Specificity Part VII: The Effect of Part-Whole Practice and Variable Practice on Performance & Learning

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Abstract

Millions of athletes have been told that breaking a task up into various parts would enhance learning. Examples include half reps to improve the weak portion of a movement and breaking a baseball swing up into sections. Another mantra spread today is the use of variable practice. From a qualitative standpoint, this would include running on the track to improve skating capacities. From a quantitative standpoint, this would include adding donuts to a bat to improve batting capacities. However, evidence suggests that the way these methods have been applied are ineffective, and in some cases may in fact degrade learning.

Therefore, the purpose of this paper was to analyze the effect of part-whole practice and variable practice on performance and learning, and demonstrate how to effectively apply these principles to a training program.

Part vs. Whole Practice

A common method used to facilitate sensory motor skill acquisition is breaking a task up into various components to simplify the movement, and then transfer these separate movements into one movement. This is known as part-whole training. Part practice divides a task into its components, while whole entails practicing the task in its entirety. The following sections will analyze the effect of part vs. whole practice on learning motor skills under various scenarios.

The Effect of Part vs. Whole Practice on Learning of Continual and Discrete Tasks

A continuous task is a task with no discernable beginning or ending point. This would include swimming, running, or driving a car. Continual tasks typically have many simultaneous, coordinating parts required in a movement. Briggs and Brogden (1954) and Briggs and Waters (1958) investigated the effects of part-whole training on learning a continuous task. The apparatus consisted of a two-dimensional (forward-backward, left-right) lever positioning machine. Participants were instructed to perform the whole task, using both dimensions, or to break the task into parts, using one dimension per trial. Results found that part practice transferred to the whole task, but was much less effective than whole practice. Similar results are seen in complex continuous tasks such as helicopter operations, in which there are numerous parts that must interact with each other to perform the task (Zavala et al. 1965).

Wenderoth et al. (2003) investigated the effects of part vs. whole task training on a star-line drawing paradigm, which required a high degree of limb interactions. Results found that when transferred to the bimanual task, the group that performed bimanual training (whole practice) had the greatest improvements in error and variability; however, the group that performed unimanual training had little transfer to bimanual training, resulting in values similar to that of the control group. These results were particularly profound when highly incompatible movements had to be coordinated together. Conversely, results found that unimanual training improved unimanual training; however, there was little transfer from bimanual training to unimanual training. The authors concluded that, “athletic, musical, or ergonomic skills that require a high degree of interlimb coordination are best served by whole-task practice.” This is inline with numerous other studies that entail coordination of the limbs (Briggs & Brogden, 1954; Briggs & Naylor, 1962; Briggs & Walters, 1958; Klapp et al., 1987; Stammers, 1980; Summers & Kennedy, 1992).

The theoretical rational for these results is that in continuous tasks the components strongly interact with each other. Therefore, practicing a continual task in parts would not allow the learner to acquire the complex coordination required to perform these skills. Further, the learner also is learning a different reference correctness than that used in the whole task, resulting in less transfer. This is inline with the Specificity Hypothesis, which suggests that the underlying attributes of a task are specific to that task and not transferable (task-specific) (Sawyer, 2005). This concept was discussed in-depth in previous issues of this series.

A discrete task is a task with a discernable beginning and ending point. This would include swinging a bat or a golf club. Discrete tasks are characterized by rapid movements, with very short movement times (I.e. less than 1 millisecond). Lersten (1968) investigated the effects of part-whole training on learning a discrete task. Participants were instructed to grasp a handle and rotate it in a horizontal plane through 270 degrees until it hit a stop, upon which the participants were instructed to release the handle and move forward to knock over a barrier. The movements were rapid, being completed in approximately 600 ms. Participants were divided into a whole practice condition, in which they practiced the entire movement, and part practice conditions, in which they practiced the task in segments. Results found the greatest performance when practicing the task as a whole. Practicing the circular component of the task transferred a mere 7% to the circular phase when transferred to the whole task. Other part practice conditions had no transfer to the whole task; moreover, practicing the linear component of the task negatively transferred (-8%) to the whole task! Suggesting that practicing a discrete task in parts either transfers in negligible amounts, or hinders performance of the whole task.

