SPECIFICITY VERSUS GENERALITY OF RELATIONSHIPS BETWEEN INDIVIDUAL DIFFERENCES IN MOTOR ABILITIES

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In the field of study of gross motor skills many authors have supported the theory of generality in reference to the interrelationships between motor skills. Within the profession today there are many adherents to the generality theory as witnessed by many current teaching practices. Supporters of the principle of generality imply that there is an appreciable relationship between individual differences in motor skills. Hence a person who ranks high on one motor skill could be predicted to rank high on all other motor skills. Therefore teaching should become simplified in that from the results of one test individuals could be successfully ranked on all other motor abilities and the formation and the teaching of homogeneous groups would then become a relatively easy matter. Generality of transfer of learning abilities would also greatly facilitate the learning of motor skills.

However the groups who are adherents to the theory of specificity support the contention that there are a preponderance of statistically low interrelationships between individual differences in motor abilities and prediction of a person's potential ranking on a motor skill from a known ranking on another skill is extremely hazardous.

How have researchers from each of the two opposition camps decided upon what statistical criteria to support their theoretical position? Relationships between individual differences in motor abilities have been statistically expressed by correlation indices (Pearson Product moment, bi-serial, tetrachoric, multiple, etc.) In the research area of physical education the ultimate evaluation of the theories of generality and specificity is the degree of interrelationships which exist within a wide array of motor skills.

Teachers are confronted with the practical problem of deciding how large correlations should be between individual differences in motor skills in order to be taken seriously and influence and/or be the stimulus for modifying or drastically changing their current teaching practice.

As correlation indices have been the chief statistical tool utilized in the specificity versus generality controversy one should consider if there is some arbitrary dividing line which could be used as a possible criterion for deciding upon what magnitude of a correlation coefficient could be supportive evidence for either theory. How high should a reliability or correlation index be? A magic inflexible index cannot be worshipped as the criterion but the following common sense principle may be used as a guide line, "The more important the decision to be reached, the greater is our need for confidence in the precision of the test and the higher is the required reliability coefficient."17

Guilford34 has bluntly stated that, "Tests with a coefficient of validity less than .50 are practically useless, except in distinguishing between extreme cases, since at that value of r the forecasting efficiency is only 13.4 percent."

Although situations could be cited in which objections could be raised against Guilford's contentions, his statement is generally acceptable when applied to the predictive validity of many tests used in the field of physical education. How many teachers or administrators would place full confidence in a test which has a forecasting efficiency of only 13.4 percent as contrasted to a possible forecasting failure rate of 86.6 percent?

Accuracy of Prediction

As the magnitude of correlation indices have been the main source of evidence for the proponents of theories of generality and specificity, one must be cautious in the evaluation of correlation coefficients.

Guilford34 has written: "There are other ways in which r and some of its derivatives can be used to indicate accuracy of prediction. Three of the common derivatives are the coefficient of alienation, the index of forecasting efficiency, and the coefficient of determination. Each has its unique
story to tell about the closeness of correlation between two things and about the utility of predictions." Guilford continues, "Another mode of interpretation of \( r \) is in terms of \( r^2 \), which is called the coefficient of determination. This statistic is also sometimes symbolized as \( d \). The coefficient \( r^2 \) gives us (when multiplied by 100) the percentage of the variance of the variable in \( Y \) that is associated with or determined by variance in \( X \). When \( r = .50 \), the percentage of the variance in \( Y \) that is accounted for by variance in \( X \) is 25, or one-fourth. To account for half the variance of any set of measurements the \( r \) with another variable would have to be .7071. The proportion of the variance in \( Y \) not determined or associated with variance in \( X \) is given \( k^2 \), which is called the coefficient of nondetermination.

Garrett also notes: "Inspection of the coefficients of determination for small \( r \)'s emphasizes the very slight degree of association which these \( r \)'s disclose. An \( r \) of .10, for instance, or .20 or even .30 between two tests \( X \) and \( Y \) indicates only 1%, 4% and 9%, respectively, of the variance of \( Y \) to be associated with \( X \)."

