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COGNITIVE STRATEGIES, PERCEPTION OF EFFORT AND HEART RATE IN ENDURANCE CYCLISTS

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ABSTRACT

The purpose of this study was two-fold: To develop a cycling-specific cognitive classification system, and to investigate the differential and interactive effects of effort and competitive status, on associative strategy use in cyclists. Subjects consisted of eight elite, eight average and eight recreational cyclists. A light-weight micro-cassette recorder was used to document the subjects' verbalised thoughts while training. Effort was measured by the rate of perceived exertion (RPE) at the completion of each ride, and through the recording of heart rate every 60 seconds. A cycling-specific sub-category of thought "equipment monitoring" was created, which had not previously been required in similar research on marathon runners. Statistical analyses showed no support for the notion that cognitive strategy use varies according to competitive status. Neither did they show support for the notion that it varies according to effort. The statistically non-significant findings are discussed in the light of the stochastic nature of cycling, and recommendations are made to cater for this in future research.

Keywords: Cognitive strategies; Perception of effort; Heart rate; Endurance cyclists; Association and disassociation; Thought verbalization; Attentional style.

INTRODUCTION

Endurance sports such as long-distance running, cycling and swimming are physically and psychologically very demanding. The study of cognitive approaches used by athletes to cope with the pain and boredom of ongoing training could help develop more individualised cognitive training programmes to maximise athletes' performance levels.

Schomer (1986) used a tape-recorder to record the verbalised thought processes of novices, average and superior marathon runners during their training runs in order to investigate the cognitive strategies utilised. The content analysis of the transcribed tapes pointed towards ten exhaustive, mutually exclusive and independent theme categories, based on an amalgamation of Morgan and Pollock's (1977) association/dissociation framework with Nideffer's (1981) system of attentional style categorisation. The ten categories identified were (1) Feelings and affects (2) Body monitoring (3) Command and instruction (4) Pace monitoring (5) Environmental feedback (6) Reflective activity thoughts (7) Personal problem solving (8) Work, career and management (9) Corse information and (10) Talk and conversational chatter.

Schomer (1986) also found a strong direct relationship between the associative cognitive strategy and perceived cognitive strategy and perceived training intensity within and across the three categories of runners. Schomer contended that irrespective of the runner's competitive status, high training intensities could only be attained and sustained effectively and safely when runners primarily used an associative cognitive strategy. The existence of this positive linear relationship has been independently confirmed by Tammen (1996).

The majority of studies that have investigated the cognitive strategies of athletes has involved the sport of long-distance running (Schomer & Connolly, 2002). The present study was therefore designed as a replication and extension of Schomer's (1986) study in order to determine whether the cognitive strategy classification system developed for marathon runners could also be applied to the endurance sport of cycling.

A further aim of this study was to investigate the relationship between the use of associative cognitive strategies among recreational, average and elite cyclists and their perception of effort. In accordance with the findings by Schomer (1986), it was expected that no relation would be found between the use of associative thinking and competitive status, but rather that there would be a relationship between association and perceived effort.

Due to the nature of the activity of cycling, there was some concern about whether a single rate of perceived exertion for the entire ride would be an adequately accurate measure of effort. As cycling entails different levels of intensity and cyclists are able to free-wheel, especially downhill, there may be a greater range of effort within any one ride than there would be in a marathoner's training run. It was therefore decided that heart rate (HR) would be used as an additional physiological measure of effort to supplement the single rating of perceived exertion (RPE) value.

METHOD

Subjects

Subjects were chosen to fit into three distinct status categories: recreational, average and elite. Contact was made through advertisements at cycling clubs and in a cycling publication. Only male subjects were used, as no female cyclists initially responded. All subjects had completed the Argus Cycle Tour (105 km, in Cape Town, South Africa) at least once and were classified according to their fastest times recorded for this race.

1) Recreational cyclists (n = 8) had times ranging from 3h 51min - 5h 45min (mean: 4h 23min). One exception was a subject who had completed all 17 Argus Tours and had achieved a time of 2h 50min eight years previously. He now considered himself a "recreational" cyclist with a time of 4h 00min (age range: 16-57 years; mean age: 30.25 years).

