THE EFFECTS OF NORMAL, DECREASED, MASKED AND ABNORMAL AUDITORY CUES ON THE PERFORMANCE OF SKILLED AND HIGHLY SKILLED RACQUETBALL PLAYERS

by

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ABSTRACT

TITLE: The Effects of Normal, Decreased, Masked and Abnormal Auditory Cues on the Performance of Skilled and Highly Skilled Racquetball Players.

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The purpose of the investigation was to determine the effects of normal, decreased, masked and abnormal auditory cues on the performance of skilled and highly skilled racquetball players.

The subjects were tested utilizing a recognized racquetball wall volley test under varying auditory cue conditions. The test involved volleying a ball against the front wall of the test court for 30 seconds, once from the short line and once from 12 feet behind the short line. A count was taken of the number of legal hits of the ball against the front wall in both of the tests and the total score for each condition was the sum of the scores for the short wall test and the long wall test.

The data was analyzed utilizing a repeated measures design analysis of variance and covariance. A significant F ratio was found for the difference between tests performed under reduced, masked and abnormal conditions. A significant F ratio was also found for the difference in scores between the skilled and highly skilled subjects. A non-significant F ratio was found for the

test of interaction of the skilled and highly skilled groups in relation to the varying cue conditions. A post-hoc test run for the reduced cue conditions against the other cue conditions indicated that the significant difference lay in the performance of the test under the reduced cue conditions.

Within the scope of the study the investigator concluded that the performance of a motor task strongly dependent upon auditory cues was adversely affected by interference with those cues. Reducing the auditory feedback was found to produce the greatest decrement in the performance of racquetball skills. Both the skilled and highly skilled players were affected equally by the varying auditory cue conditions in which the test was performed.

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A THESIS

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Chapter 1

INTRODUCTION

Auditory perception, although not as critical as visual perception, nevertheless plays an important role in motor performance. Effective and efficient learning and performance in motor activities depend on audio cues either alone, or in conjunction with other sensory cues. It is sound combined with visual information that provides a more precise representation of events in space. Some sports require auditory communication between team mates, while pthers are started by auditory stimulus. However in most sports sounds provide indirect cues to such aspects as speed of the ball as it is caught or hit, location of teammates or opponents who are out of the field of vision, and various other cues or feedback sensations necessary to the performer.

Traditionally the study of auditory perception has focused on speech and music. However it is necessary for this study to focus only on auditory space perception, since this is more important in motor performance. Sage (27) stated that

> "The auditory world is spatial, just as the visual world is. Sounds have location direction and distance. The design of the auditory system permits discrimination of frequency and intensity only, but these cues are used to produce discrimination of direction and distance that is quite accurate". (186)

The ability to localize sounds in space is a critical auditory function according to Geldard (12). The detection of direction and distance of sound is strongly dependent upon binaural hearing. The deaf demonstrate that although it may be difficult at first to get along sufficiently without auditory imput, it is possible to compensate for the lack of cues. This can be seen when observing the deaf perform at skill levels commensurate with that of a "normal" individual.

Some sounds or auditory cues are of more importance than others. Persons accustomed to sleeping near a railway line will not for example, be disturbed by the sound of a train passing, however they will awake at the cry of their young baby in the next room. This serves to illustrate that the human brain can eliminate sounds which are familiar or unimportant to a person. Hockey (14) found that noise affects some tasks adversely while facilitating other tasks. His studies indicated that noise only affects tasks which demand complete attention with little margin for error. He established that adverse effects are more likely with "complex" tasks where facilitatory effects are gained when noise is added with "simple" tasks.

The use of feedback by a performer is recognized as being valuable to the learning process. A performer who is at an advanced level may be able to select specific perceptual cues termed informational feedback, and utilize these cues during the performance of a skilled movement. The player has then reached the point of reliance upon intrinsic cues. These cues are present regardless of the environment in which the movement is performed, and are fundamental to the specific skill or action involved. (24)

In recent years substantial research has been completed in the area of industrial noise. Federal laws now require companies to either diminish noise levels at source, or require workers to wear ear-plugs or ear-muffs. The legal limit of 90dB for an eight hour day was established by the Walsh-Healey act of 1936. Other studies have shown that excessive levels of noise have been found to cause emotional and psychological problems and possibly affect efficiency at work. (4),(16),(22) It is apparent then that noise is a positive hazard to public health.