The theoretical rationale for these results is the motor program. Henry and Rodgers (1961) suggest that the motor program is a rich, unconscious store of motor memory. Sawyer (2005) suggests that the motor program contains the spatial and temporal elements available to the learner prior to the presentation of a stimulus, that when initiated, allows for the expression of skilled movement(s). This was discussed in-depth in previous issues of this series.

Therefore, practicing the task in parts would use a different motor program, yielding little transfer to the criterion task. Further, practicing the task in parts may change the motor program developed for the whole task, explaining the negative transfer seen in the aforementioned studies.

The Effect of Part vs. Whole Practice on Learning of Serial Tasks

A serial task is a task which has a series of discrete tasks tied together. An example would be a tennis serve, in which the ball is tossed in the air and then struck. Seymour (1954) thoroughly investigated the effects of part-whole training on learning a novel serial task. Participants were instructed to perform part practice on a serial task, which had both difficult and easy components. Results found that if the difficult parts were practiced separately, without practicing the easy parts, there was a substantial amount of transfer to the whole task. Adams and Hufford (1962) found similar results in serial aircraft flying tasks. Recent experiments on learning special multi-component video games designed for research purposes, have found in some cases greater than a 100% transfer using part practice, in that practicing the task in part can result in greater transfer than practicing the task in its entirety (Mane et al., 1989; Newell et al., 1989.)

It is suggested that novel serial tasks, which often have breaks in action, are controlled by separate motor programs for each discrete component of the task. Conversely, discrete and very rapid movements, are most likely controlled by one motor program. Thus, the transfer to a novel serial task would be higher than a discrete task, as each motor program would be practiced separately.

However, as discussed in previous articles in this series, Keele & Summers (1976) as well as Pew (1966) suggest that motor programs may be generated by stringing together smaller programmed units of discrete tasks so that eventually this string of discrete tasks is controllable as a single unit. For example, assume there are 9 elements in an entire sequence and these are controlled at first one at a time each by separate motor programs. With practice, the first two may be linked together, and then the next five may form another link, and the last two, a third. Finally, the entire sequence may be controlled as one. A good illustration is given in driving a car. For instance, to park a car, an individual must hit the break, put put the vehicle in park, and then turn the ignition off. This at first appears slow and mechanical in nature, and perhaps is controlled by three separate motor programs. However, with practice, the driver may soon learn to coordinate all three actions swiftly and smoothly, into one motor program. Wilson and Wilson (2005) have commonly examined this theory when parking their cars, and find it is quite applicable—and fascinating.

Klapp (1995) has brought immense support to this hypothesis, which he refers to as "motor chunking." Klapp (1995) instructed his participants to perform single and multiple element Morse code responses over 8 days, in a randomized fashion. Results found that in simple reaction time, practice lead to a smaller reaction time for multiple element responses, the difference improving from 62 ms to 14 ms. Moreover, the variability of the intervals between the key presses in the multiple element response reduced with extended practice, suggesting a more unitary response. This data suggests that practice leads to motor chunking, improving the efficiency of the motor program. Wright et al. (2004) replicated Klapps study using 30 participants; except, both random and blocked schedules were utilized. The results in the randomized group were very similar to the findings of Klapp—the difference between reaction time for multiple and single elements decreased from 42 to 12 ms. Conversely, consistent with other studies, blocked practice led to better performance in early trials, but these effects were very transient, and disappeared during the delayed retention trial.

Klapp (2004) found similar results with speech articulations. Using another line of evidence, manual responses often exhibit breaks or pauses that might represent boundaries between chunks. Interestingly enough, the duration of these intervals increases with practice, as is expected if practice leads to a more efficient representation of the action into fewer but longer chunks (Van Mier, Hulstijn, & Petersen, 1993). These findings are consistent with numerous other experiments and theoretical rationales (Steinberg et al., 1990; Klapp, 1996; Anderson, 1983; Fitts, 1964; Newell & Rosenbloom, 1981).

In summary, once these various elements are chunked together into one motor program, the results of part practice for serial tasks should be similar to the studies done on discrete tasks.