2) Average cyclists (n = 8) had times between 2h 47 min and 3h 07min (age range: 19-46 years; mean age: 27.75 years).

3) Elite cyclists (n = 8) had a best time under 2h 45min and their best position ranged from 1^{st} to 190^{th} (mean time = 2h 33min, mean position: 69.25). This translates into approximately the top 0.41% of riders completing the Tour each year (age range: 20-50 years; mean age: 25 years; the 50-year old cyclist had ridden 2h 38min in the Argus three years previously).

Apparatus

Thought verbalisations for the cyclists were recorded using an Olympus Pearlcorder S901 micro-cassette recorder, weighing 240g including the batteries. The recorder was worn in a specially designed belt around the waist with the Pearlcorder ME4 electret condenser microphone attached to the front shirt.

A card with the Borg scale (Borg, 1978) was shown to the cyclists at the end of each recording to help them rate their perceived exertion (RPE) for the session. A further measure of heart rate was recorded for the cyclists using a Polar Electro OY Vantage XL heart rate monitor, preset to record heart rate every 60 seconds for the duration of the ride.

Procedure

Each cyclist underwent between two and four experimental trials during normal training rides of not more than one hour over any course of the subject's choice. Only the data from the last two trials of each subject was analysed, thus reducing the distraction initially created by the equipment and verbalisation process.

At the start of each session, the subject was given instructions as follows: "We are interested in what cyclists think about while training. Say aloud whatever comes into your mind, in sentences, phrases or words. All the tapes will be treated confidentially, so just speak your mind, be it an idea, feeling or general thought. Are there any questions before you start?"

At the end of each session the RPE was recorded before switching off the tape recorder. The additional heart rate data was manually down-loaded. The verbalisations were then transcribed. Temporal quarters of each ride were calculated from the total time elapsed on the heart rate monitor's stop-watch function, and clearly marked on the transcriptions to enable percentages of associative thoughts to be calculated per quarter, and ultimately correlated with the average heart rates for the same quarters.

The transcribed thoughts were analysed according to Schomer's (1986) cognitive strategy classification system. Where a particular thought unit (sentence/ phrase/ word) clearly did not fit into any of the established categories, this was assumed to be cycling-specific and classified as a new category. The total number of thoughts per sub-category were added and recorded. From this the number of associative thoughts were then tallied and expressed as percentages for the entire ride, as well as per quarter.

Percentages of associative thoughts were compared across the three groups of cyclists to investigate the relationship between associative strategy use and competitive status.

Percentages of association were also correlated with RPE to see whether there was a relationship between associative strategy use and effort.

Percentages of associative thought per quarter were then compared to average heart rates per quarter, in an attempt to get a more precise indication of the relationship between association and effort in cyclists.

RESULTS

After the analysis of the thought verbalisation recordings, some thoughts were clearly specific to cycling as opposed to running, and did not fit into any of the established sub-categories. All of these cycling-specific thoughts had to do with cycling equipment, e.g. "new part seems to be holding out okay", "front tyre is looking a bit flat". These thought units were classified as associative , as they were all geared towards the maintenance of the task-related activity, i.e. cycling. In terms of attentional style, they were classified as narrow/external. Hence, a new cycling-specific, associative, narrow/external sub-category of thought called "equipment monitoring" was identified.

To test whether elite cyclists display a preference for associative strategy use, a one-way analysis of variance was executed on the total percentages of associative thoughts. For each subject, the mean percentage association of the two rides was used. (See Table 1 for summary of means and standard deviations). Analysis yielded an insignificant statistical difference between the three groups of cyclists [F(2,23) = 0.01; p = 0.988]. Elite athletes hence did not show a preference for associative strategy use.