From the point of view that too much noise is a hazard and too little is certainly of no value, Kriebel (38) believed that there may exist a noise level range below this hazard zone which is not harmful but is an asset to the individual facilitating movement in his environment through the use of auditory cues. Although many auditory cues are detrimental to the hearing mechanism, many are definitely of value and it may be that these should be employed to their fullest extent.

If as has been suggested, auditory cues play an important role in our everyday lives even though we may be quite unaware of these cues , we need to discover to what extent they are in fact employed to interpret our environment most efficiently. If these auditory cues are essential in some way so as to aid in the performance of a task, physical educators need to teach students to attune themselves to these auditory cues and employ them in activities where sound is directly related to the task.

STATEMENT OF THE PROBLEM

The purpose of the study was to determine if and to what extent the proficiency of skilled and highly skilled racquetball players was affected by normal, decreased, masked and abnormal auditory cues.

SCOPE OF THE STUDY

In order to obtain the relevant material for analysis, fifteen skilled and highly skilled racquetball players from Appalachian State University were asked to perform a racquetball wall volley test. The test was conducted under the following conditions:

The subjects volleyed:

(1) with normal hearing,

(2) with ear plugs,

(3) with a 90dB white noise masking sound,

(4) with recorded normal racquetball game noise,

(5) with normal hearing.

DEFINITION OF TERMS

For purposes of clarification, the following terms employed in this study are defined:

Perception

The process of information extraction. It is a resultant of sensation combined or integrated with past experience to form added meaning.

Auditory Perception

The act of recognizing sensations through the medium of the ear, retaining the image and relating it to previous experiences.

Binaural

Listening to or hearing an auditory stimulus with both ears.

Monaural

Listening to or hearing an auditory stimulus with one ear.

Auditory Threshold

The minimum sound pressure level that evokes an auditory sensation.

Localization

The determination by auditory responses alone, of the direction from which sound comes to the ears.

Cue

A perceived signal for action.

Auditory Feedback Cue

A recording of the sounds that a subject can hear during the performance of a skill.

White Noise

A sound whose frequency spectrum is continuous and uniform.

LIMITATIONS

The results of the study were subject to the following limitations.

(1) The court was not of regulation size causing the long wall volley test to be performed under restricted conditions.

(2) The subjects tested were low in number.

(3) The study tested only skilled and highly skilled subjects.

(4) Only two of the subjects underwent a comprehensive hearing acuity threshold test. This provided a measure of the hearing loss caused by the ear plugs.

Chapter 2

REVIEW OF LITERATURE

The absence of directly related literature with regard to audition as it affects the performance of a gross motor task, has led the author to review literature that can be closely compared with the intentions of this study. The review of literature is divided into five parts: Auditory perception and localization, the role of sensory cues and feedback, masked and delayed auditory feedback, sensory deprivation and the psychological and sociological effects of noise.

Auditory Perception and Localization

In "normal" hearing individuals the detection of the direction and distance of sound is dependent on binaural hearing. However it is possible to locate the direction and distance of sound with only one functional ear, although it is necessary to turn the head in order to do so. Sage (27) suggested that people typically turned their heads often unnoticeably in order to change the stimulation pattern at the two ears, thus making it possible to pin-point the exact location of a sound.

The properties of sound waves and the function of different parts of the auditory system interact to produce sound localization. Sage (27) described the process of a sound coming from one side of the head as arriving at the ear on that side a little sooner than it did the contralateral ear. Although the difference in arrival time of the sound was less than one thousandth of a second, this he stressed was used as a powerful cue for the perception of direction of sounds.