With a few exceptions research workers (specificity and generality) in the field of physical education have mainly supplied associative (correlative) evidence in contrast to causal evidence.

It is to be noted that, "A correlation coefficient is not a judgment—it is only a number summarizing the relationship of two sets of facts to each other. It is not a substitute for thinking—quite the contrary. It should be the impulse which starts the thinking process going. The size of a given coefficient is important, but why it is that size is much more important."

In a discussion of the "hidden relationship" of correlations Ross and Sigerseth made the following comment: "The 'Pearson \( r \)' for this data is .884. A quick estimate of the predictive efficiency of this so described relationship may be obtained from the formula for the coefficient of forecasting efficiency \( E = 1 - \sqrt{1-r^2} \). For an \( r \) of .884 the \( E \) is .592. In other terms, predicting \( Y \) when \( X \) is known is slightly better than 53 percent efficient." In essence a correlation must be at least .87 for the forecasting efficiency of the test to reach the 50 percent level.

Factor Analysis

In a discussion of factor analysis Fleishman states that, "This technique starts with the correl-
to psychologists and physical education investigators who followed Thorndike. R. Seashore\textsuperscript{76} Buxton and Humphrey\textsuperscript{77} H. Seashore\textsuperscript{77} Owens\textsuperscript{83} and others have provided evidence which has been strongly supportive of the specificity principle of relationship between fine motor skills.

Henry and Rogers\textsuperscript{45} have presented a neuromotor model which reflects the hypothesis regarding specificity among motor abilities. The theory "proposes a nonconscious mechanism that uses stored information (stored memory) to channel existing nervous impulses from brain waves and general afferent stimuli into the appropriate neuromotor coordination centers, subcenters, and efferent nerves, thus causing the desired movement." It was speculated that in addition to innate neuromotor coordinations there is a comprehensive source of motor memory at the non-conscious level which is available for motor performance requiring neuromotor skill. The mechanism of the motor drum storage concept has been likened, in some respects, to the electronic computer.

Henry's theory of specificity is in opposition to the theory of generality, the exponents of which imply that there is a high relationship between individual differences in motor abilities. McCloy\textsuperscript{59} Brace\textsuperscript{1} Carpenter\textsuperscript{15} and others who have stressed the importance of General Motor Capacity and General Motor Educability batteries of tests, have influenced many of the practices in the field of physical and sports education in the United States.

If the generality of relationships between individual differences is an experimentally substantiated principle, individuals who are highly proficient in swimming should also rank highly on all other sports skills, such as gymnastics, soccer, and basketball. Also if the principle of generality is valid, from the knowledge of an individual's score on a test or battery of tests one should be able to predict an individual's skill in other sports events.

The extent to which generality of relationship exists between two variables is reflected by the percentage of common variance ($r^2 \times 100$). Hence if the correlation, which has been corrected for attenuation, between leg strength and running speed is $r = .30$ the amount of common variance, or the degree of generality between these two motor abilities is nine percent. Unaccounted variance or specificity of relationship is reflected by an unknown 91 percent of association. For practical prediction purposes the principle focus of attention in the evaluation of the comparative degrees of generality or specificity which exists between motor abilities, should not be directed toward the interpretation of whether the correlation coefficient is significant at the one or five percent level of confidence, but an evaluation of the comparative percentages of common versus unaccounted variance between the two variables.

What has been the consensus of findings of recent research workers who have investigated the relationships between motor abilities and the success of the prediction of motor ability from a knowledge of an individual's ranking on a motor ability test? A survey of research literature concerning the interrelationships between motor abilities reveals an overwhelming predominance in favor of specificity of interrelationships.