The Effect of Part vs. Whole Practice on Learning of Novel Intricate Tasks

In some cases it is almost impossible, and often dangerous for an athlete to perform a novel task in its entirety. For instance, stunts in gymnastics can result in serious injury if done incorrectly, increasing the fear of the athlete. In such cases, if the athlete cannot perform the skill as a whole, or is afraid to, it would be advantageous to perform part-whole practice. The degree of transfer would be minimal; however, it would increase the persons self efficacy—which is the situation specific confidence of an athlete to perform a skill—and decrease their phobia of the task. This method is referred to as lead up activities, and has been used in studies of phobias; for instance, to desensitize the learner from snake phobia, fake snakes, which progressively become more and more realistic, are introduced to the learner, eventually leading to the introduction of a real snake (Bandura, Blanchard, & Ritter, 1969). It is advised that backward chaining be used when practicing part-whole. This entails practicing in a format so that the last element in the sequence is systematically preceded by earlier and earlier parts until the whole chain is completed (Wightman & Lintern, 1985; Wightman & Sistrunk, 1987). Practicing all the parts in isolation does not appear to be as effective (Sheppard, 1984).

But as soon as possible, the learner should change to whole practice, and maintain this for the remainder of their careers.

For numerous of other studies supporting these recommendations, refer to a meta-analysis on part vs. whole practice by Templet & Hebert (2002).

Programmed Variations

Adaptation can be defined as an acute or chronic modification of an organism or parts of an organism that make it more fit for existence under the conditions of its environment. In this context, modification is triggered by a change in the environment. These changes are known as variation, and can occur quantitatively through an increase in magnitude of a given stimulus, or qualitatively through the introduction of novel or unaccustomed stimuli. For the human athlete, the environment can be thought of as training conditions, with subsequent adaptation occurring in response to variation in these conditions. If the stimulus is continuous then accommodation or monotony occurs. Accommodation is a biological law which states that the response of an organism to the same given stimulus decreases over time. For instance, load for elite athletes is roughly 10 times that of beginners having 6 months experience. Elite weight lifters (Bulgarians) lift around 5,000 tons a year. The load for novices is only 1/10th this level (Zatsiorsky, 1995). This means that when an athlete trains the same way for extended periods of time, they either plateau or experience maladaptation.

Thus, we have two principles in conflict—training programs should be both variable to avoid accommodation, and stable for specificity purposes.

Wilson and Wilson (2005) discussed the issue of accommodation in-depth in the past issue of JHR on the subject of periodization. This can be read here, JHR, May 2005.

Building on the work of Wilson and Wilson (2005) the following paragraphs will discuss this conflict, and how to optimize transfer from variable tasks. The first factor that will be covered is qualitative transfer, through introduction of novel or unaccustomed stimuli (i.e. practicing exercises other than the criterion task). The second factor that will be covered is quantitative variation, through an increase in magnitude of a given stimulus, and schema learning.

The Learning Curve

Evidence suggests that performers move through stages of learning. This phenomenon has been termed the learning curve. Ebbinghaus (1885) revolutionized the field of psychology by suggesting that "higher mental processes" of learning could be studied experimentally. Ebbinghaus proposed the law of frequency, which suggests that the more frequently an experience occurred, the more readily the experience could be recalled. To test this, he invented what is referred to as non-sense material, to nullify the effects of previous experience on learning. This consisted of syllables containing a vowel between two consonants (i.e. XUW).

However, some of the syllables actually made sense; what was non-sense about his material was the order of the syllables, which were commonly arranged in groups of twelve, and made little sense as a sentence. Ebbinghaus used himself as a participant for his study. He examined each syllable in the group for less than a second, rested 15 seconds, and then repeated the procedure. He continued in this manner until he could recite each word without error. During this procedure, he plotted how many exposures it took to master the material, and the number of errors made on each successive trial, thereby, creating psychology's first learning curve.

Snoddy (1926) proposed that learning occurred in two stages. First was the adaptation stage, in which the learner acquired the pattern of a skill, and second was the efficiency or facilitation stage, in which the learner refined the pattern of the skill.