In a study by Yates (36) groups of high and low susceptibility on the basis of speech disturbance under binaural delayed auditory feedback were determined and then tested on shadowing tasks under four conditions, single stimulation presented binaurally, stimulation presented monaurally with either, white noise, an irrelevant cue, or delayed feedback of the repetition of the cue presented to the contralateral ear. No difference between the susceptible and non-susceptible groups in the binaural and white noise conditions were discovered, but the susceptible group exhibited a much larger increase in errors under the conditions of the irrelevant stimulation and delayed feedback. Susceptibility, Yates suggested, was possibly a function of the degree of dependence on auditory feedback for the normal monitoring of speech as compared with dependence on other sensory information. He concluded that if the task were greatly dependent on auditory feedback, then the normal auditory sensations or cues would have been seriously disturbing to the performer.

Gerber (13) suggested that not only was the relative time of arrival of a sound at the two ears vital, but that the amplitüde and frequency of the sound played an equally important role in perceptual auditory location. He stressed that these cues usually worked together but that any one was effective alone.

However, he believed that the arrival time factor was the most important. Wertheimer (34) conducted experiments with a ten minute old infant and found that the child demonstrated eye movements in the direction of a click which indicated primitive auditory localization and interaction between hearing and vision even at an early age.

In an effort to understand the role that learning plays in auditory perception, Sage (27) discussed studies which involved the use of an instrument called a pseudophone. This instrument permitted sounds from the right to enter the left ear first and sounds from the left to enter the right ear first. The results of the investigations indicated that when the subjects first utilized the instrument, they experienced complete confusion of sound localization. However, after a time the subjects adapted to the pseudophone and were able to locate various sound sources accurately.

The Role of Sensory Cues and Feedback

In most studies concerning cues in relation to feedback an attention set is being formed through some type of guidance. Singer (29) stated that practice became more productive and meaningful when the learner was attentive to particular cues; these cues being the most important elements in a given situation. He concluded that improvement in motor performance during practice was dependent upon the attention that the learner displayed to the act in general and to certain cues in particular. Norman (23) and Fogel (10) have likewise pointed out the importance of attention and have related it to the limited ability of man to attend to too many simultaneous stimuli. Singer (29) has associated the ability to be selectively attentive to stimuli with highly skilled performance. He stated that at this point in learning attention sets had been formed. Singer also stated that formation of these attention sets was necessary in all motor activity.

There are several bases for stimulus selection. Singer (29) pointed out that skilled individuals differ as to what they attend to when presented with identical situations. Stimulus selection depended on the environment and reflected the nature and state of the human organism.

Many studies have been completed including those by Whiting (35) and Holding (15) on the importance of visual guidance during performance of a motor task, however virtually no research has been completed in the area of auditory guidance or the use of auditory cues. Lockhart (21) alluded to its importance by stating that sounds which accompanied performance served as a means of guiding the performer and gave immediate knowledge of results. The effectiveness of using sound cues characteristic of a particular activity was discussed by Smith (30) and Whiting (35).

Fogel (10) stated that the human operator normally derives a significant amount of information from his environment by means of his auditory channel. On that basis, it would appear that maximum use of the auditory channel in performing and learning skills, would be of importance. Fogel stated further that the purpose of the auditory channel was to receive and transform sounds into neural codes capable of conveying intelligence to the human operator.

Pohlman (40) cited Robb as having discussed the importance of auditory cues during the second phase or practice phase of learning. Robb had stated that the importance of auditory cues lay in the fact that they did not require assessment of direction or distance for processing as did visual cues. This fact indicated that the learner could listen and perform at the same time. Auditory guidance it was assumed, could be an appropriate method of enabling a learner to make full or better use of auditory cues.

Malina (39) described the role of feedback as directive; that is, feedback indicated how the present outcome differed from the intended goal. This then provided an indication for any necessary adjustments to be made during subsequent attempts. According to Robb (25) feedback could be thought of as "error information" and could further be distinguished by the arrival time of information concerning the performance.