Cratty\textsuperscript{26} has provided a historical survey of trends in research: "Research delving into the specificity versus general question has evidenced the following trends during the past 60 years. Initially the earlier, more subjective investigations carried out during the early part of the 1900's indicated that various general performance characteristics do exist.... During the 1930's as intelligence testing was separated from motor skills evaluation and as more objective performance measures were developed research indicating the specific nature of motor skill was published..... In the late 1950's and early 1960's Franklin Henry and his colleagues demonstrated that tasks involving movement, speed, reaction time and strength seem largely based upon factors unique to the movement. Although at times their concept of a coordinated movement seemed somewhat narrow and appeared to include tasks emphasizing spatial accuracy. These finding have generally served to shake the traditional concept of 'general coordination' formerly espoused by physical educators as underlying a number of sports activities."

**Motor Learning**

Brace\textsuperscript{3} has defined motor ability as that ability which is more or less general, more or less inherent and which permits an individual to learn motor skills easily and to become proficient in them. However Brace's assertion that motor ability is more or less general is not supported by research findings from a later study\textsuperscript{4} by the same author in which he reported intercorrelations between the average learning scores and the Brace

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Motor Ability Test, Iowa-Brace motor ability and other tests, viz., .32, .27 and .37, which are quite low and have an extremely low predictive validity. His later findings also reflect the same trend, very low intercorrelations between six learning tests (sports, stunt, motor rhythm, McCloy General Motor Capacity Test, Brace and the Iowa-Brace).

In the field of motor learning recent evidence has supported the theory that there are highly specific interrelationships among motor abilities which are associated with the process of learning motor skills.

In a significant study, "Specificity versus Generality in Learning and Performing Two Large Muscle Tests," Bachman, after analyzing the data from three hundred and twenty subjects, comments: "Certainly the outcome seems to rule out the presence of general motor coordination ability in the ordinary usage of the term. It also rules out the presence of a motor learning ability. Instead the abilities are task-specific both for performance and for motor learning. The results show little more than zero correlation between performance of the two tasks, and therefore substantiate the theory of task specificity of motor abilities."

Similarly, Nelson demonstrated that transfer of motor learning is also highly specific. Cratty in an experiment which involved the comparison of learning a fine motor task with learning a similar gross motor task stated that—"discovery of a general factor involved in the learning of spatial patterns awaits further research." Smith investigated the relationship between the rate of learning to swim and General Motor Capacity and demonstrated that the latter variable had an extremely low index in predicting an individual's rate in learning to swim.

Cratty's purpose in "An Investigation of Motor Educability" was to determine whether a common factor of motor educability as defined by McCloy was common to the learning of two maze tasks. Results gathered from sixty male university students disclosed that improvements between the first and final trials performed on the two mazes resulted in a correlation of .237 with an r of .234, between performance improvements on the two mazes as measured from the slowest to the fastest trials. The r between trials 3 and 12 on the two mazes was only -.002. Cratty concludes, "There seemed to be only a slight indication that the ability to improve performance on one maze was related to the same ability in the other."

The findings from Cratty's study support the conclusions of Perrin, and Gire and Espenschade. The latter investigators reported that batteries of motor learning skills did not accurately measure the rate with which subjects learn new sports skills (basketball, volleyball, and baseball) or relearn previously acquired skills.

Nelson and others have also shown that in addition to there being evidence for supporting specificity between the learning of motor skills there is also a high degree of specificity of transfer of learning between different learning tasks.

Cumbee, Meyer and Peterson and others have also reported low correlations between the learning of various motor skills.

**Strength and Speed**

Rogers has claimed that the prediction of speed, in running the 100-yard dash, from strength (or of strength from speed) might be reduced to a mathematical formula. Larson was of the opinion that, "The muscular power component and speed are highly related. Muscular strength and speed may be considered, if so desired, together." It was later stated by Clarke that the strength index "is an excellent measure of general athletic ability... an individual with a high Strength Index should, after adequate instruction and practice, perform well in a number of activities of the large-muscle type. The Strength Index is especially useful in equating opponents for team games."

In contrast to the foregoing statements studies by Rasch and Clarke and Henry have demonstrated the low degree of common variance which exists between individual differences in static strength and strength in action, viz., speed of movement.

