

REFERENCES

1. Brayan, W.L., and Harter, N. : 'Studies on the Telegraphic Language the Acquisition of a Hierarchy of Habits', *Psychological Review*, 6, 4, pp.345-375 (1899).
2. Woodworth, R.S. : 'The Accuracy of Voluntary Movement', *Psychological Monographs*, 3, whole no.13 (1899).
3. Espenschade, A. : 'Motor Performance in Adolescence', *Social Research in Child Development Monographs* 5, 1-33 (1940).
4. McCloy, C.H. : 'The Measurement of General Motor Capacity and General Motor Ability,' *Research Quarterly Supplement* 5, pp.46-61 (1934).
5. Schmidt, R.A. : 'Motor Skills', Harper and Row, New York (1975).
6. McGeoch, J.A. : 'The Acquisition of Skill', *Psychological Bulletin*, 24, pp.437-466 (1927).
7. McGeoch, J.A. : 'The Acquisition of Skill', *Psychological Bulletin*, 26, pp.457-498 (1929).
8. Bartlett, F.C. : 'The Measurement of Human Skill', *Occupational Psychology*, 22, pp.31-38 (1948).
9. Adams, J.A. : 'A closed-loop Theory of Motor Learning', *Journal of Motor Behaviour*, 3, 2, pp.111-149 (1971).
10. Baddeley, A.D. : 'The Psychology of Memory', Harper and Row, New York (1976).
11. Lashley, K.S. : 'The Accuracy of Movement in the Absence of Excitation from the Moving Organ', *American Journal of Physiology*, 43, pp.169-194 (1917).

12. Keele, S.W. : 'Movement Control in Skilled Motor Performance', *Psychological Bulletin*, 70, pp.387-403 (1968).

13. Keele, S.W., and Summers, J.J. : 'The Structure of Motor Programs' in 'Motor Control: Issues and Trends' Ed. Stelmach, G.E., Academic Press, New York, pp.109-142 (1976).

14. Schmidt, R.A. : 'A Schema Theory of Discrete Motor Skill Learning', *Psychological Review*, 82, 4, pp.225-360 (1975).

15. Sherrington, C.S. : 'On the Proprioceptive System, Especially in its Reflex Aspect,' *Brain*, 29, pp.467-482 (1906).

16. Broadbent, D.E. : 'Perception and Communication', Pergamon, London (1958).

17. Brown, J. : 'Some tests of the Decay Theory of Immediate Memory', *Quarterly Journal of Experimental Psychology*, 10, pp.12-21 (1958).

18. Peterson, L.R., and Peterson, M.J. : 'Short-term Retention of Individual Verbal Items,' *Journal of Experimental Psychology*, 58, pp.193-198 (1959).

19. Neumann, E. and Ammons, R.B. : 'Acquisition and Long-term Retention of a Simple Serial Perceptual Motor Task', *Journal of Experimental Psychology*, 53, pp.159-161 (1957).

20. Ammons, R.B., Farr, R.G., Bolch, E., Dey, M., Marion, R., and Ammons, C.H. : Long-term Retention of Perceptual-Motor Skills,' *Journal of Experimental Psychology*, 55, pp.318-328 (1958).

21. Adams, J.A., and Dijkstra, S. : 'Short-term Memory For Motor Responses', *Journal of Experimental Psychology*, 71, 2, pp.314-318 (1966).

22. Posner, M.I., and Konick, A.F. : 'Short-term Retention of Visual and Kinesthetic Information', *Journal of Organizational Behaviour and Human Performance*, 1, pp. 71-88 (1966).