Chase (6) summarized the role of feedback by stating;

> " The fact that sensory information is vital for initiation and control of normal voluntary movement suggests that the sensory information which is produced as a function of movement is used by the nervous system during the course of movement. The concept

> of sensory information from a motor performance functioning as a persistent controlling influence on the motor performance fits the formal model of a servo system developed by engineering theory. In this model,..... the sensory information from a motor performance is called 'feedback'." "This sensory information returns to the central nervous system and is used to control the ongoing motor activity."
>
> "Futher evidence of the importance of sensory information for the control of voluntary movement is afforded by clinical observations of the speech difficulties of deaf patients and of the ataxia which follow lesions in dorsal roots and dorsal column." (6) (153-167)

In two separate studies performed by Shankweiler and Studdert-Kennedy (28), and Bakker (1) similar results were obtained. Both reported that digits and other verbal material were retained best by the presentation of this material to the right ear, while non verbal material such as brief melodies or sonar signals were retained more accurately when presented to the left ear. Bakker went on to present a developmental aspect of this phenomenon.

Costa (7), Birch (3) and Fisher (9) performed studies relating two sensory modalities. Costa found that "normal" subjects produced more rapid responses to paired stimulation that to stimulation in either the visual or auditory modality alone. Costa reported that reaction time to auditory stimulation was shorter than reaction time to visual stimulation, however the presence of both stimuli together yielded shorter reaction time to either alone. Whiting (35) made a similar comment when he stated:

> "While in most ball games concern will be with reaction time to visual stimuli (often the ball), the contribution of other senses in this respect must not be ignored. Although for example, the sound of a ball hitting a wall or a bat, is apparent in most games, the possible utilization of sound cues does not seem to have been investigated. If these do play a part in organizing responses it is worth noting the faster reaction to an auditory stimulus." (35) (184)

Similarly, Legge (19) stated that proprioception, when integrated with other sensory information, may form the basis for the organization of skilled movements. Welford (33) emphasized the importance of adequately controlling the process of bringing past material to bear on the present situation. Failure to do this would have yielded one of three kinds of results: (1) incoming data may touch off more than one pre-existing organization with the results that perception or action was confused; (2) correct actions may be produced but not ordered in correct temporal sequence; or (3) there would be a failure to use feedback data to control the pre-existing organization. Birch (3) concluded that integration of the auditory and visual senses was most rapid in the early school years and that those and other important intermodal relationships were being established during that time. Findings indicated that this integration and intelligence quotient are associated but not synonymous. Results from the studies of Fisher (9) implied that agreement among the information processed by different spatial senses was apparent rather than actual.

Masked and Delayed Auditory Feedback

Laszio (17) performed studies on keytapping with a reduction of the senses - kinesthetic, tactile, auditory and visual. Loss of kinesthesis was found to cause the greatest decrement. With kinesthetic sensations intact, while reducing both visual and auditory sensations, no decrement in performance was reported. In contrast Chase (6) reported significant changes in the rate and intensity of tapping under conditions of decreased auditory feedback, decreased visual feedback, vibration and combination conditions.

Smith (30) reported that limited investigations had been completed in the area of nonvocal activities. However the results that were available indicated that feedback delay produced comparable effects on different movement patterns. Similarly results obtained by chase (6) suggested that the complexity of a task was one determinant of the degree to which that task would be disturbed by a delay in sensory feedback. Chase also reported physical difficulties including increased vocal intensity, increased intonation time and a tendency to repeat sounds during experiments with delayed auditory feedback.

Kriebel (38) cited Dinnerstein as having provided some important information concerning latency of perception. Two views were presented concerning "extra" stimulation. Traditional views suggested that an irrelevant stimulus drew attention away from the task, where other theoretical discussion suggested that a compelling irrelevant stimulus might monopolize the perceptual system. This monopolizing effect would require information to be stored and consequently cause delay in the perception of those stimuli. Kriebel continued with the investigations of Dinnerstein who had related to the fact that delayed sensory feedback produced blocking, slurring, slowing and syllable repetition in speech and apparently also affected "all types of motion". Kriebel noted that no gross motor tasks were among those listed as "all types of motion". Included in the list were singing, speech, drawing, dotting, object manipulation, object assembly and panel control operations. The most noticeable effects were reported with concurrent delayed feedback that is when delayed feedback was presented simultaneously with the on-going preformance.