However, if a survey is conducted of many of the current motor ability tests, one will find the inclusion of static strength items which supposedly have magical powers in the prediction of dynamic motor abilities. Static strength and speed of movement are unrelatedly task and directional, hence from a knowledge of performance in static strength items one cannot successfully predict where individuals will rank in performance in activities involving speed of movement.

In support of the previous contentions Smith and Whitley have reported the results of an ex-
experiment whereby the subjects were allowed to build up their maximum static limb strength immediately prior to a maximal speed of movement. Results substantiated earlier studies which demonstrated that static strength is virtually uncorrelated to the ability to execute a fast limb movement. Burley, Dobel and Farrell also found very low relationships between motor activities involving power and speed.

Gross, Griesel and Stull investigated the relationship between two motor educability tests, a strength test and the learning of wrestling. They reported that, "The individual predictive value of this Quotient (McCloy, General Strength) was of little worth. The two 'motor educability' tests, Iowa-Brace and Metheny Revision of the Johnson test, were of less individual predictive value, in ability to learn wrestling, than McCloy's general Strength Quotient."

Guilford in discussing the nature of "whole-body factors" also asserts that "two of them, general strength and general reaction time, genuinely appear to be general factors that can be attributed to positive intercorrelations of tests applied to various bodily parts."

Recent studies have shown that "positive intercorrelations of tests applied to various bodily parts" are very low and are task specific. Smith evaluated data collected from seventy college men. Computations of $r$ and $k$ from the intercorrelations revealed that individual differences in all measures (maximal speed, reaction latency of limb movements, and strength) tended to be highly specific to the particular limb, its direction of movement, and a particular element of the limb action, i.e., strength, speed, or reaction latency.

Nelson and Fahrney recorded the following summary and conclusions: "Three groups of 23, 31, and 19 male subjects were tested for strength and speed of an elbow flexion movement. Moderately high, statistically significant ($P < .001$) correlations of .74, .75, and .79 between strength and speed were found. A detailed comparison of subjects, experimental design, and test procedures used in this and previous studies was included. Within the experimental limitations of this study we conclude that a statistically significant, positive relationship exists between strength and speed of movement. The hypothesis of independence between strength and speed as measured in this investigation is not tenable."

Before one is tempted to prematurely abandon the theory of specificity in reference to the relationship between individual differences in motor co-ordinations it may be significant to note that all the results of the twenty-three references quoted in Nelson and Fahrney's review of the literature have supported the theory of specificity. The validity of their study must first be corroborated by other workers before its implications can be seriously evaluated.

Endurance

Caldwell of the U.S. Army Medical Research Laboratory at Fort Knox, in a series of studies which mainly involved the investigation of strength and endurance, has provided abundant evidence concerning the low predictive relationship which exists between these two variables. For example after testing 64 males he obtained a correlation of less than -.10 between strength and endurance tasks which were set at four relative loads.

In another study Caldwell tested both men and women and reported an $r$ of .13 between the measures of strength and endurance. Working with 64 male college subjects he substantiated his earlier work in reference to the specificity of relationship which exists between strength and endurance: strength as measured at a 150-degree elbow angle correlated with the endurance measures at four relative loads -.08, -.03, -.09 and -.04. Caldwell concluded, "With the use of relative loading, individual differences in endurances were unrelated to differences in strength."

Pierson reported no significant correlations in a study which was concerned with discovering the relationships between isometric strength and the occurrence of fatigue and work decrement. Very low correlations of .01, .36 and .09 were found to exist between isometric strength and the occurrence of fatigue, reaction time decrement and movement time decrement. A more recent study by Pierson substantiated his earlier results in which he reported, "No significant correlation was found for normal RT or MT and the occurrence of fatigue ($r = 0.04$ and $0.20$, respectively), work decrement ($r = 0.05$ and $0.31$), or the limit of endurance ($r = 0.02$ and $0.24$)."