23. Posner, M.I. : 'Characteristics of Visual and Kinesthetic Memory Codes,' *Journal of Experimental Psychology*, 75, pp.103-107 (1967).
24. Scripture, E.W. : 'The New Psychology', Scott, London (1905).
25. Stelmach, G.E. : 'Prior Positioning Responses as a Factor in Short-term Retention of a Simple Motor Task', *Journal of Experimental Psychology*, 81, 3, pp.523-526 (1969).
26. Stelmach, G.E. : 'Short-term Motor Retention as a function of Response Similarity', *Journal of Motor Behaviour*, 1, pp.37-44, (1969).
27. Mountcastle, V.B., and Powell, T.P.S. : 'Central Nervous Mechanisms Subservicing Position Sense and Kinesthesia', *Johns Hopkins Hospital Bulletin*, 180, pp.175-200 (1959).
28. Skoglund, S. : 'Anatomical and Physiological Studies of Knee Joint Innervation in the Cat', *Acta Psychologica Scandinavica Supplementum*, 124 (1956).
29. Mountcastle, V.B., Poggio, C.F., and Werner, G. : 'The Relation of Thalamic Cell Response to Peripheral Stimuli Varied over an Intensive Continuum', *Journal of Experimental Psychology*, 75, pp.103-107 (1963).
30. Keele, S.W., and Ells, J.G. : 'Memory Characteristics of Kinesthetic Information', *Journal of Motor Behaviour*, 4, pp.127-136, (1972).
31. Marteniuk, R.G., Shields, K.W., and Campbell, S. : 'Amplitude, Position, Timing and Velocity as Cues in Reproduction of Movement', *Perceptual and Motor Skills*, 35, pp.51-58 (1972).
32. Marteniuk, R.G., and Roy, E.A. : 'The Codability of Kinesthetic Location and Distance Information', *Acta Psychologica*, 36, pp.471-479 (1972).

33. Laabs, G.J. : 'Retention Characteristics of Different Reproduction Cues in Motor Short-term Memory', *Journal of Experimental Psychology*, 100, 1, pp.168-177 (1973).
34. Hermelin, B., and O'Connor, N. : 'Location and Distance Estimation By Blind and Sighted Children', *Quarterly Journal of Experimental Psychology*, 27, pp.295-301 (1975).
35. Roy, E.A. : 'Spatial Cues in Memory for Movement', *Journal of Motor Behaviour*, 9, 2, pp.151-156 (1977).
36. Roy, E.A. : 'Role of Preselection in Memory for Movement Extent', *Journal of Experimental Psychology*, 4, 4, pp. 397-405 (1978).
37. Stelmach, G.E., and McCracken, H.D. : 'Storage Codes for Movement Information', in 'Attention and Performance', Ed. Requin, J., Vol.VII, Lawrence Erlbaum, New York (1978).
38. Jones, B. : 'Outflow and Inflow in Movement Duplication', *Perception and Psychophysics*, 12, pp.95-96 (1972).
39. Jones, B. : 'The Role of Central Monitoring of Efference in Motor Short-term Memory', *Journal of Experimental Psychology*, 102, pp.37-43 (1974).
40. Marteniuk, R.G. : 'Retention Characteristics of Motor Short-term Memory Cues', *Journal of Motor Behaviour*, 5, pp.249-259 (1973).
41. Stelmach, G.E., Kelso, J.A.S. and Wallace, S.A. : 'Preselection in Motor Short-term Memory', *Journal of Experimental Psychology: Human Learning and Memory*, 1, 6, pp.745-755 (1975).
42. Kelso, J.A.S., and Frekany, G.A. : 'Coding Processes in Preselected and Constrained Movements: Effect of Vision', *Acta Psychologica*, 42, pp.145-161 (1978).

- 214  
514
43. Stelmach, G.E., Kelso, J.A.S., and McCullagh, P.D. : 'Preselection and Response Biasing in Short-term Motor Memory,' *Memory and Cognition*, 4, 1, pp.62-66 (1976).
  44. Roy, E.A. and Diewert, G.L. : 'EncODing of Kinesthetic Extent Information', *Perception and Psychophysics*, 17, 6, pp.559-564 (1975).
  45. Roy, E.A., and Diewert, G.L. : 'The Coding of Movement Extent Information', *Journal of Human Movement Studies*, 4, pp.94-101 (1978).
  46. Jones, B. : 'When are Vision and Kinesthesia Comparable?', *British Journal of Psychology*, 40, pp.587-591 (1973).
  47. Kelso, J.A.S. : 'Planning and Efferent Components in the Coding of Movement', *Journal of Motor Behaviour*, 9, 1, pp. 33-47 (1977).
  48. Roy, E.A., Magee, L., Kennedy, J. and Diewert, G.L. : 'Active Movement and Memory in the Receptor and Effector Functions of the Hand' in 'Psychology of Motor Behaviour and Sport', Eds. Landers, D.M. and Christina, R.W., Human Kinetics Publishers, Illinois (1978).
  49. Stelmach, G.E. : 'The Accuracy of Reproducing target Positions under various Tensions', *Psychonomic Science*, 13, 6, pp.287-288 (1968).
  50. Adams, J.A., Marshall, P.H., and Goetz, E.T. : 'Response Feedback and Short-term Motor Retention', *Journal of Experimental Psychology*, 92, 1, pp.92-95 (1972).
  51. Adams, J.A., Goetz, E.T., and Marshall, P.H. : 'Response Feedback and Motor Learning', *Journal of Experimental Psychology*, 92, 3, pp.391-397 (1972).
  52. Adams, J.A., Gopher, D., and Lintern, G. : 'Effects of Visual and Proprioceptive Feedback', *Journal of Motor Behaviour*, 9, 1, pp.11-22 (1977).

