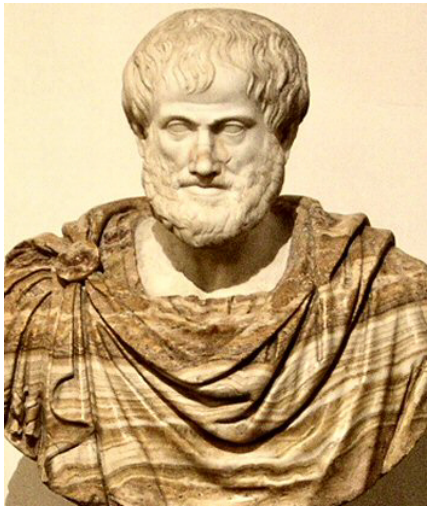
# Specificity Part 2: Specificity Theories



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## Abstract

Thorndike and Woodworth (1901) proposed the Identical Elements Theory of Transfer, which suggests that the amount of transfer or benefit training in one situation would have on another would be determined by the number of elements that the two situations had in common. In this context the purpose of this paper was to review the current theoretical explanations behind the Specificity Hypothesis in order to identify those elements. Theoretical rationales cover the dominant explanations from the past 100 years of research.

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## Introduction

As discussed in 'Historical Perspectives in Specificity' Thorndike and Woodworth (1901) proposed the Identical Elements Theory of Transfer, which suggests that the amount of transfer or benefit training in one situation would have on another would be determined by the number of elements that the two situations had in common. Hergenton and Olson (2005) stated that ' Thordike believed that learning will transfer from the classroom to the environment outside only insofar as the two situations are similar.' In 1906 he summarized his thoughts by suggesting that "A man may be a gifted poet, but an ignoramus in music; he may have a wonderful memory for figures and only a mediocre memory for localities, poetry or human faces; school children may reason admirably in certain sciences and be below the average in grammar…'

Thorndike was primarily concerned with the transfer of cognitive tasks. However, the small amount of transfer seen in intelligence tasks, has also been found in Motor tasks (Henry, 1958; Drowatzky and Zuccato,1967; Schmidt and Lee, 1999, Sawyer, 2005, Sawyer, Ostarello, Sues, and Demsey 2002, Elliott & Jaeger, 1988; Proteau, Marteniuk, & Levesque, 1992; Proteau 1992, Soucy & Proteau, 2001, Bennett & Davids, 1995, 1997, 1998; Elliott, Lyons, & Dyson, 1997; Proteau, Tremblay, & DeJaeger, 1998; Robertson & Elliott, 1996). This was summarized in a recent study by Sawyer, Ostarello, Sues, and Demsey (2002) who state 'research has shown that the transfer effect between movements at different resistances, rates, and movement patterns is limited (13, 15). So practicing one task to improve performance on a second task (transfer) may not be as effective as practicing the desired task itself. Improvement in squat press performance would not necessarily result in improved 40-yd dash time (15).'

Thordike proposed that any transfer seen was a function of the elements which underlie any two situations. Nearly a century latter, two of the dominant scientists in Motor Learning, Schmidt and Lee (1999) acknowledged the importance of Thordike and Woodworth's (1901) contribution, however they suggested that ' the problem with this theory was that it never specified what the 'elements' could be…' In this context the purpose of this paper was to review the current theoretical explanations behind the Specificity Hypothesis in order to identify those elements. Theoretical rationales from the past century will be examined. A second purpose of this paper was to identify differences between individuals in their ability to perform a given task.

## Foundational Theories Which Address Specificity

The first theories explaining Specificity and transfer were devised by Connectionists or Behavior Learning Psychologists, who along with Cognitive Learning Psychologists provided the precursor framework to the modern day field of Motor Learning. According to Sawyer (2005) many of the underlying processes of learning, whether from a Cognitive or Motor standpoint are similar. Therefore these early theories have great bearing to motor skill aquisition.

The connectionists were so called because they felt that the acquisition of a skill (learning) required the formation of a bond between a stimulus and a response (Hull, 1943; 1952; Hergenhahn and Olson, 2005, Schmidt et al., 1999) . The stimulus could be a pitch in baseball, with the response being a perfectly executed swing, or a most muscular pose during a bodybuilding contest. In this context performance was measured as the proportion of correct responses to a given set of stimuli (Hergenhahn and Olson, 2005) . They were known as behaviorists because they were empiricists, meaning that they had to see the results and manipulations of their experiments. This required clear observation of behavior or performance (Skinner, 1974, 1978, 1988). It was thought that skill acquisition could be inferred through behavior.

