performance (20.10 for the high-arousal group, 20.05 for the low-arousal group).

Statistical Analysis

We performed statistical analyses with a repeated measures analysis of variance (ANOVA), a paired  \( t \) test, and an independent  \( t \) test by using SPSS software (Version 10.0). We set statistical significance at  \( p < .05 \).

Results

The mean heart rate values and mean SCAT scores of participants performing the task in the high-arousal state were significantly higher than were those of participants performing the task in the low-arousal state; \( t(35) \) ranged from 3.260 to 8.646,  \( p < .001 \), ensuring that the two experimental groups were exercising (or performing) the task at their determined and given arousal states. Figure 1 shows the task scores for the two groups throughout the experimental period. As can be seen in the figure, both groups improved similarly in task learning and performance.

A repeated measures ANOVA showed significant within-participant differences, \( F(22, 770) = 30.367, p < .001 \), but revealed no significant between-group differences, \( F(1, 35) = .106, p > .747 \).

To investigate the effect of change in arousal state (arousal switching) or whether arousal integrates with performance, we compared the mean score that the high-arousal group achieved in participants’ 18th session of practice (practice peak performance) with its mean score in their first posttest, which we administered when the group was in a low-arousal state (i.e., we removed motivational factors). We found a significant decrease, \( t(18) = 5.45, p < .001 \). We also found a significant decrease for the low-arousal group, which was initially tested in the low-arousal state and then, in the posttest, in the high-arousal state (i.e., in the presence of motivational factors), \( t(17) = 3.15, p < .001 \).

We compared the practice peak performance of the high-arousal group with its mean score in the second posttest, which we administered when the group was at a high-arousal state. We found no significant difference. We also found no significant difference for the comparison between the low-arousal group’s 18th session of practice and its posttest in a low-arousal state.

To investigate whether the results obtained in the two posttests persisted, we compared the practice peak performance of the high-arousal group with its mean score in the first retention test, which we administered when the group was in the high-arousal state. We found no significant difference. We also found no significant difference for the low-arousal group when we tested it in a low-arousal state.
We compared the practice peak performance of the high-arousal group with the mean score on its first retention test, which we administered when the group was in a low-arousal state. We found a significant decrease, \( t(18) = 4.07, p < .001 \).

We found the same result when we tested the low-arousal group at a high-arousal state, \( t(17) = 4.01, p < .001 \).

**Discussion**

In the present study, our main purpose was to determine whether learning is specific to the arousal state in which a player attempts basketball free throws. We found that posttest performance and retention performance are specific to the training context.

Our findings are consistent with the specificity of learning hypothesis in motor behavior, which stems from Henry’s (1958/1968) studies of individual differences. According to that hypothesis, changing the conditions under which a task is performed requires a substantial shift in abilities because skills are very specific. In other research areas, investigators have called that view the hypothesis of state-dependent learning (Schmidt & Lee, 1999) or state-dependent memory: In general, people who have learned something in one situation or state better remember it later in a similar situation or state than in a different situation or state (Anderson, 1995).

The results of this study support the idea of practice specificity (Henry, 1958/1968; Proteau et al., 1992) and suggest that practice specificity is as important as researchers originally thought. From a practical perspective, these results suggest that performers can benefit if practitioners require them to practice in an arousal state in which they have to compete. Experiencing a task in a practice arousal state that

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**TABLE 1. Arousal State During the Initial Practice, Pretest, Acquisition (Acq.) Phase, Posttest, and Retention Test for the Two Groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>Initial practice</th>
<th>Pretest</th>
<th>Acq. phase</th>
<th>Posttest</th>
<th>Retention test</th>
</tr>
</thead>
<tbody>
<tr>
<td>High arousal</td>
<td>ND</td>
<td>ND</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Low arousal</td>
<td>ND</td>
<td>ND</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

*Note.* In the acquisition phase, there were 18 practice sessions. Low = low-arousal state, High = high-arousal state, ND = arousal state not defined.
matches the test arousal state as closely as possible should lead to better performance on posttest and retention.