TABLE 1. **MEANS AND STANDARD DEVIATIONS OF PERCENTAGE ASSOCIATION FOR ELITE, AVERAGE AND RECREATIONAL CYCLISTS**

		Mean	Standard deviation
Elite	8	46.27	18.52
Average	8	45.81	17.37
Recreational	8	45.26	10.26

To test whether, within each subject, the level of effort measured by RPE could have determined associative strategy use, differences in percentages of association, and differences in RPE values across the two experimental trials, were calculated for each subject. The calculated differences of percentage association and RPE were then correlated for all subjects. This a non-significant correlation of 0.291 (p = 0.345). Table 2 shows percentage associative thoughts and RPE values for all subjects.

TABLE 2. **PERCENTAGE ASSOCIATIVE STRATEGY USE AND RPE VALUES FOR ALL SUBJECTS**

	% Assoc	**% Assoc**	**RPE**	**RPE**
Subject	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Elite 1	41.50	30.69	11	13
E2	48.97	79.26	10	18
E3	32.69	40.32	10	11
E4	79.02	75.24	9	13
E5	14.60	35.48	6	11
E6	54.47	60.94	13	16
E7	41.10	50.88	9	15
E8	23.58	31.58	10	11
Average 1	72.20	58.69	14	16
A2	75.89	66.03	11	17
A3	44.03	50.63	11	15
A4	17.24	39.78	11	13
A5	21.37	18.33	11	15
A6	34.38	38.37	9	13
A7	49.21	52.88	11	12
A8	36.85	57.05	11	15
Recreational 1	53.38	51.77	10	15
R2	32.26	37.06	13	14
R3	50.01	40.82	10	13
R4	62.49	55.98	9	13
R5	52.83	32.76	11	12
R6	50.64	50.67	9	13
R7	21.44	32.63	11	12
R8	51.79	44.45	11	14

Factorial analysis of variance was used to analyse the interactive effects of competitive status and effort, on associative strategy use. Average heart rate per quarter of each experimental trial was used as an indicator of effort, rather than RPE. Due to logistical problems, heart rate was however not recorded for all the experimental trials. Hence some subjects had eight average recorded heart rate measurements (from two experimental trials), some had four (from one experimental trial), and others had none. The latter were not included in this analysis. Across the three groups of subjects, a total of 24 training rides were completed using a heart rate monitor (seven by four elite cyclists, 10 by seven average cyclists, and seven by five recreational cyclists). Table 3 shows heart rate measures and percentage association for the four quarters of each experimental trial.

TABLE 3. **MEAN HEART RATE MEASURES (HR) AND PERCENTAGE ASSOCIATION (ASS) FOR THE FOUR QUARTERS OF EACH EXPERIMENTAL TRIAL (IN WHICH HEART RATE WAS RECORDED)**

Subject		1st quarter	2nd quarter	3rd quarter	4th quarter
E1	Ass	57.14	96.46	80.37	66.00
	HR	177.44	160.89	142.11	125.13
	Ass	90.38	82.61	61.70	62.50
E1	HR	164.54	178.92	174.23	167.00
E2	Ass	40.00	10.00	22.22	70.00
	HR	130.07	120.33	115.40	139.67
	Ass	45.45	41.67	36.84	77.55
E3	HR	155.64	167.50	158.20	166.20
E3	Ass	100.00	70.00	43.75	47.62
	HR	158.92	181.42	166.00	152.08
	Ass	50.00	63.64	58.33	20.00
E4	HR	123.20	159.50	155.00	143.29
E4	Ass	61.11	30.43	5.88	50.00
	HR	125.14	124.40	115.00	120.79
A1	Ass	50.50	48.86	64.20	77.14
	HR	122.92	130.27	132.33	134.79
	Ass	77.97	66.00	68.85	75.47
A1	HR	126.33	128.25	142.50	129.42
A2	Ass	68.42	76.00	80.00	77.78
	HR	153.17	163.17	149.50	144.46
	Ass	43.90	63.72	13.24	37.93
A3	HR	151.47	172.60	58.40	44.33
A4	Ass	12.50	9.09	37.50	0.00
	HR	122.56	119.30	130.40	134.89
	Ass	5.26	21.95	26.32	47.37
A5	HR	144.83	162.23	158.54	145.92
	Ass	50.00	62.96	50.00	3.03
	HR	133.07	145.62	169.62	135.62
	Ass	71.43	9.09	57.14	14.29
A6	HR	117.92	123.00	115.54	112.42
A7	Ass	36.67	35.90	40.00	40.74
	HR	147.38	162.88	161.25	157.00
	Ass	39.29	55.00	58.70	68.49
A7	HR	145.50	150.60	155.73	156.29
	Ass	31.58	32.76	41.89	17.02
R1	HR	132.27	149.91	142.45	141.27
R2	Ass	54.55	47.22	66.67	57.50
	HR	160.40	167.40	152.80	154.11
	Ass	37.50	25.64	26.80	31.00
R3	HR	146.20	135.00	143.53	142.38
R4	Ass	52.33	51.28	42.57	54.26
	HR	134.50	153.40	144.80	123.22
	Ass	52.48	64.86	53.51	46.74
R4	HR	148.25	162.25	159.08	141.55
	Ass	33.33	51.02	47.92	43.14
R5	HR	176.62	172.77	168.62	138.62
R5	Ass	52.00	63.83	54.55	28.57
	HR	173.33	178.64	164.73	149.18