**S-R**

Figure 1

Figure 1 graphically demonstrates The bond between a Stimulus and a Response.

## Pavlov's Theory of Specificity

Pavlov was one of the earliest connectionists. Pavlov was responsible for the discovery of classical conditioning. Essentially, he found that pairing a neutral stimulus or a stimulus that would not normally cause a response with an innate stimulus or a stimulus that causes a reflexive response would eventually lead to the neutral stimulus being able to cause the reflexive response (Pavlov, 1928, 1941, 1955). For example, normally a bell (neutral stimulus) would not cause a dog to salivate. However, if every time an experimenter rings a bell they feed the dog, soon the dog associates the bell with the feeding stimuli (Innate or Unconditioned Stimulus) to the point where they will drool upon hearing the bell.

In this context he proposed one of the first fundamental theories in learning. A fundamental theory attempts to use principles that are as close as possible to "reality." However, his was quite exotic in its attempt (Pavlov, 1955). Pavlov believed that an innate stimulus activated an innate neural center in the brain. Activation would cause the neural center to 'radiate' out electrical activity. The radiating wave would travel out and activate the center responsible for causing the response. The innate stimulus center may be a center for feeding stimuli while the response center would initiate salivation. If the neutral stimulus, such as a bell activated another neural center, specific to that stimuli at the same time then the innate stimulus center (food center) and the neutral stimulus center (bell center) would both radiate out at the same time such that their fields would overlap. He called this overlap 'Generalization.' The overlapping of the two centers' fields of excitation formed a connection between the neutral stimuli center and the innate stimuli center. With enough pairings (practice) the connection becomes so strong that presenting the neutral stimulus alone can excite the innate neural center and thus indirectly elicit the innate response.

Pavlov believed that each stimuli activated a specific neural center. He therefore suggested that the greatest improvement in practice would come from activating the specific neural center that the investigator would want to cause the desired response in. Therefore if the experimenter wanted a bell at a frequency of 'X' to cause an animal to drool, then they needed to continually pair the innate stimuli such as food with a bell rung at frequency X. He felt that generalization or transfer of training occurred in so much as the neutral stimuli were similar to each other. Similar stimuli centers were suggested to be close to each other. In this context when they were activated, their wave of excitation could activate other similar stimuli. Therefore if a bell was rung at a frequency of Y, it would activate a distinct neural center which, if similar to X, would activate neural center X, which could then activate the response.

In summary, Pavlov suggested that the more similar the conditions of practice were to the criterion task, the greater the transfer.

While Pavlov's theory has solid predictive value, the physiological aspects of his theory do not adequately fit with current knowledge of the nervous system (Hergenhahn and Olson, 2005).

## Hull's Explanation on The Specificity of Performance and Learning

Hull (1943, 1952) was the first to quantitatively distinguish between performance and learning or skill acquisition. Hull (1943, 1952) denoted performance as the reaction potential of an organism. The reaction potential was defined as the probability, and speed with which a behavior occurred to a given stimulus. In this context he quantitatively defined performance through 'Hull's equation.' The equation is a complex set of variables which attempts to compute the performance of an individual in a given situation (see Wilson 2005 for a review). For example, what is the probability of an athlete lifting X amount of weight on the bench press on a given set? His work was critical because it predicted that performance was determined by both permanent and temporary factors. For example, a person may have learned how to be polite and smile when a non amusing joke was told. However if they are tired, they may not express this learned behavior. It is only recently however when the distinction between performance and learning has become standard in motor behavior research (Schmidt and Lee, 1999; Sawyer and Noel, 2001). The critical nature of such distinction was notably supported by Sawyer and Noel (2001). They had participants practice a tracking task with and without an audience. In acquisition it was found that the group performing in front of an audience had a lower performance than the no audience group. However, when the audience was removed in retention there was no difference in performance. This suggested that though they may have both learned how to track, their distinct performances were due to the differing environments.

Hull's (1943) equation in numerous situations has had great predictive value, and can predict the average response in a wide variety of situations. In this context, Hull does an excellent job of predicting the Specificity of Performance. His theory would predict that the performance of a given individual in situation A would transfer to situation B in so much as the situations were similar. This is similar to the identical elements of transfer theory, except that it acknowledges temporary variables, and identifies those variables as clearly as possible.