In this study both the high-arousal and low-arousal groups performed the task similarly throughout the experimental period, but each group achieved its peak performance at its experienced arousal level. The groups’ performances dropped significantly when we tested them at an arousal level that differed from what they had experienced while learning the task. In fact, the performance of the task integrated with the arousal level of the learners (or performers) during learning (or training). Those findings are consistent with the specificity of practice hypothesis.

We suggest that the arousal level at which a learner or athlete learns or exercises a task integrates with performance so that peak performance occurs only in the presence of the same arousal level. If a basketball player experiences lower arousal levels while performing free throws throughout training sessions, he does not need to be highly aroused when competing in a test (posttest and retention) to achieve his own peak performance. In other words, if that player experiences a higher arousal level during the test, he cannot do his best, and his performance therefore declines.

The findings of this study raise questions concerning the validity of traditional and recent theories about the arousal–performance relationship because those theories do not take into account individuals’ arousal state in the training sessions and do take into account arousal adjustment only in an athletic event. Researchers applying such theories do not ask athletes to relate their experiences of arousal during training and the competition period. We found that the two arousal states (some consecutive training sessions and evaluation) must be related if the athlete is to achieve optimal performance. Therefore, to achieve a high level of performance (peak performance), the individual does not have to experience a moderate level of arousal, as is proposed in the inverted-U hypothesis. The higher levels of arousal may not result in better performance, as drive theorists argue. Furthermore, it is not entirely correct that individuals interpret arousal differently depending on their present state and that the interpretation affects their performance, as reversal theorists assume. A sudden and abrupt drop in performance may not occur as arousal increases, and arousal may get beyond the optimal level, as catastrophe theorists predict. Last, for best performances to occur, athletes may not need individualized optimal levels of arousal and other emotions, as theorists of the zones of optimal functioning argue. For best and peak performances to occur, athletes need only to create an arousal level similar to the one they have experienced throughout training sessions. For peak performance, athletes do not need to have high or low arousal levels. It is important that they create the same level of arousal throughout training sessions and competition. In other words, high levels of arousal can be beneficial if athletes experience such heightened levels of arousal during some consecutive training sessions. Similarly, low levels of arousal can be beneficial if athletes experience such low levels of arousal during some consecutive training sessions.

In sum, the results of the present study lead us to suggest that motor learning involves a controller that integrates the motor components with the arousal state that is available during practice. The integration results in specificity during posttest and retention so that performance is optimal to the degree that the conditions available during posttest and retention match the conditions available during practice.

We have demonstrated that achieving peak performance depends on the resemblance between the arousal state throughout training sessions and the arousal state in competition. In other words, investigators would expect peak performance when the level of arousal achieved in competition is similar to that experienced throughout practice sessions. Conversely, when the training arousal state differs from the competition arousal state, the degree of dissimilarity interferes with the quality of the performance and results in poor performance. To achieve peak performance, athletes’ arousal level in competition must be similar to the arousal level they experienced throughout training sessions. The greater the similarity of the arousal state throughout training sessions and in the competitive situation, the better the performance will be. No peak performance takes place when there is little or no similarity between the two arousal levels (training and competition). Therefore, it is not important for athletes to have a high-, moderate-, or low-arousal level while competing and while being evaluated; it is important for them to have the same arousal level throughout training sessions and competition.

The findings of the present study may help practitioners and coaches decide how to establish performance arousal states in the acquisition phase or training sessions that will best prepare performers in sport for the criterion arousal states under which the learning or performance will be applied. It appears that designers of training settings must understand the level of arousal that an individual needs or creates in a specific competition and try to create the same arousal level for practice sessions. Performance of the task seems to integrate with the arousal level of the performers in sport during training. Therefore, we offer investigators and designers of training settings a practice-specificity-based model of arousal that can enable performers to achieve peak performance.

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Biographical Notes

Ahmadreza Movahedi teaches motor learning, motor control, motor development, and sport psychology and investigates motor coordination and control; the role of motor learning in speech, cognition, and moral development; and the arousal–performance relationship.

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