Sensory Deprivation

After experiments with cats, Sterritt and Robertson (31) reported that early sensory deprivation caused a deficit in the ability to use information presented in the affected sense modality. Fuerst and Zubek (11) studied sensory and perceptual deprivation to determine the effects on open ended cognitive tasks. No significant differences were found when both groups (one sensorily and the other perceptually deprived) performed on the Guilford battery of creative thinking. Zubek (37) cited Zuckerman, Levine and Biase whose experiments tested thirty-six undergraduate males and thirty-six undergraduate females in a confinement situation for three hours under the following conditions: (1) total sensory deprivation no light, no sound; (2) auditory deprivation with visual stimulation; (3) visual deprivation with auditory stimulation. The results supported the conclusion that some reduction of external stimulation facilitated reported visual sensations, although stimulation in other sensory modalities did not necessarily inhibit reported visual sensations. Similar results were obtained for reported auditory sensations. Kinesthetic reported sensations were significantly more frequent under total deprivation conditions than under either of the partial deprivation conditions. These phenomena then appeared to be inhibited by the competing stimulation of other modalities.

Zubek (37) discussed studies by Myers, Murphy, Smith and Windle 1962, in which auditory vigilance was measured by the subjects speed of reaction to a brief tone signal presented at a rate of 12 signals per 48 minute period, and occuring at irregular intervals. The test was presented before and after 3 days of sensory deprivation. Furthermore, because it was known that irrelevant stimulation could facilitate vigilance, two control groups were employed, one tested in a lighted room and the other in a darkened test room. The results indicated a decrement on the vigilance task with all three groups performing poorer on the second half of the task than on the first. The performance of the lighted room control group was significantly better than that of the darkened room control group. However the experimental group outperformed both of the control groups in the vigilance task.

Thus the vigilance performance of the isolated subjects did not differ from the control group tested in the light, but it was significantly better than that of the control group tested in the darkness. Observations were also made on a measure of simple auditory reaction time. The results again revealed no differences between the experimental group and the lighted room control group, but indicated a significantly faster reaction time in the experimental group relative to the darkness control group. In conclusion Zubek reported that from the studies reviewed it was clear that the level of illumination present in a test room was an important variable to be considered in future research.

Psychological and Sociological Effects of Noise

The action of noise on the performance of tasks has been studied extensively in the laboratory and in actual work situations. Miller (22) reported studies by Broardbent, 1957; Burns, 1968; Cohen, 1969; Kryter, 1970. From these studies he determined that when a task required the use of auditory signals, speech or non-speech, then noise at any intensity level sufficient to mask or interfere with the perception of those signals would interfere with the performance of that task. When mental or motor tasks did not involve auditory signals the effects of noise on their performance were difficult to assess. However certain general conclusions emerged: (1) Steady noises without special meaning did not appear to interfere with human performance that did not include auditory components unless the noise level exceeded 90dB. (2) Irregular bursts of noise were more disruptive than steady noises. (3) High frequency components of noise produced more interference with performance than low frequency components of noise. (4) Noise did not appear to influence the overall rate of work, but high levels of noise may have increased the variability of the rate of work. (5) Noise was more likely to reduce the accuracy of work than to reduce the quantity of work. (6) Complex tasks were more likely to be adversely influenced by noise than were simple tasks. Miller suggested that the effects of noise on human performance could be conceptualized in terms of three classes of effects - arousal, distraction and specific effects. Arousal of bodily systems including the musculature could result in either detrimental or beneficial effects on human performance. The direction of the effect depended on the task and on the persons state prior to exposure. Distraction could be thought of as a lapse in attention or a diversion of attention from the task in hand. Distraction could also often be related to the physiological responses to noise or responses to messages carried by the noise. Specific effects were described as including auditory masking and muscular activation.

Miller (22) continued by stating that many physiological and psychological responses to sound diminished or disappeared when noises became regular or predictable. Also he believed that under certain conditions noise could even result in better concentration due to auditory isolation provided by the masking effect of that noise. This he found especially true when the sound was regular or rhythmic. Miller concluded that the ideal acoustical environment was one that did not disturb human performance either because of the properties of the noise itself or because of irrelevant messages carried by the noise, but maximized the chances that important relevant messages carried by sound would reach the appropriate party.