A perfect example is the Specificity of pre game warm ups. In motor control there is a unique drop in performance classified as the Warm Up Decrement. In a review Adams (1961) provided extensive evidence that after a break, the first trials on a given task are normally below the performance of the last trials. One rationale to explain this is the Set Hypothesis. Schmidt and Lee (1999) define a Set as one or more temporary internal states that underlie and support the skill in question. They further suggest that during practice various supporting Sets are constantly adjusted to maximize performance, while at rest these Sets fall to a point that supports rest. Arousal is an excellent example of a Set. In order to maximize performance, arousal will need to be heightened to a specific level which supports that performance. This causes several issues with bench players. Starters are able to warm up and raise their Set to game standards; however bench player's Sets are lowered to states specific to rest. Therefore when they come off the bench they may experience severe warm up decrements.

His theory also predicts that performance will be specific to the environment, suggesting that practice conditions should closely mimic such conditions. This was again supported by the Sawyer and Noel (2001) study above, which suggested that performance in practice without an audience (fans) may not accurately predict how a team will perform in front of an audience. A further example is Olympic lifting.

Often high level performers can only reach their top performances when in competition (Landers, 1980). This may reflect such aspects as higher arousal levels elicited by a loud crowd, while near fellow competitors. In this context, to prepare for a contest, the Olympic lifter should consider participating in smaller competitions before the major competition to prepare themselves to operate in that environment. Feedback conditions are also critical to take into consideration in practice. Evidence suggests that feedback can have several positive and negative effects. One of the negative effects is known as Dependency (Schmidt and Lee, 1999; Sawyer 2005, Salmoni, Schmidt, & Walter, 1984; Schmidt, 1991; Young & Schmidt, 1992). Dependency occurs when feedback is given too frequently (see Swinnen, 1996, for a review on the 'Guidance Hypothesis'). For example, if a coach continually stands near their athletes and constantly talks them through their events in practice, their performance will begin to depend on the coach's guidance. However, during competition when such interaction is not allowed a severe decrement will be seen in performance. This suggests that even coaching should factor in practice how to maintain a similar environment to game time conditions. In this context Swinnen et al. (1990) suggests that continual feedback not intrinsic to the movement causes the participant to rely more heavily on that feedback rather than intrinsic feedback.

In summary, Hull's equation predicts that performance in one situation can predict performance in another situation in a similar manner to the identical elements of transfer theory. This is unique as it suggests that even if a person performs the criterion task, if the environment or internal state (arousal, hunger, glycogen stores) of an individual change, the extent of that change will directly change performance. Therefore practice conditions should mimic the criterion environment or competition and the internal state that the athlete seeks to excel in.

## Guthrie's Theory of Specificity

Guthrie (1950, 1952) provided perhaps the most parsimonious theory of all the connectionists. He again defined performance as the probability of a response occurring to a given stimulus set. In this context, Guthrie formulated his ' One Law of Learning." Guthrie suggested that '**-** "A stimulus pattern gains its full associative strength on the occasion of its first pairing with a response (Hergenhahn and Olson, 2005)." As stated the acquisition of a skill in the connectionist framework occurs as a bond is formed between a stimulus and a response, or if an already existing bond is strengthened. The one Law of learning suggests that when a response occurs to a given stimuli, not only is the bond formed, but at full strength. It is important to understand that if the learning process were to be graphed, it would create a negatively accelerated curve (Balov, 1971; Fitts and Posner's 1967). This means that at the start of learning, improvement occurs rapidly and slows as the process continues. This seems at first to conflict with Guthrie's theory. However, Guthrie's theory was molecular in nature. He suggested that in the environment there were an endless number of stimuli. For example the temperature, humidity, surrounding lighting, and people serve as each separate stimuli. Due to processing limitations, no organism can sample all of the stimuli in the environment at once. However, when they make a response all the stimuli sampled in the environment are attached to that response. The learning curve accelerates rapidly at the beginning because more and more stimuli could be attached to the given response. Each time the organism attached new stimuli, a lower number of new stimuli could be attached to the response, and therefore the possibility of improvement lowered. Practice was therefore a function of attaching more and more stimuli to a given response.