Guthrie (1952) suggested that learning was a product of attaching more and more stimuli to responses. To explain the learning curve, he suggested that at first, there are not many stimuli that are attached to a novel response; thus, when the response occurs, many stimuli's attach to it, explaining the rapid improvement in early stages of learning. However, as trials progressed, less and less new stimuli were available to attach to the response, explaining why learning was inversely correlated to amount left to be learned.

More recently, Fitts and Posner (1967) proposed a three stage learning curve, characterized by an asymptotic and negatively accelerating nature. This is now the most widely accepted explanation of the learning curve (Sawyer, 2005).

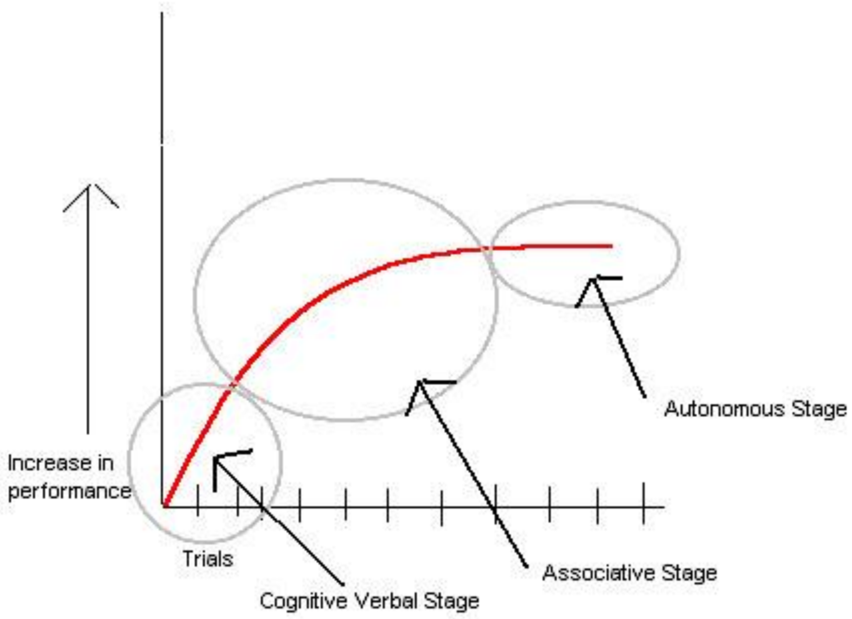

Figure 1.

The Learning Curve

Figure 1 graphically depicts this three stage learning curve. Stage one is Cognitive Verbal, characterized by the acquisition of a movement pattern, which entails abandoning inadequate strategies for adequate strategies, resulting in the greatest rate of learning and variability in the learning curve. Stage two is Associative, and contains the greatest amount of learning. It is concerned not with what to do, but how to perform a movement more efficiently. Stage three is Autonomous, in which the skill can be performed with relatively little interference from other activities (automatic).

The Changing Components hypothesis (CCH) has been proposed to explain the learning curve, and suggests that practice results in a shift in the abilities underlying a task (Schmidt and Lee, 1999). Abilities or attributes can be defined as stable traits, genetically defined and unmodifiable by practice, which underlie skilled performances (Schmidt and Lee, 1999). More recently, Sawyer (2005) posits that attributes are the underlined capacities within an individual which allow for the expression of skill; these are presently viewed as genetically pre-disposed and typically unaffected by practice or experience. Ackerman (1988) suggested an integration of the learning curve and the CCH. Ackerman's (1988) theory suggests that cognitive verbal requires cognitive abilities; associative requires abilities related to inter and intramuscular coordination; while autonomous involves peripheral abilities such as the number of fast twitch motor units.

The CCH is supported by correlative studies, known as the remoteness and adjacent trial effects (Schmidt and Lee, 1999). The remoteness trial effect is found when correlating one trial individually with all other trials. For instance, correlating trial 1 with 2, then trial 1 with 3, then 1 with 4, and so on. The remoteness trial effect typically finds that the correlation between any two trials decreases as the distance between those two trials increases, suggesting differing attributes being used as practice continues. The adjacent trial effect is found when correlating adjacent trials. For instance, correlating trial 1 with 2, 3 with 4, 5 with 6, etc. The adjacent trial effect typically finds that the correlation between any two adjacent trials increases as practice continues, suggesting a lowered reordering of abilities as they become more optimal for the criterion task. This would explain why the rate and variability of learning are negatively accelerating on the learning curve.

