

Table of Contents

From Theoretical Background to Practical Implications.....	11
1 Introduction	12
2 The Contextual Interference Effect	17
2.1 Potential moderating variables	19
2.1.1 Task (dis)similarity.....	20
2.1.2 Task complexity.....	21
2.1.3 Interaction of task similarity and task complexity.....	24
2.2 A couple of attempted explanations.....	28
2.3 Analyzing the neural basis by means of fMRI and TMS	32
3 The Differential Teaching and Learning Approach	38
3.1 Synergetics and coordination dynamics.....	39
3.1.1 Synergetic principles derived from inanimate nature	41
3.1.2 Non-linear dynamics of rhythmic uni- and bimanual coordination	44
3.1.2.1 Modeling coordination dynamics: the classic HKB model and its progression	47
3.1.2.2 Central neural correlates of relative phase dynamics	53
3.1.3 Phase transitions on short time scale: beyond standard finger coordination.....	61
3.1.3.1 Further control parameters and coordination constraints	61
3.1.3.2 From rhythmic interlimb through to discrete gross-motor coordination.....	63
3.1.3.3 Interpersonal coordination	66
3.1.3.4 On some further coordination domains of human nature	70
3.1.4 Phase transitions on medium time scale: motor and perceptual learning	73
3.1.4.1 Motor learning in the framework of coordination dynamics	74
3.1.4.2 The influence of initial coordination dynamics on learning and memory	75
3.1.4.3 Findings on gross-motor learning of continuous and discrete sport-related skills.....	81
3.1.4.4 Neural indices of learning-induced changes in coordination dynamics	83
3.1.4.5 Individual routes of learning-induced changes in perceptual dynamics.....	85
3.1.5 Phase transitions on long time scale: developmental psychology and psychotherapy.....	85
3.1.5.1 Anomalous variability as a harbinger of abrupt changes in child development ...	85
3.1.5.2 Detecting and using periods of anomalous variability in psychotherapy.....	90
3.2 Stochastic resonance	94
3.2.1 Generic theoretical models and characterization quantities	101

3.2.2 Noise and its degree of (non-)determinism.....	105
3.2.2.1 Variability amplitude versus randomness using the example of postural control	108
3.2.2.2 The different colors of noise.....	109
3.2.2.3 1/f noise.....	116
3.2.3 Stochastic resonance and its origins in physics	125
3.2.4 The benefits of noise in biological functioning: simulations and experiments from ion channels to behavior	126
3.2.4.1 Optimal noise can improve neural processing	127
3.2.4.2 Optimal noise can improve sensory and perceptual processing.....	130
3.2.4.3 Optimal noise can improve behavioral processing in animals and humans.....	140
3.2.5 Stochastic resonance and the link to (differential) motor learning.....	148
3.3 Biological and computational neuroscience	152
3.3.1 Extracting rules out of experiences: the ability to generalize	152
3.3.2 Neural plasticity as the natural base for the generalization ability.....	156
3.3.2.1 The synaptic plasticity hypothesis	158
3.3.2.2 Synaptic changes: different mechanism on different time scales	162
3.3.2.3 Principles of plasticity or biological learning rules	169
3.3.3 Artificial neural networks: mathematical models of nature	174
3.3.3.1 Fundamental components and principles.....	175
3.3.3.2 Basis network architectures.....	177
3.3.3.3 Basic learning rules	180
3.3.3.4 Topographic mapping of common features.....	186
3.3.4 Associative memory, self-organization and generalization quality	205
3.3.4.1 Distributed memory storage.....	205
3.3.4.2 Self-organization: learning by examples	208
3.3.4.3 Validating generalization and some general factors of influence	211
3.3.5 Motor learning as the extraction of appropriate sensorimotor rules.....	213
3.3.5.1 The need for rule extraction even in closed conditions.....	213
3.3.5.2 Learning to utilize non-muscular forces	215
3.3.5.3 The whole may be different from the sum of its parts	218
3.3.5.4 The change of structuredness of execution variability during learning.....	219
3.3.6 Implicit generalization: an essential ability and ubiquitous phenomenon	224
3.3.6.1 Physical world comprehension.....	225
3.3.6.2 First language acquisition.....	227
3.3.6.3 Finite-state artificial grammars	232
3.3.6.4 Perceptual illusions.....	238
3.3.6.5 Superstition: extracting rules even if there are none	242
3.3.6.6 Logical reasoning even by relatively simple animals	243
3.3.6.7 Detecting abstract-rule-encoding neurons in monkeys.....	245

3.3.7	Interpolation is better than extrapolation	247
3.3.7.1	Concerning artificial neural networks.....	247
3.3.7.2	Concerning humans and animals	250
3.3.8	Meta-plasticity: changing the learning rate over time	259
3.3.8.1	The change of plasticity in natural learning.....	262
3.3.8.2	Meta-plasticity as a function of the learning process itself.....	263
3.3.9	A “perfect” memory: is it really desirable?.....	265
3.3.9.1	The problem of over- and underfitting in computational networks	266
3.3.9.2	When memorizing idiosyncratic details becomes patho-logical.....	271
3.3.9.3	Implications for (motor) learning	278
3.3.10	Random noise and its beneficial effects on neural network performance	279
3.3.10.1	Adding random noise to computational networks	279
3.3.10.2	From computational to biological networks.....	300
3.3.10.3	Simulated annealing	307
3.3.11	Simulating contextual interference by computational networks.....	348
3.3.11.1	Evaluating acquisition and retention.....	349
3.3.11.2	Evaluating generalization and relearning	351
3.3.11.3	Beyond the simple multi-layer perceptron.....	355
3.3.11.4	A brief résumé	359
4	Summary and Discussion	361
4.1	The seeming paradox of reducing noise by noise	363
4.2	The time-dependent structure of movement time series and the coupling between effectors.....	369
4.3	The predictive brain notion: forming a (causal) model of the world	377
4.4	The improvement of neural networks by random perturbations	397
4.5	The improvement of neural networks by structured variability	412
4.6	The contextual interference effect	430
4.7	The differential learning approach	447
Empirical Study	468	
5	Statement of the Problem	469
6	Methods	475
6.1	Overall study design	475
6.2	Subjects	475
6.3	Intervention program.....	477

6.4	Test design and data collection	492
6.5	Statistical analysis.....	493
7	Results	495
7.1	Target shooting	495
7.2	Slalom dribbling.....	497
7.3	Target shooting – slalom dribbling relationship	499
8	Discussion and Conclusion	501
	Bibliography.....	511
	Appendix A: questionnaire	598