Since there were unequal numbers in each group, and either four or eight measures of heart rate per subject, a least-squares approach to the analysis of variance was used, which adjusts the effect of each factor for all other effects, and tests only the unique variance attributable to each.

None of the factors, nor the interaction showed any significant effects. Differences between subjects within the same group that were unrelated to effort accounted for a large part of the variability in association . Heart rate , although not significant , had a much larger effect size than status (see Table 4). Of the three factors being investigated, heart rate had by far the greatest effect size (Table 4).

TABLE 4. **SUMMARY TABLE OF THE FACTORIAL ANALYSIS OF VARIANCE FOR EFFECTS OF STATUS, HEART RATE (HR), STATUS/HEART RATE INTERACTION, AND SUBJECTS**

Source	Df	SS	MS	F
Status	2	241.2	120.6	0.36
HR	1	804.4	804.4	2.432
Status/HR	2	136.8	68.4	0.207
Subjects*	6	7781.0	1296.8	
Error	90	29762.3	330.69	

* Subjects x treatments within groups

DISCUSSION

A cycling specific cognitive strategy classification system

The content analysis of the verbal thought processes of the cyclists during their training rides indicated that most of their thoughts could be categorised according to the cognitive strategy classification system developed by Schomer (1986). However, some thoughts were clearly specific to cycling as opposed to running. Therefore a new cycling-specific sub-category of thought, termed Equipment Monitoring (Q) was identified in addition to Schomer’s 10 sub-categories created for marathon runners. This new category includes thoughts about the bicycle and its individual parts, for example the gears, the brakes, the wheels, etc. Figure 2 shows where it fits into Schomer’s classification scheme relative to other subcategories.

FIGURE 1. **REVISED, CYCLING-SPECIFIC COGNITIVE STRATEGY CLASSIFICATION SYSTEM**

A	Feelings and affects	ASSOCIATIVE MENTAL STRATEGY
B	Body monitoring	
C	Command and instruction	
Q	Equipment monitoring	
P	Pace monitoring	
E	Environmental feedback	DISSOCIATIVE MENTAL STRATEGY
R	Reflective activity thoughts	
S	Personal problem solving	
W	Work, career and management	
I	Course information	
T	Talk and conversational chatter	

The following is a complete description of each of the subcategories in the cycling-specific cognitive strategy classification system:

1) Feelings and affects (A). Thoughts concentrating on general sensations of the whole body, like feelings of vitality or fatigue, overall tiredness and stiffness without mention of specific body parts (for example: “I feel bushed”, “still feeling fine”, “I could embrace the world now, no aches and pains”, etc.).

2) Body monitoring (B). Thoughts of a here and now nature containing specific mention of anatomy, body parts, or body physiology like breathing rhythm, heart-beat or painful calf muscles (for example: “That thigh does seem a bit tired”, “shoulders are stiff”, “hands are cold”, etc.).