Application of the Learning Curve to Specificity and Qualitative Variations

There are numerous applications from studying the learning curve. However, for the purpose of this article, the authors want the reader to understand one important feature. That is, the learning curve for any skill becomes asymptotic with practice or experience. This means that as the learner gets closer to autonomous efficiency, their rate of learning will steadily slow to a crawl (asymptote). However, evidence suggests that even in the most advanced individuals, learning still occurs with practice. For instance, one study had over 8 million trials, with people wrapping Cubin Cigars, and they were still getting better with practice (Sawyer, 2005)!

Applying this to the principle of specificity, the current authors have demonstrated that the most benefit for an athlete will come from practicing the criterion task itself;

practicing something other than the criterion task, has demonstrated to result in small transfers, of mere percentages. Now, it is important to understand that the human body can only withstand so much stress. With the limited amount of time an individual has to train, it would be advisable to stick to movements that will get the individual the most transfer possible. However, once the learner hits the stage of autonomous, improvement from the criterion task will rapidly decrease. This being the case, getting just a small amount of transfer from variable exercises could make all the difference. Thus, implementing variable exercises may be of benefit for autonomous athletes. Which is why Sawyer, Ostarello, and Dempsey (2002) state "Although, Henry's specificity hypothesis suggests that the amount of transfer between skills would be low, it is usually not zero; thus, it is important to note that even a small amount of improvement may make a significant difference for high-level performers."

Now, it is important to understand, that if the athlete is to use variable exercises, they must be sensitive to 4 variables of specificity. This is that the closer the exercise performed is to the rate, pattern, resistance, and environment of the criterion task, the more transfer they will get (see practical applications for how to apply qualitative variation).

However, as discussed in previous issues of this series, the learner must be extremely careful not to train *to* close too the criterion task, or they risk the chance of negative transfer. Here is a quote explaining (Wilson and Wilson, 2005):

> Sawyer (2005) posits that the motor program contains the spatial and temporal elements within an individual, that when initiated allows for the expression of complex movement behavior. In this context, the Spatial elements represent the pattern, or geometric aspects of a particular movement sequence. Two outcomes can occur through adjustment of movement patterns. First, the pattern can be adjusted such that an entirely new program is needed. Secondly, if the adjustments are subtle enough, and practiced for a long enough time, modification of the program's spatial elements can occur. In a review on transfer of training Uebel (1987) suggests that when choosing exercises other then the criterion task the participant must be careful with movements that are similar, but not identical to the task, as they may have a negative transfer effect.
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> An example of this can be found in added resistance paradigms. Lockie et al. investigated the effects of sled towing on acceleration sprint kinematics in field-sport athletes. Twenty men completed a series of sprints without resistance and with loads equating to 12.6 and 32.2% of body mass. It was found that Stride length was significantly reduced by approximately 10 and approximately 24% for each load. Stride frequency also decreased. In addition, sled towing increased ground contact time, trunk lean, and hip flexion. Upper-body results showed an increase in shoulder range of motion with added resistance. Paradisis (2001) investigated the effect of a 3-degree incline on sprint kinematics. It was found that there were significant changes in posture on the touchdown and takeoff. Further stride length decreased by 5.2 %, which was associated with changes in posture along with reduced flight distance. The authors summarize the results as follows: 'Given the interaction between the acute changes in step length and posture when sprinting on a sloping surface, our findings suggest that such changes in posture will detract from the specificity of training on such surfaces. ' Far worse however is the danger of negatively changing the movement pattern.

Therefore, any form of practice should be extremely cautious when tampering with the geometry of the movement.