53. Diewert, G.L. : 'The Role of Vision and Kinesthesia in Coding of Two Dimensional Movement Information', *Journal of Human Movement Studies*, 3, pp.191-198 (1976).

54. Stelmach, G.E. : 'Feedback: A Determiner of Forgetting in Short-term Motor Memory,' *Acta Psychologica*, 37, pp.333-339 (1973).

55. Roy, E.A., and Marteniuk, R.G. : 'Mechanisms of Control in Motor Performance: Closed-loop versus Motor Programming Control', *Journal of Experimental Psychology*, 103, 5, pp.985-991 (1974).

56. Kelso, J.A.S. : 'Motor Control Mechanisms Underlying Human Movement Reproduction', *Journal of Experimental Psychology: Human Perception and Performance*, 3, pp.529-543 (1977).

57. Posner, M.I., Nissen, M.J., and Klein, R.M. : 'Visual Dominance: An Information Processing Account of its Origins and Significance', *Psychological Review*, 83, pp.157-171 (1976).

58. Roy, E.A., and Williams, I.D. : 'Memory for Location and Extent: The Influence of Reduction of Joint Feedback Information', in 'Psychology of Motor Behaviour and Sport', Eds. Roberts, G.C. and Newell, K.M., Human Kinetics Publishers, Champaign, Illinois, pp.229-240 (1979).

59. Posner, M.I., and Keele, S.W. : 'Attention Demand of Movements' in 'Proceedings of the XVith International Congress of Applied Psychology', Swets and Zeittinger, Amsterdam, pp.418-422 (1969).

60. Klapp, S.T. : 'Feedback versus Motor Programming in the Control of Aimed Movements', *Journal of Experimental Psychology: Human Perception and Performance*, 104, pp.147-153 (1975).

61. Hollingworth, H.L. : 'The Inaccuracy of Movement', *Archives of Psychology*, 2, pp.1-87 (1909).

62. Elson, D.G. and Wheeler, L. : 'The Range Effect', Technical Report 4, Wright Patterson Air Force Base, U.S. Air Force Material Command, Dayton, Ohio (1947).
63. Peeper, R.L., and Herman, L.M. : 'Decay and Interference Effects in Short-term Retention of a Discrete Motor Act,' Journal of Experimental Psychology Monograph, 83, 2, Pt.2 (1970).
64. Stelmach, G.E. : 'Retention of Motor Skills' in 'Exercise and Sports Sciences Review' Ed. Wilmore, J.R., Academic Press, New York (1974).
65. Laabs, G.J. : 'Motor Learning in Absence of Extrinsic Feedback', Paper Presented at WPA, Los Angeles (1976).
66. Shea, J.B. : 'Effects of Labelling on Motor Short-term Memory', Journal of Experimental Psychology: Human Learning and Memory, 3, 1, pp.92-99 (1977).
67. Wallace, S.A. : 'The Coding of Location: A Test of Target Hypothesis', Journal of Motor Behaviour, 9, pp. 157-159 (1977).
68. Connolly, K. and Jones, B. : 'A Developmental Study of Afferent-Reafferent Integration', British Journal of Psychology, 61, pp.259-266 (1970).
69. Jones, B., and Connolly, K. : 'Memory Effects is Cross-modal Matching', British Journal of Psychology, 61, pp.283-287 (1970).
70. Pick, H.L. : 'Systems of Perceptual and Perceptual Motor Development', in 'Minnesota Symposia on Child Psychology', Ed. Hill, J.P., Vol.4, University of Minnesota Press, Minneapolis (1970).
71. Goodnow, J.J. : 'The Role of Modalities in Perceptual and Cognitive Development', in 'Minnesota Symposium of Child Development', Ed. Hill, J.P., Vol.5, University of Minnesota Press, Minneapolis (1971).