Summary

It could be concluded from the literature that when normal auditory cues were changed or altered in any form, the activity being studied would be disrupted in many different ways. Those tasks which were greatly dependent upon auditory cues would be the most affected when these cues were disturbed.

Chapter 3

PROCEDURES

This chapter encompasses the procedures employed in testing skilled and highly skilled racquetball players under varying auditory cue conditions. The procedures are divided into four sections, subjects, testing device, testing procedures and statistical treatment.

Subjects

The subjects tested were selected from the leading racquetball players at Appalachian State University, Boone, North Carolina. Fifteen subjects were selected from the 1979-1980 racquetball intramural competitions. Five of the subjects were determined to be highly skilled, the remaining ten as skilled. This ranking was established from the results of each subject's final placement in the intramural competitions. Of the fifteen subjects twelve were male and three were female. The subjects' ages ranged between 21 years 1 month and 51 years 3 months. The number of years playing experience of the subjects ranged between 2 years and 10 years with a mean of 4.8 years. All of the subjects were given an overall wideband screening hearing test to ascertain that no gross hearing losses were present. No gross hearing defects were detected in any of the subjects. In addition two of the subjects underwent a comprehensive hearing acuity threshold test. This test provided a measure of the hearing loss caused by the ear plugs.

Testing Device

The testing device employed in this study was a racquetball skills test devised by Hensley, East and Stillwell (41). The test comprised both a short wall volley test and a long wall volley test.

Each of the subjects was required to volley the ball against the front wall of the test court for 30 seconds, a point being scored each time the ball hit the wall legally. Both the short and long wall tests were utilized and the total score was the sum of the legal hits of the two trials. No points were scored when a subject stepped over the restraining line to volley the ball or when the ball hit the floor on the way to the front wall.

The designers of the test determined the reliability of the long wall volley test to be $R = 0.82$ for women and $R = 0.85$ for men. For the short wall volley test the reliability was determined as $R = 0.86$ for women and $R = 0.76$ for men. Content validity because of the nature of the test was logically assumed. Concurrent validity was established by utilizing instructor ratings of the subjects as the criterion measure. The instructor of the class being tested subjectively evaluated students on their ability to sustain a rally. A rating scale of 5 - Excellent to 1 - Poor was employed in the evaluation. The ratings were obtained after the skill testing; however the instructor had no prior knowledge of individual students' test performances. There were no substantial differences between men and women in the validity of the two tests. Therefore the validity coefficients for men and women combined were .79 for the short wall volley and .86 for the long wall volley tests.

The similarity in the administration of the two tests suggested a high degree of communality. However, the correlation between the short wall volley and the long wall volley tests indicated that approximately 54 percent of the variance was common to both tests.

Testing Procedures

The testing area in which the study was administered was racquetball court number sixteen in Varsity Gymnasium, Appalachian State University, Boone, North Carolina. The area measured 32.5 feet by 20 feet by 20 feet. The lighting in the court was constant during the entire study. The only lighting used was that from the overhead lights standard in each court.

All testing was completed between July 21 and July 25, 1980. All subjects were scheduled to participate in groups to facilitate rest periods between each test session.

Equipment pertinent to the testing portion of the study included an audiometer, recorded white noise from a white noise generator, a tape recorder, a matched speaker system, recorded racquetball sounds and fifteen sets of E.A.R. industrial ear plugs. Other equipment included the subjects' own racquetball racquets, eight new regulation Z-ball racquetballs, colored floor marking tape and a stop watch.

After proper explanation and demonstration of the test, the subjects were permitted a two minute practice period. The wall volley test consisted of two 30 second trials one from behind the short line and the other from behind a line marked on the floor 12 feet behind the short line. Each subject began the test by holding two racquetballs. Two additional balls were held by the timekeeper who was located within the court near the back wall.