Reaction Time and Speed of Movement

McCloy and Brace and Carpenter and other influential American physical educators have supported the concept of a General Motor Ability and/or Capacity factor.
Two physical abilities related to success in many motor activities are reaction time and speed of movement. However, within a group of individuals can one predict ability in speed of movement from a knowledge of the individual's reaction time? Early studies by Westerland and Tuttle, Peters and Wenborne, Coleman, and McCloy supported the theory of a general speed factor, while in contrast the work of Tinker, Miles, Lautenback and Tuttle, Harrison and Dorcas did not support the general speed theory. However, recent research work has provided strong experimental evidence supporting the theory of specificity. In particular, it is generally accepted that the ability to react quickly and ability to move quickly are almost entirely unrelated. Hodgkins, in a study involving 930 men, women and children aged 6-84, also concluded that the majority of the groups showed no relationship between speed of reaction and speed of movement.

If judgment can be partially based upon the many references in the literature to the factorial investigation, a system of psychomotor studies by the eminent psychologist and statistician J.P. Guilford has had a decisive influence upon present day thinking regarding the interrelationships between motor abilities. However, recent experimental findings strongly contradict his assertion that, "There is much evidence of a general reaction-time factor pertaining to many parts of the body by generally positive inter-correlations." Again confusion can result from determining what is the magnitude of "generally positive inter-correlations."

Rarick, who thirty years ago was among the first brave pioneers to brilliantly reveal the specificity of relationship which exists between motor abilities, utilized Thurstone's method of factor analysis to study the factors associated with simple athletic activities. Intercorrelations were computed from 22 variables which included, two sprint events, right and left hand strength, back lift strength, leg lift strength, gastrocnemius reaction time, triceps reaction time, etc. Among the total of 42 correlations between the two reaction times and the other variables the highest relationship was with leg lift strength (.22). The correlation between reaction time-triceps and reaction time-gastrocnemius was only .33. However sad to relate, very few of the early physical education investigators realized the potential importance of Rarick's findings.

Singer provided strong evidence supporting the theory of specificity of interrelationships between individual differences in motor abilities. Singer summarizes his findings with the following statement, "Five of the six correlations, including preferred arm and non-preferred arm, preferred leg and non-preferred leg, preferred arm and non-preferred leg, non-preferred arm and non-preferred leg, and preferred arm and non-preferred leg, were positive; low but significant. However, when analyzed for generality and specificity factors of performance, the highest generality (29 percent) was obtained when comparing leg performance. There is evidence of strong specificity in limb performance, and thus more support for a specificity theory of learning and performance."

Cratty in reference to research relevant to the specificity of movement time, reaction time, and strength, states that "within recent years there has been a proliferation of studies demonstrating that movement time, reaction time, and strength are largely independent and combined in specific parameters to produce a simple direct movement." Cratty showed that neuromotor specificity, strength and maximum arm speed, limb speed and limb reaction (time taken to initiate the movement after the stimulus is given), and arm mass and speed of movement were found to be independent phenomena.

Implications

As there is a preponderance of recent research literature which has strongly supported the theory of specificity of relationships between motor abilities, the use of General Motor Educability and General Motor Ability and Capacity test batteries as a means for successfully predicting motor performance rests upon outdated, arm-chair specula-
tion rather than genuine scientific evidence.

In General Motor Test Batteries the low interrelationships which exist between motor abilities have often been statistically magnified by the use of complicated multiple regression equation formulas. For example, to predict gymnastic ability the following conversion of the Wettslone regression formula into the form of a T-Score has been suggested by McCloy:55

\[-2.048 (100 \times \text{thigh girth}) + 1.15 (4 \times \text{squat—thrust height})
+ 1.804 (\text{pull ups} + \text{dips} + \text{leg lifts}) + 75.94\]

Where is the experimental evidence for Generality in regard to sports skills and motor abilities? Because of the unpredictable and unpatterned relationships which have been found to predominate between individual differences in motor skills, General Motor Ability tests are doomed to failure. It is also strongly suggested that many other current tests, for example fitness tests, are not valid criteria for the practical prediction of an individual's performance in the many diverse areas of physical fitness. Prediction of motor performance from motor ability tests is also especially hazardous as the psychological stresses (fatigue, competition, etc.) and other complexities imposed during sports events are virtually impossible to reproduce in sports and motor ability tests.