72. Millar, S. : 'The Development of Visual and Kinesthetic Judgement of Distance', *British Journal of Psychology*, 63, pp.271-282 (1972).

73. Friedes, D. : 'Human Information Processing and Sensory Modality: Cross-modal Functions, Information Complexity. Memory and Deficit,' *Psychological Bulletin*, 81, pp.284-310 (1974).

74. Friedes, D. : 'Information Complexity and Cross-modal Functions', *British Journal of Psychology*, 66, pp.267-270 (1975).

75. Newell, K.M., and Shapiro, A.C. : 'Knowing Which Modality to Reproduce in the Matching of Visual and Kinesthetic Information', Paper presented at the 7th Psychomotor Learning and Sport Psychology Symposium, Quebec City (1975).

76. Diewert, G.L., and Stelmach, G.E. : 'Intramodal and Intermodal Transfer of Movement Information', *Acta Psychologica*, 41, pp.119-128 (1977).

77. Marteniuk, R.G., and Rodney, M. : 'Modality and Retention Effects in Intra and Cross Modal Judgement of Kinesthetic and Visual Information', *British Journal of Psychology*, 70, 3, pp.405-412 (1979).

78. Newell, K.M., Shapiro, A.C., and Carlton, M.J. : 'Cordinating Visual and Kinesthetic Memory Codes', *British Journal of Psychology*, 70, 1, pp.87-96 (1979).

79. Marshall, P.H. : 'Recognition and Recall in Short-term Motor Memory,' *Journal of Experimental Psychology*, 95, 1, pp. 147-153 (1972).

80. Kantowitz, B.H. : 'Modality Effects in Recognition Short-term Motor Memory', *Journal of Experimental Psychology*, 103, 3, pp.522-529 (1974).

81. Laabs, G.J. : 'Short-term Recognition Memory for Movement Distance and End-location', Paper Presented at M.P.A., Chicago (1975).

82. Laabs, G.J. : 'Recognition and Recall of Motor Movements', Paper presented at APA, Toronto (1978).

83. Faust-Adams, A.S. : 'Interference in Short-term Retention of Discrete Movements', *Journal of Experimental Psychology*, 96, pp. 400-406 (1972).

84. Duffy, T.M., Montague, W.E., Laabs, G.J., and Hillix, W.A. : 'The Effect of Overt Rehearsal on Motor Short-term Memory', *Journal of Motor Behaviour*, 7, 1, pp.59-63, (1975).

85. Hangman, J.D. : 'Specific Cue Effects of Interpolated Movements on Distance and Location Retention in Short-term Motor Memory', *Memory and Cognition*, 6, pp.432-437 (1978).

86. Miller, G.E., and Pilzecker, A. : 'Experimentelle Beiträge zur Lehre vom Gedächtnis', *Zeitschrift für Psychologie, Supplement*, no.1 (1900).

87. Webb, L.W. : 'Transfer of Training and Retroaction: A comparative study', *Psychological Monographs*, 24, Whole No. 104 (1917).

88. Schmidt, R.A., and Ascoli, K.M. : 'Attention Demand During Storage of Traces in Motor Short-term Memory', *Acta Psychologica*, 34, 4, pp.497-504 (1970).

89. Stelmach, G.E. : 'Kinesthetic Recall and Information Reduction Activity', *Journal of Motor Behaviour*, 2, pp.183-194 (1970).

90. Williams, H.L., Beaver, W.S., Spence, M.T., and Rundell, O.H. : 'Digital and Kinesthetic Memory with Interpolated Information Processing', *Journal of Experimental Psychology*, 80, 3, pp. 530-536 (1969).

91. Roy, E.A., and Kelso, J.A.S. : 'Movement Cues in Motor Memory: Precuing versus Postcuing', *Journal of Human Movement Studies*, 3, pp. 232-239 (1977).

92. Ascoli, K.M., and Schmidt, R.A. : 'Proactive Interference in Short-term Motor Retention', *Journal of Motor Behaviour*, 1, pp.29-36 (1969).