Lastly, for elite athletes several factors must be taken into account, such as force (mass * acceleration). If the reader is a football player for example, and goes against an athlete who has practiced sports specific as much as the reader, if the opponent weighs twice as much the reader, and has similar underlined attributes, and there is a collision, the reader will most likely get crushed. All these factors must be taken into account when training to become the ultimate athlete. Thus, an athlete may use weight lifting and other activities, not for transfer to their criterion skill, but for body composition purposes. Interestingly enough, Daniel et al. (1984) found that the correlation between football player rankings (starters, players, and non-players) and body composition was significant. This was in agreement with the findings of Burke et al. (1980).

Quantitative Variations and Schema Learning

Quantitative variation can be applied using the concepts of the Schema Theory of Motor Learning (see movement control theories for an in depth discussion). In review, Schmidt (1975) posits the existence of two memory states. The first memory system represents the structure of the movement (motor program), while the second memory state is responsible for scaling the program to the environment (recall schema). For example, a motor program may contain the elements to perform a flat bench press, while the recall schema could adapt the bench press to various environments such as greater resistance, or the need to perform the task more explosively. Evidence supporting separate memory states is extensive (Schmidt, 2003). For example, numerous studies have demonstrated that low variation within parameters enhances motor program learning early in practice (Lai and Shea, 1999; Lai, Shea, Wulf, et al., 2000; Whitacre and Shea, 2000, 2002). Shea et al. (2001) denotes this as the Stability of Practice Hypothesis. Therefore, blocking parameter variation would enhance program learning. However, this is opposite in parameter learning in which evidence suggests that recall schema is strengthened with greater variation (Margolis & Christina, 1981; McCracken & Stelmach, 1977; Moxley, 1979; Newell & Shapiro, 1976; C. H. Shea & Kohl, 1990, 1991; C. H. Shea, Kohl, & Indermill, 1990; Wrisberg & Ragsdale, 1979; Wulf, 1991; Shapiro & Schmidt, 1982, Schmidt, 1975; 1985; Schmidt & Lee, 1999; Schmidt, 2003, Sherwood and Lee, 2003). This is known as the variability of practice hypothesis (Shapiro and Schmidt, 1982). The effects of variable practice appear to be maximized through randomizing parameters (Lai, Shea, Wulf, et al., 2000; C. H. Shea, Lai, et al., 2001). For example, if a participant were to throw a football 20 yards, 30 yards, and 40 yards then the order would not be 20, 20, 20…30, 30, 30…., but 20, 40, 30 and so on. This, however, lowers the stability of practice and would not be conducive to early program learning.

Roth (1988) also suggested that schema learning cannot effectively take place unless the Motor Program has been properly developed. This is because, early in practice when the program is ‘primitive’ it undergoes constant change and variability, in turn leading to the need for the schema to accommodate this variability. To test this hypothesis Lai, et al. (2000) found that program and schema learning increased to a greater extent when constant practice was instituted for the first half of trials (i.e. blocked), and variable practice for the latter half. This has several implications. First, it supports the stability hypothesis, as the first half provided a stable environment. Second, it supports the contention that variable practice is best instituted after a stable movement pattern (motor program) has been established. Therefore, early on in learning, variability in parameters should be lower to establish the program, followed by variation as the program stabilizes.

Variation in sports skills can be implemented in several ways. For example, Malcom (1993) investigated the effect of practicing a single basketball shot at 12 feet verses practicing the basketball shot at 12 feet, 8 feet, and 15 feet combined (variable group). They found that learning of the 12 foot shot was greater in the variable practice group then the group who only practiced the shot itself! This suggests that the ability of the schema to match the criterion distance is strengthened with greater data entry, similar to a regression line. However, it should also be noted that something specific does appear to be learned with greater practice at a given parameter. For example, Young and Schmidt (1990) investigated the specificity of parameter learning by having basketball players shoot from numerous distances. The mid distance was 15 feet, which is the free throw line, and is assumed to have been practiced the greatest number of trials. They then plotted a regression line, with the point of predicting the proportion of shots made against the distance the shot was taken at. It was found that while the regression line could predict the outcome of the other distances, it did not predict the number of correct trials in the free throw shot, which had a higher proportion of shots made. This suggests that both rule learning, along with something specific to well practiced parameters is learned.