The subjects stood behind the short line dropped a ball and volleyed it against the front wall for 30 seconds. Each subject was required to hit the ball from behind the short line. The ball could be hit in the air after rebounding or could be hit after bouncing. There was no restriction on the number of bounces the ball could take before being hit. If the ball failed to return past the short line the subject was allowed to step into the front court to retrieve the ball but had to return past the short line for the succeding stroke. If the subject missed the ball, a second ball could be put into play in the same manner as the first, or the subject could retrieve the missed ball and continue to volley. If both of the initial balls were missed the subject had the option of obtaining a new ball from the timekeeper or retrieving a missed ball and putting it into play in the same manner as the first. Any stroke could be utilized in order to keep the ball in play. In addition to the timekeeper a scorer and recorder operator was utilized. The scorer was positioned on the balcony overlooking the test court and recorded all legal hits of the ball against the front wall within the 30 second test period.

Each of the subjects was tested under the following conditions;

(1) with normal hearing,

(2) with reduced audio cues,

(3) with a 90dB white noise masking sound,

(4) with recorded normal racquetball game noise,

(5) with normal hearing.

The conditions (2) (3) and (4) for testing each subject were selected by random choice.

Statistical Treatment

The study was a two factor experiment, the factors being the type of sound modification (normal, reduced, masked and abnormal) and the order in which the subjects received the four conditions.

An analysis of variance and covariance including repeated measures on the same subject was employed in order to compute the collected data.

Chapter 4

RESULTS AND DISCUSSION

Included in this chapter is a presentation and discussion of the results of the investigation.

Results

A comparison between treatment 1 (normal conditions) and treatments 2, 3 and 4 (reduced, masked and abnormal conditions) indicated a significant difference of 0.0015 at a 0.05 level of confidence. This difference indicated that test performance under the treatments 2, 3 and 4 as stated above, was significantly affected by the test conditions. A post-hoc test computed among all treatments revealed that the significant difference lay in the test conducted under reduced auditory cue conditions. No significant difference was indicated in a comparison of the two groups, skilled and highly skilled, with respect to performance under the varying auditory cue conditions. The analysis was summarized in Table 1.

In an attempt to determine whether any group differences occured, an analysis of variance including repeated measures on the same subject was computed from the test results. A significant difference of 0.0018 was found at the 0.05 level of confidence. The analysis of this data was summarized in Table 2

A pre-test and post-test were given to each subject in order to determine whether learning had taken place during the test

Table 1

Summary of Comparisons between Normal,
Reduced, Masked and Abnormal
Auditory Cue Conditions

Source	SS	df	MS	F
	211.46667	4	52.86667	5.13 -
	25.86667	4	6.46667	0.63
Error	535.60000	52	10.30000	

- F value gave a significant difference at a 0.05 level of confidence.

Table II

Summary of Test for
Group Differences

Source	SS	df	MS	F
	770.66667	1	770.66667	15.36 -
Error	652.40000	13	50.18462	

- F value gave a significant difference at a 0.05 level of confidence.

performance. A t-test analysis of the data was computed and results indicated an improvement in test performance with a mean difference of 4.0 and a standard deviation of 4.99. The t score was given as 3.107 and was found to be significant at the 0.05 level.

Discussion

The results of the study indicated that a significant difference did occur in the performance of the test under the varying auditory cue conditions. The most noticeable affect occured when the subjects were tested with reduced auditory cues. Singer (29) suggested that skilled individuals differ in what they attend to when presented with informational feedback. There was no significant difference reported however, under the varying conditions of testing between the skilled and the highly skilled subjects. This lack of significance indicated that both the skilled and highly skilled players utilized auditory cues to the same extent.

A significant difference did occur in the analysis of scores between the skilled and highly skilled groups. This difference signified that the reliability of the test was acceptable for both groups of players.

Concerning the delayed or abnormal conditions, Chase (6) suggested that the complexity of the task played a role in determining the degree of disturbance. Subjects reported that the delayed or abnormal condition was different and that although it caused some difficulty, the condition would have been more troublesome had the test been performed over a longer length of time or more demanding in terms of complexity.

The investigator observed that the reduced feedback condition appeared to produce an increase in the level of anxiety demonstrated by each subject. This factor could therefore be related to the significant difference expressed in the computer analysis of the reduced feedback condition compared with the masked and abnormal conditions.