- 93. Williams, I.D. : 'The Effect of Practice and Prior Learning in Motor Memory', *Journal of Motor Behaviour*, 3, pp. 205-212 (1971).
- 94. Montague, W.E., and Hillix, W.A. : 'Intertrial Interval and Proactive Interference in Short-term Motor Memory', *Canadian Journal of Psychology*, 22, 2, pp. 73-78 (1968).
- 95. Schmidt, R.A., and Ascoli, K.M. : 'Intertrial Intervals and Motor Short-term Memory', *Research Quarterly*, 41, 3, pp. 432-438, (1970).
- 96. Boswell, J.J., and Bilodeau, E.A. : 'Short-term Retention of a Simple Motor Task as a Function of Interpolated Activity,' *Perceptual and Motor Skills*, 18, pp.227-230 (1964).
- 97. Stelmach, G.E., and Wilson, M. : 'Kinesthetic Retention, Movement Extent and Information Processing', *Journal of Experimental Psychology*, 85, 3, pp.425-430 (1970).
- 98. Stelmach, G.E., and Barber, J.L. : 'Interpolated Activity in Short-term Motor Memory', *Perceptual and Motor Skills*, 30, pp.231-234 (1970).
- 99. Herman, L.M., and Bailey, D.R. : 'Comparative Effects of Retroactive and Proactive Interference in Motor Short-term Memory', *Journal of Experimental Psychology*, 86, pp. 407-415 (1970).
- 100. Patric, J. : 'The Effect of Interpolated Motor Activities in Short-term Motor Memory', *Journal of Motor Behaviour*, 3, pp.39-48 (1971).
- 101. Craft, J.L., and Hinrichs, J.V. : 'Short-term retention of simple Motor Responses: Similarity and Prior and Succeeding Response', *Journal of Experimental and Psychology*, 87, pp.297-302 (1971).
- 102. Roy, E.A., and Davenport, W.G. : 'Factors in Motor Short-term Memory: The Interference Effect of Interpolated Activity', *Journal of Experimental Psychology*, 96, 1, pp.134-137 (1972).

103. Trumbo, D., Milone, F., and Noble, M. : 'Interpolated Activity and Response Mechanisms in Motor Short-term Memory', *Journal of Experimental Psychology*, 93, pp.205-212 (1972).

104. Kahneman, D. : 'Attention and Effort', Prentice-Hall, Englewood Cliffs, New Jersey, (1973).

105. Kerr, B. : 'Processing Demands During Mental Operations'. *Memory and Cognition*, 1, pp.401-412 (1973).

106. Laabs, G.J. : 'The Effect of Interpolated Motor Activity on the Short-term Retention of Movement Distance and End-location', *Journal of Motor Behaviour*, 6, 4, pp.279-288 (1974).

107. Diewert, G.L. : 'Retention and Coding in Motor Short-term Memory: A Comparison of Storage Codes for Distance and Location Information', *Journal of Motor Behaviour*, 7, 3, pp.183-190 (1975).

108. Laabs, G.J. : 'A Note Concerning the Effect of a Kinesthetic Memory Load on the Retention of Movement End-location', *Journal of Motor Behaviour*, 8, 4, pp. 313-316 (1976).

109. Laabs, G.J. : 'The Effect of Cue Designation and Size on Movement Reproduction', Paper presented at W.P.A., Seattle (1977).

110. Stelmach, G.E., and Walsh, M.F. : 'Response Biasing as a Function of duration and extent of positioning Act', *Journal of Experimental Psychology*, 92, 3, pp.354-359 (1972).

111. Stelmach, G.E., and Walsh, M.F. : 'The Temporal Placement of Interpolated Movement in Short-term Motor Memory', *Journal of Motor Behaviour*, 5, pp.165-173 (1973).

112. Scott, R.A. : 'The Socialization of Blind Children' in 'Handbook of Socialization Theory and Research', Ed. Goslin, D.A., Rand McNally and Company, Chicago, pp.1025-1045 (1969).

113. Lowenfeld, B. : 'Psychological Foundation of Special Methods in Teaching Blind Children', in 'Blindness' Ed. Zahl, P.A. Princeton University Press, Princeton, New Jersey, pp. 89-108 (1950).

114. Berkeley, G. : 'An Essay Toward a New Theory of Vision', in 'The Work of ...', Eds. Luce, A.A., and Jessop, T.E., Vol.1, Thomas Nelson, London (1948).

115. Goldstein, K., and Gelb, A. : 'Psychologische Analysen hirnpathologischer Fälle auf Grund von Untersuchungen Hirnverletzter. II Über den Einfluss des vollständigen Verlustes des optischen Vorstellungsvermögens auf das taktile Erkennen', Z.Psychol.Physiol.Sinnesorgane, I Abt, 83, pp.1-94 (1920).