While Guthrie's theory seems extremely simplistic, it has a tremendous amount of predictive value and perhaps explains home field advantage and practice specificity better than any other (see Types of Specificity in article 4). A common example can be found in the student who studies all week at home for an up and coming mid term. They feel extremely confident entering the exam. However, when they sit down and put pen to paper they completely blank. None of the answers come to them. However when they again arrived at home they remembered the answers exactly. Guthrie would predict that the answers or what he called responses did not occur because the stimuli present in the student's home, were not present in the class room environment and therefore the probability of producing the given response was severely lowered.

This concept can also explain home field advantage in athletics. The performance of a given individual is suggested to be dependent on the surrounding stimuli (Wright and Shea, 1991; Courneya & Carron, 1992). The disadvantage of being on the road is that the amount of stimuli which elicit a given athletic response are not present.

The implications are again to practice in a surrounding environment that is as close to game time conditions as possible. For example if a game is at night, teams should practice as much as possible that week underneath the stadium lights.

## Henry's Specificity Hypothesis

Henry's background was experimental psychology. Being familiar with studies involving the specificity of intelligence, Henry proposed the Specificity Hypothesis of Motor Behavior, which suggests that the underlying attributes of a motor skill or task are specific to that skill or task and not transferable (task-specific) (Sawyer, 2005). In this context an attribute can be defined as the underlying capacity within an individual which allows for the expression of skill. These are presently viewed as genetically predisposed and not easily modifiable by practice (Sawyer, 2005, Sawyer, Ostarello, Sues, and Demsey 2002, Schmidt and Lee, 1999). Attributes can be subdivided into body configuration attributes such as height, intellectual attributes, and motor attributes which are important for the expression of movement behavior such as various types of movement speeds, and muscle fiber ratios. Henry's (1958) Specificity Hypothesis suggests that individuals have an extremely large compilation of attributes, up to thousands. It was further suggested that each attribute was independent and not effected by the capacity of any other attribute. In this context, each individual contained a collection of genetically predisposed attributes which varied in strength from poor to extremely strong. The final aspect of the Specificity Hypothesis posits that each task or skill is dependent on a great compilation of attributes. By changing the task, the underlying collection of attributes which support the task are suggested to change in order to support the new task. The evidence supporting the Specificity Hypothesis is overwhelming, and reviewed in part six of this series. It is so extensive that Sawyer (2005) suggests that it is one step below being classified as a Law.

The predictions made by the Specificity Hypothesis are that correlations between any two tasks should be low. It is critical to understand that Henry (1958) proposed that these attributes were task specific. A classic example is a study by Drowatzky and Zuccato (1967) who investigated participants' performances on six different balance tasks. The study was meant to investigate whether an underlying attribute such as

balance existed. It was found that specificity between balance tasks ranged from 96 % to 90 %! This suggests that balance is not general in nature but task-specific.

According to Henry (1958) the greatest gains in any practice session will come from practicing the criterion task itself. However, recently Ostarello (2005) suggested that individuals should realize that Specificity is not an all or none phenomenon. Going back to the concept of a negatively accelerated learning curve, participants should realize that as they progress in experience, they will receive less return with greater effort. In this context, a small amount of transfer can provide a significant benefit (Sawyer, Ostarello, Sues, and Demsey 2002). This concept is investigated further in this series when conditions of practice are discussed.

The Specificity Hypothesis is critical and useful in that it identifies the elements which were missing in Thorndike's and Woodworth's Identical Elements of Transfer Theory. It also suggests that the similarity of the collection of attributes supporting any two tasks will converge in so much as the tasks themselves are similar.

Similarity of any two tasks can be subdivided into numerous categories. However, five are typically discussed. These factors include the Rate at which the task is performed, the Resistance provided through the task, the Pattern of the task, the Environment the task is performed in, as well as the underlying Processes which occur during task execution.

## Conclusion

The purpose of this paper was to identify the dominant theories explaining the Specificity phenomenon. Pavlov suggested that the specificity of any two tasks was a reflection of the proximity between the neurological structures controlling the two tasks. Hull posited that performance was made of a number of sub elements, such as internal and external states. The closer these states were from practice to the criterion task the greater the transfer between any two tasks. Guthrie introduced a theory which suggested that learning involved practicing a particular response in the context of specific stimuli and that the transfer between any two environments would be proportional to the number of shared stimuli within those two environments. Finally, Henry (1958) proposed the Specificity Hypothesis which suggests that the underlying attributes of an act or task are specific to that act or task and not transferable (task-specific). In the above theories, the commonality found is within the concept that transfer of training is proportional to the similarity between any two tasks.

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