3) Command and instruction (C). Thoughts reflecting emphatic self-regulatory instructions to whole body functioning distinctly related to the activity and maintenance of running (for example: “Relax your shoulders”, “slow, slow, go easy”, “breathe deeply now”, etc.).

4) Equipment monitoring (Q). Thoughts of a here and now nature containing specific mention of cycling equipment, like the brake or gear systems, wheels or pedals, necessary to the satisfactory continuation of cycling (for example: “New part seems to be holding out OK”, “front tyre's looking a bit flat”, “bike feels terrible today”, etc.).

5) Pace monitoring (P). Verbalised feedback on current performance with respect to time, distance, speed or any other available form method of pacing (for example: “Running a bit fast for this section”, “about a minute to go”, “three kilometres to go”, etc.).

6) Environmental feedback (E). Thoughts of a here and now nature on the weather condition, temperature, light conditions, smell and noise level (for example: “Bit of cloud over there, not too hot”, “once you're on this stretch it's so calm”, “these car fumes - terrific, jic!”, etc.).

7) Reflective activity thoughts (R). Thoughts on past and future issues related to cycling, like past race experiences or training sessions, and future race preparation and planning (for example: “The times I have run this race I have always made it”, “I will enter the Argus Cycle Race next year - give it a try”, “I remember the way I struggled up this hill”, etc.).

8) Personal problem solving (S). Thoughts revolving around issues of an intra-personal or interpersonal nature including reflective introspection, belief system evaluation and modification (for example, “Shame, I wonder how my girl is”, “feeling very self-conscious about that revolting photograph in the paper”, “you know, as a kid I couldn’t get myself to look into people’s eyes”, etc.).

9) Work, career and management (W). Thoughts spent on job, work and careeer opportunities including thoughts centering around the execution, planning and construction of work (for example: “Must get the kids to school on time tomorrow”, “I’m supposed to cut the lawn - rats”, “I wonder if the patient I treated at work today is going to have another operation”, etc.).

10) Course information (I). Thoughts of a descriptive nature about scenery and general whereabouts that are of no consequence to pace (for example: “those mountains look absolutely great at sunset - absolutely beautiful”, “I’m going to run around this shopping complex”, “flowers all around me, what a scene”, etc.).

11) Talk and conversational chatter (T). Direct speech when in communication with other cyclists and thoughts expressing follow-up chatter to initial exchanges, as well as unintelligible or extraneous chit-chat (for example: “Hi (name), good to see you out here again - ya, I’m well”, “how are your new Nikes? Comfortable?”, “That was (name), hell of a fellow, you know”, etc.).

These thoughts are classified as associative in nature because they are task-related to the activity of cycling. In terms of Nideffer’s (1981) attentional style categorisation they are classified as narrow and external.

Effects of cycling status on associative strategy use

The results showed no significant differences in the percentage associative strategy use between the three groups of cyclists. That is, elite cyclists did not use associative thinking more than the average or recreational cyclists. Although negative, this finding is consistent with Schomer’s (1986) findings that superior marathoners didn’t use the associative coping strategy more than the non-superior marathoners. A contributing factor to the non-significant results in the present study may have been the definitions (in terms of race times) used to define the cyclists’ competitive status. A few of the average cyclists’ times were very close to the 2h 45min threshold which signified elite status. Hence, there was not a very clear distinction between the two groups of cyclists and this may have blurred the results to some extent.

The standard deviation of percentage association amongst the recreational riders was substantially below those of the elite and average cyclists. The greater variability could indicate that the better (i.e. elite and average) cyclists are more flexible when it comes to cognitive strategy use than recreational cyclists. It has previously been suggested that different strategies are more effective under different circumstances. It can therefore be assumed that flexibility of cognitive strategy use has an adaptive function in sport. In the light of this assumption, it is not surprising that elite and average cyclists (whose classification criteria according to time were not very distinct), showed more flexibility of cognitive strategy use than recreational cyclists.