116. Revesz, G. : 'The Psychology and Art of the Blind', (Wolff, H.A. Trans.), Longmans, Green, New York (1950).

117. Jones, B. : 'Spatial Perception in the Blind', British Journal of Psychology, 66, 4, pp. 461-472 (1975).

118. Axelrod, S. : 'Effects of Early Blindness: Performance of Blind and Sighted Children on Tactile and Auditory Task,' American Foundation for The Blind, 15 West 16th Street, New York 11 (1959).

119. Brown, M.S., and Stratton, G.M. : 'The Spatial Threshold of Touch in Blind and Seeing Children', Journal of Experimental Psychology', 8, pp.434-442 (1925).

120. Drever, J. : 'Early Learning and Perception of Space', American Journal of Psychology, 68, pp. 605-614 (1955).

121. O'Connor, N., and Hermelin, B. : 'Seeing and Hearing and Space and Time', Academic Press, New York (1978).

122. Senden, M. von : 'Raum und Gestalt Auffassung bei operierten Blindgeborenen vor und nach der Operation', Barth, Leipzig (1932).

123. Gregory, R.L. : 'Eye and Brain, the Psychology of Seeing', Widenfeld and Nicholson, World University Library, London (1966).

124. Worchel, P. : 'Space Perception and Orientation in the Blind', Psychological Monographs, 65, whole No.332, (1951).

125. White, B.L., Castle, P., and Held, R. : 'Observations on the Development of Visually directed reading', Child Development, 35, pp.349-364 (1964).

126. Gomulicki, B.R. : The Development of Perception and Learning in Blind Children', Psychological Laboratory, Cambridge University (1961).

127. Fraiberg, S. : 'Parallel and Divergent Patterns in Blind and Sighted infants,' Psychological Study of the Child, 23, 264-300 (1968).

128. Shagan, J. : 'Kinesthetic Memory Comparing Blind and Sighted subjects', Unpublished Dissertation, George Washington University (1970).

129. Jones, B. : 'The Development of Cutaneous and Kinesthetic Localization in Blind and Sighted Children', Developmental Psychology, 6, pp.349-352 (1972).

130. Kool, V.K. : 'Short-term Recall of Linear and Curvilinear Movements by Blind and Sighted Subjects', in 'Attention and Performance', Ed. Nickerson, R.S., Vol.8, Lawrence Earlbaum Associates, N.J., U.S.A., pp.541-553 (1980).

131. Clark, F.J., and Burgess, P.R. : 'Slowly Adapting Receptors in Cat Knee Joint: Can They Signal Joint Angle?', Journal of Neurophysiology, 38, pp.1448-1463 (1975).

132. Bizzi, E., Polit, A., and Morasso, P. : 'Mechanisms Underlying Achievement of Final Head Position', Journal of Neurophysiology, 39, pp.435-444 (1976).

133. Salmoni, A.W., and Sullivan, S.J. : 'The Intersensory Integration of Vision and Kinesthesia for Distance and Location Cues,' Journal of Human Movement Studies, 2, pp.225-232 (1976).

134. Laabs, G.J. : 'Comments on "Retention Characteristics of Motor Short-term Memory Cues",' Journal of Motor Behaviour, 7, 2, pp. 147-149 (1975).

135. Schutz, R.W., and Roy, E.A. : 'Absolute Error: The Devil in Disguise', Journal of Motor Behaviour, 5, pp.141-153 (1973).

136. Stelmach, G.E., and Kelso, J.A.S. : 'Memory Processes in Motor Control', Paper Presented at Attention and Performance Symposium VI, Stockholm, Sweden (1975).

137. Marteniuk, R.G. : 'Further Considerations of "Retention Characteristics of Motor Short-term Memory Cues": A Reply to Laabs', Journal of Motor Behaviour, 7, 2, pp. 151-152 (1975).

138. Marteniuk, R.G. : 'Motor short-term Memory Measures as a Function of Methodology', Journal of Motor Behaviour, 9, 3, pp. 247-250 (1977).

139. Bilodeau, E.A., Sulzer, J.L., and Levy, C.M. : 'Theory and Data on the Interrelationship of three Factor of Memory', Psychological Monograph, 76, 20 whole no. 539 (1962).