As there are virtually no practical predictable relationships between fundamental motor factors such as strength, speed, and reaction time, only a magician's wand could create conditions by which General Motor Ability Tests involving these factors and other factors would successfully predict an individual's relative ability in motor abilities. At the tails of the normal curve of the distribution of physical skills, extremely motor gifted and retarded individuals often will display a fairly homogenous high or low level in specific motor skills which could be interpreted as evidence for a General Motor Ability. However, these individuals are virtually motor-ability "freaks" when compared to the heterogenous scatter of motor abilities which are common to individuals who represent the bulk of the normal population.

Teaching and coaching would be greatly simplified if the theory of generality of motor abilities had been substantiated by experimental evidence. For example, an individual who ranked ninth in strength would also rank ninth in speed, reaction time, and other motor and sports abilities. But, unfortunately for the hard working teacher and coach, individuals do not possess a homogenous interrelated cluster of sports and motor abilities. Ragsdale and Breckenfeld71 and many other investigators have reported very low intercorrelations between sports skills, while Cumbee did not discover a high degree of common variance between sports and motor abilities. Because of research findings which have in general shown very little evidence of positive transfer between motor abilities, teachers and coaches cannot hope to achieve the Utopian dream of coaching the reaction time, the speed, the strength, the sports skill and hope that the training of these mythical general factors will positively transfer to improve performance in other motor or sports activities.

In light of the depressing portrait painted previously in regard to the lack of interrelationship between motor abilities and the relative absence of a positive training transfer between different sports events, assertions that tests are capable of predicting a person's motor ability potential should be evaluated with extreme caution. A teacher's or coach's flexible subjective evaluation, in addition to a cumulative record of the relative performance of the individual during a series of competitive training and motor performances, has a greater probability of success in the prediction of an individual's future sports potential than having blind reliance upon the dubious predictive powers of a General Motor Ability Test.

In reference to implications for physical education practice, Henry46 cautions that, "Our curriculum planners should become more aware of the research findings—it is no longer possible to justify the concept of unitary abilities such as coordination and agility, since the evidence shows that these abilities are specific to the task or activity."

Following the presentation of additional relevant evidence Henry elaborates as to his position concerning the theory of specificity:

"The theory of specific motor abilities implies that some individuals are gifted with many specific abilities and others have only a few; it follows that there will inevitably be significant correlations between total test battery scores when tests involving many abilities are lumped together. The general motor factor which thus makes its appearance is a sample, fundamentally, of how many specifics the individual has, and general
motor ability does exist in this sense. This is not a question of definition; it is, on the contrary, a matter of basic theoretical insight into the problem. Failure to appreciate this distinction has blurred our thinking in the past, and has erroneously led us to expect that practicing a motor skill would improve general coordination. However, there is no general coordination ability except perhaps in the very young. Repetition of a motor act improves the specific skill that is practiced, but individual differences in ability to profit by practice are specific to the skill and definitely do not predict the ability to improve by practice in some other skill.

Disraeli, the controversial English Prime Minister has been reputed to have asked a research investigator, "What practical use is this experiment?" The researcher quite aptly countered with the following cutting reply, "What use is a baby?" It may be worthwhile to consider that practicality is not the only criterion.

"Knowledge, scientifically speaking, is the equivalent of confirmed theories (why and how do certain things affect other things, and how does it work)."

References

26. ______. Movement Behavior and Motor Learning, Lea
88. Thorndike, E.L. The Psychology of Learning, N.Y. Teachers College 16, 17, 19-23, 45, 46, 204, 1913.

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