The apparent adoptive function of flexibility in the use of cognitive strategy has important implications for the design and implementation of cognitive strategy training programmes. One cannot simply teach developing athletes particular strategies, but must also teach them when particular strategies are more desirable than others in order to maximise the chances of achieving the “ideal performance state” under different conditions and thereby maximising performance potential.

Effort and associative thinking

The present study found an insignificant correlation between effort sense as measured by RPE and percentage association. This result is in marked contrast to Schomer’s (1986) results which have indicated a strong direct relationship between associative cognitive strategy use and perceptions of effort, i.e. increases in associations were related to increases in training intensities. Furthermore, in the present study, neither HR nor RPE, taken either alone or together, had any significant relationship with association.

The non-significant results between association and training intensity (as measured by both RPE and HR) in the present study could have been due to low statistical power and other methodological factors. Most of the cyclists’ training rides in the present study were an hour long. It is possible than this duration of one hour was not representative of the cyclists’ typical training rides which may have lasted longer than one hour. Moreover, the calculated average HR per temporal quarter of the training rides was therefore usually representative of approximately a 15-minute period, and it is thus possible that any cyclist could have climbed and descended one or more hills during this time. The mean HR over these 15 minutes would, however, not show these extreme (highest and lowest) recordings of HR, as they would cancel each other out. Hence preciseness of the relationship between association and effort (training intensity) would be lost because of measures of mean HR per temporal quarter may not be sufficiently accurate.

To study the association/effort relationship in cyclists more precisely, it may be necessary to obtain more regular measures of effort. This could be achieved in different ways. Cyclists could be requested to verbalise their perceived exertion (RPE) onto the tape at regular intervals. Or, the cyclists’ thought verbalisation could be over-layed with HR as measured at the time of verbalisation. Future research with cyclists in field settings could also obtain more detailed information about the course and the cyclists’ activities. This could by achieved by asking cyclists to verbalise onto the tape what they are doing, for example “cycling uphill”, "free-wheeling", etc. or alternatively, an observer could monitor the cyclists' training ride and course and record such information.

The cognitive strategy classification system that was developed by Schomer (1986) and the present study was based on the thoughts of athletes during training runs or training rides respectively. Masters and Lambert (1989) pointed out some differences between training runs and a marathon race, namely that the distances covered may vary and the atmosphere and motivations that are associated with the competitive event are quite different. These differences, presumably, would also apply to cycling. One important difference in a cycling event is that a lot of time is spent cycling in a bunch because of the drafting effect serves to lower energy expenditure. This raises the question of whether athletes' thoughts during a race that are related to their strategies and tactics, e.g. breaking away from the bunch, passing other competitors, etc. would require a further new sub-category of thought, possibly called "Tactical awareness".

Thoughts about tactical awareness would be associative by nature because they are task-related. Tactical awareness would be the only associative sub-category of thought occurring in the broad/external quadrant of attentional focus. These thoughts rarely occur during training. However, to ensure that athletes are adequately prepared for competition, some tactical strategising is vital during the training phase. This could take on the form of developing competition plans and using techniques such as imagery.

Athletes are understandably reluctant to carry recording equipment to record their verbalised thoughts during a competition. Information about the cognitive strategies used by athletes during competition will therefore have to be obtained through post-event interviews or questionnaires.

CONCLUSION

The present study was a replication and adaptation of Schomer's (1986) study and focused on the sport of cycling. It was concluded that although the cognitive strategy classification system developed by Schomer for marathon runners was generally applicable to cyclists, an additional sub-category of thought termed "Equipment monitoring" was identified and incorporated into Schomer's scheme in order to develop a cycling-specific cognitive strategy classification system. These findings support the viewpoint that every sport has unique characteristics and demands which must be understood by sports consultants and integrated with an appreciation of the athlete's needs in order to develop the most productive cognitive training programmes that will help to maximise the performance level of the athlete in his or her specific sport (Taylor, 1995; Tennenbaum, 2001).

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