140. Sulzer, J.L. : 'Manual Lever D: A Basic Psychomotor Apparatus for the Study of Feedbacks', Perceptual Motor Skills, 16, pp.859-862(1962).

141. Kirk, R.E. : 'Experimental Design: Procedures for the Behavioural Sciences,' Brooks/Cole Publishing Company, Belmont, California (1969).

142. Kool, V.K., Singh, S.J., and Pathak, K.C. : 'Response Biasing in Blind and Sighted Subjects', Paper presented to Centenary Celebration: 100 Years of Experimental Psychology held at Department of Psychology, Calcutta University, Calcutta (1979).

### ACKNOWLEDGEMENTS

Dr. V. K. Kool, my Research Supervisor, deserves my deepest sense of gratitude for functioning simultaneously as a thought provoking wise mentor, an exacting taskmaster and a sympathetic well-wisher for me. It is he whose stimulating thought and guidance inspired me to select motor memory of visually handicapped as an issue for my research. Without his generous permission to register for my Ph.D. degree while I am serving as a Research Fellow in his project sponsored by the Department of Social Welfare, Govt. of India, it would have been virtually impossible to conduct this research work.

I thankfully acknowledge the fruitful suggestions provided by Dr. O. B. Sayeed of my own department, and Prof. M.N. Vartak of the Department of Mathematics for the statistical analysis of data. I also thank Mr. Warrior, Mr. Singh, Mr. Advani and Mr. Satyamurthy who helped in computerizing my data.

The blind and sighted subjects deserve special appreciation for their patience and sense of contribution to knowledge. I am also grateful to the Heads and other staff members of the institutions for the blind and the sighted subjects and also to my friends through whom I approached the aforesaid, for their vital cooperation in procuring subjects for my study.

It is pleasant to acknowledge the help offered by my colleagues Miss M. Rana, Mr. K.C. Pathak, Miss Raj K. Bansal, Mr. R. Krishnan in crucial times.

My thanks are also due to Mr. Kunju, Mr. S.K. Pawar and Mr. Kalambate for their sincere and hard work in preparing the typescript, cyclostyling, and tracing figures.

IIT-BOMBAY

SHYAM JI SINGH

JULY 1980

## S U M M A R Y

The present research work consists of 3 experiments which aim at comparing sighted and congenitally blind subjects for their retention of discrete graded movements recalled at short delays. The major objective of this comparison is to throw light on the role of visual system in coding and retention of various motor informations.

A given simple movement provides two basic informations concerning change in the position of the limb or the body, i.e. location and distance. Location refers to the exact end position of the movement, while distance signifies the total extent of movement between the starting point and the criterion target. In an isolated location task, a subject is required to reproduce the exact end position of the movement from a point other than the original starting point used for learning the movement. On the other hand, in an isolated distance task the subject is required to reproduce the total extent of the movement from a point other than the original starting point used for learning the movement. Thus, in the isolated location condition a distance cue is held unreliable, while in the isolated distance condition a location cue is held unreliable. These movements have also been categorized otherwise as subject defined (preselected) or experimenter defined (constrained). In the preselected condition the

target is chosen by the subjects and in this case they get information about termination of their movement prior to its initiation. Constrained movements are exploratory in nature and the target is determined by the experimenter, i.e. a subject knows about the termination of a movement only when he meets the stop peg.

In all the three experiments a linear slide was employed to gauge the reproduction errors of the subjects for their horizontal hand movements. The reproduction errors were measured in terms of (a) absolute error, i.e. the mean of unsigned mismatches, (b) variable error, i.e. the standard deviation of algebraic mismatches, and (c) constant error, i.e. the mean of algebraic mismatches. A mismatch refers to the difference between the criterion and reproduction responses recorded in centimeters.

Experiment I deals with short-term recall of location and distance targets which were either preselected or constrained. A 5-way factorial design (2 x 2 x 2 x 2 x 2) was employed to examine the effects of groups (sighted or blind), informations (location or distance), preselection (preselected or constrained), targets (short-5-10 cm or long-20-25 cm), and retention intervals (5 or 90 sec). In each of these 32 conditions 5 new subjects were assigned who received 5 trials of the same experimental condition. In all 80 blindfolded sighted and 80 congenitally blind male adults participated in this experiment.