Results of the hearing tests suggested no gross hearing deficiencies in any of the subjects. However five of the subjects did have minor deficiencies within the high frequency range of sounds. The investigator determined that these deficiencies would not affect the study as the frequency range inaudible to those subjects was beyond that normally found in racquetball courts. Results of the comprehensive hearing acuity threshold test revealed a necessary increase of 12dB at a frequency of 500 to an increase of 50dB at a frequency of 4000 in order to hear the tones with the ear plugs in place.

Chapter 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of the study was to determine the effects of normal, decreased, masked and abnormal auditory cues on the performance of skilled and highly skilled racquetball players.

The subjects were selected from the leading players of the intramural racquetball competitions held at Appalachian State University, Boone, North Carolina. The subjects were grouped according to competition placement as skilled and highly skilled players. Subjects were tested utilizing a racquetball wall volley test under varying auditory cue conditions. The test involved volleying a ball against the front wall of the test court for 30 seconds, once from the short line and once from 12 feet behind the short line.

A pre-test and post-test under normal hearing conditions were utilized in order to determine whether learning had taken place during the complete testing session.

A significant difference was found in the test performances between normal cue conditions and each of the other variable conditions. The most significant difference appearing with the reduced audio cue condition. The reliability of the test was confirmed by the computed significant difference indicated between the scores of the skilled group compared to those of the highly skilled group.

No significant difference was indicated for the test of interaction of groups in relation to the varying cue conditions.

Conclusions

Within the scope of the investigation the following conclusions are warranted:

(1) The performance of a motor task strongly dependent upon auditory cues is adversely affected by interference with those cues.

(2) Of the four variable conditions, reduced auditory feedback produces the greatest decrement in the performance of racquetball skills.

(3) Both skilled and highly skilled players are affected equally by the varying auditory cue conditions in which the test is performed.

Recommendations

(1) Continue research in the area by comparing skilled players to unskilled players. The investigator believes that highly skilled performers may integrate more fully and meaningfully all stimuli important to the task being performed.

(2) Continue research utilizing a larger sample.

(3) Present subjects with experimental conditions for

longer periods of time.

(4) Conduct research involving groups experiencing only normal conditions.

(5) Continue research where testing under all conditions is not presented at one session.

(6) Continue research in the area comparing males and females.

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APPENDICES

APPENDIX A

Raw Score Data from Summation of Short and Long Wall Volley Test Scores

Subjects	Pre-Normal	Condition I	Condition II	Condition III	Post-Normal
1	43	37	47	42	45
2	28	33	37	34	37
3	41	46	48	51	53
4	44	43	46	46	47
5	49	40	37	44	43
6	37	34	39	37	46
7	44	48	46	46	47
8	39	42	43	38	44
9	37	45	41	43	48
10	36	35	36	36	37
11	39	34	40	36	36
12	44	45	46	51	48
13	39	27	33	38	39
14	37	41	44	45	43
15	41	39	44	45	45

APPENDIX B

Raw Score Data from Summation of Short and Long Wall Volley Test Scores of the Highly Skilled Subjects

Subjects	Pre-Normal	Condition I	Condition II	Condition III	Post-Normal
	43	37	47	42	45
	41	46	48	51	53
	44	43	46	46	47
	44	48	46	46	47
	44	45	46	51	48

APPENDIX C

Raw Score Data from Summation of Short and Long Wall Volley Test Scores of the Skilled Subjects

Subjects	Pre-Normal	Condition I	Condition II	Condition III	Post-Normal
	28	33	37	34	37
	49	40	37	44	43
	37	34	39	37	46
	39	42	43	38	44
	37	45	41	43	48
	36	35	36	36	37
	39	34	40	36	36
	39	27	33	38	39
	37	41	44	45	43
	41	39	44	45	45

APPENDIX D

Mean Scores and Standard Deviations
for each Audio Cue Condition

Treatment	Mean	St. Dev.
Normal	39.876	4.85
Reduced	39.276	5.86
Masked	41.800	4.62
Abnormal	42.533	6.27
Normal	43.867	4.82