The current authors suggest that while memory states may be independent, that the program itself when practiced the majority of the time at one parameter may be modified to utilize certain characteristics at that parameter, whether muscular or mechanical. If this is the case, then variable practice of various parameters is beneficial; however, a great deal of additional practice at the criterion parameter is also necessary and should be emphasized as the competition nears.

Another example of how to incorporate variability can be found in resistance training. Hunter et al. (2001) compared the effects of linear high-resistance training, 3 times per week at 80% maximum strength, with 3 times per week of variable resistance training (once-weekly training at 80%, 65%, and 50% 1RM). It was found that the variable condition had a greater percentage of strength gains. More Recently Wilson and Wilson (2005) reviewed over a century of studies on the effect of linear verses non linear (periodized) weight training on weight training performance. It was overwhelmingly found that non linear (varied) practice was superior to linear training (for information on how to vary weight training practice see Periodization Part III; also read part I and II for an in depth descriptions on the physiological basis of periodization).

One of the more controversial issues is added resistance to sports skills, such as weighted bats and weighted balls. However, numerous studies have indicated that variation within these tasks can lead to significant increases in performance (Derene, 1985, 1990, 1993, 1995 Konstantinov, 1979; Toyoshima, 1973). For example Derane (1985, 1990, and 1993) found in three studies that baseball throwing velocity increased for both lighter and heavier balls. He also found great evidence for this in batting. For example, Derane (1995) found that variation in standard, under and overweight bats for 12 weeks in 60 collegiate baseball players had greater batting velocity increases than the group who only performed with their standard bat, suggesting that the schema theory of variation may apply to weighted implantation variation as well.

There are several issues to consider when adding resistance to the criterion task. For example, running uphill, or the addition of a sled has been shown to change the pattern of running significantly (Paradisis, 2001, Lockie, et al.). When practicing a task with modified patterning, it could result in permanent changes in motor program dynamics (see resistance and pattern specificity in the article on 'Types of Specificity' for a review). Therefore, when adding resistance, it should only be added, or subtracted in very small increments so as not to drastically alter the pattern. Further, resistance added which is not inherent to the task may need to be avoided entirely. For example, a sled in running adds an unnatural resistance; however, a slight subtraction of weight from a ball is more similar to the criterion task. Another example was found by Levi (2003) who had participants warm up with a bat with a donut, a hollow plastic bat, and the criterion standard bat. It was found that immediately after warm up (a measure of acute changes) that practice with the criterion bat yielded the greatest velocity increase. However, the problem is that the donut and plastic bat are completely foreign from the standard bat. It is also suggested that warm ups for an event should be specific to the task, as performance is acutely maximized as stability of the environment increases. Variable practice, for example, could create a non optimized set, or create contextual interference. Therefore, a retention trial should have been used to tease out the temporary influences of performance from learning. However, even if the study were chronic, the same results would have most likely occurred, as the implements used were far from similar to the criterion environment and task (again see the 'Types of Specificity' article).

Conclusion

In conclusion, part-whole practice is inneffective for discrete and continous tasks. It should therefore, only be used when performing a novel a task, which is intricate and perhaps dangerous, to improve self efficiacy. Evidence suggests part-whole practice may be beneficial for serial tasks. It is suggested that novel serial tasks are composed of several motor programs that are eventually chunked together with practice and experience. Once chunked into one motor program, it is suggested that part practice would yield similar results to discrete tasks, and should therefore, be avoided.

Evidence suggests that very little transfer will come from practicing with tasks other than the criterion skill; however, when an athlete as reached autonomousy, even a small amount of transfer may make a significant difference. If the athlete has reached this stage, implementing varying exercises may be of benefit.

Lastly, early on in practice, a stable environment should be encouraged. As the athlete develops a stable movement pattern, and variability lowers, variable practice should be performed in a random format. While variable practice appears to strengthen schema/rule learning, something specific appears to be obtained at the most practiced parameters. The current authors suggest that the program may be modified to utilize certain characteristics, whether muscular or mechanical at that parameter. Therefore, specific practice at the criterion parameter must still occur. When manipulating the force parameter through added resistance to sport implements, caution should be taken not to change the pattern of the movement.

This can take place by adding only minimal resistance, and never adding resistance that is not inherent to the movement such as occurs in uphill ambulation.

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