22

In Experiment II the effect of prior motor activities involving location has been studied on short-term recall of location and distance targets. A 5-way within subjects experimental design ( $2 \times 2 \times 3 \times 3 \times 3$ ) consisting of groups (sighted or blind), informations (location or distance), retention intervals (5, 10 or 50 sec), targets (10, 20 or 30 cm), and prior activities (0, 2 or 4) was employed. In this design first two factors were manipulated between groups, i.e. 7 new subjects were assigned to blind-location, blind-distance, sighted-location and sighted-distance subgroups. The other three factors made 27 experimental conditions. Four trials of each of these conditions were given to each of the subjects. Thus, the sample of this experiment consisted of 14 blindfolded sighted and 14 congenitally blind male adults.

Experiment III was conducted to explore the response biasing effect in recall of preselected and constrained movements in which informations were not isolated. The effects of groups (sighted or blind), preselection (preselected or constrained), biasing conditions (control, backward or forward) and targets (short-5-25cm or long-25-45 cm) were studied in a 4-way within subjects design ( $2 \times 2 \times 3 \times 2$ ). The first two variables were manipulated between groups which led to formation of 4 independent subgroups, i.e. sighted-preselected, sighted-constrained, blind-preselected and

blind-constrained. To each of these 4 subgroups 15 new subjects were assigned. Thus, in all 30 blindfolded sighted and 30 congenitally blind male subjects were included in the sample. The other two variables were manipulated within subjects. There were 6 within subjects treatments and each subject was tested 5 times on each of the within subjects treatments.

The results of these experiments throw light on a few sensitive issues related to short-term recall of movements. These findings also attempt to compare recall of movements of sighted and blind subjects and highlight the distinct role of visual reference system in the coding of various movement informations and cues. Some interesting results of the present research work are summarized below.

Results of Experiments I and II suggest that location information can be coded kinesthetically by both blind and sighted subjects. On the contrary, sighted subjects seem to have coded distance information in terms of nonmotor visual reference, while blind subjects showed inability to do so due to their handicap. These results suggest that location and distance informations follow different coding processes. Coding of location can be explained by motor organization theory of Jones<sup>117</sup> which suggests integration of various sensory modalities in spatial perception and refutes necessity and primacy of vision. His visual map theory offers a better

4

24

explanation for the coding of distance. Visual map theory emphasizes the necessity and primacy of visual reference for the coding and acquisition of distance.

The blind subjects showed advantage of preselection in the coding of location information but not in coding of distance, while sighted subjects showed advantage of preselection in coding of both location and distance informations. It suggests that prior information about the termination of a movement enables coding of distance into a nonmotor visual store. This prior information may facilitate the coding of limb position or location in kinesthetic terms because the subjects can anticipate the sensory consequences of his action.

Both blind and sighted subjects showed proactive inhibition effect in recall of location information. In reproduction of distance, proactive inhibition is evident in blind but not in sighted subjects. These results suggest that prior motor activities involving location cue interfered structurally in the recall of location targets of the sighted subjects. In recalling a distance target, which does not seem to involve kinesthetic modality, proactive interference is absent. The blind subjects showed interference in recall of both location and distance informations.

Results on response biasing obtained in Experiment III indicate that sighted subjects showed biasing in recall of

284

constrained movements but not in recall of preselected movements, while blind subjects show biasing in recall of both constrained and preselected movements. These results suggest that sighted subjects were not affected by biasing effect because of their precise coding in case of preselected movements.

By and large, the findings obtained in the 3 experiments present a coherent picture of the role of visual reference system in processing of various movement informations and other crucial variables related to short term recall but these results should be evaluated in terms of variations in the experimental conditions involved in these experiments.

The significance of the present research work can be understood only in the light of its limitations. A basic limitation arises out of limited number of congenitally blind subjects available for the study. A very small percentage of blind population is congenital in nature which forced the investigator to move to several places to collect the data. Another limitation related to the sample is that only male subjects were available for the study because there are very few educational and training centres for the female blinds in India. It becomes very difficult in terms of both cost and effort to have a large sample.

The most severe limitation faced while conducting this work was nonavailability of journals and books in this area of research in India. For even a very small requirement the researcher had to depend on research workers abroad who very generously helped with reprints and books. The findings of the present research work can be extended and made more meaningful and thorough if response latency, movement time and EMG recordings were also studied to compare the performance of blind and sighted subjects. However, this was not possible in the absence of sophisticated instruments. It is hoped that future research in this area will concentrate on the analysis of such variables.

fffff  
fff  
f