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The relationship between performance and flow state in tennis competition

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Aim. **The study aimed to examine 1) the validity of the nine-factor flow model in tennis competition; 2) differences in flow state between athletes who won or lost their competition match; 3) the link between flow and subjective performance; and 4) flow dimensions as predictors of performance outcome**

Methods. **The sample consisted of 188 junior tennis players (115 male, 73 female) between 12 and 18 years of age. Participants' performance was recorded during junior ranking-list tournaments. Following the completion of a tennis competition match, participants completed the Flow State Scale-2 and a subjective performance outcome measure.**

Results. **Acceptable flow model fit indices of CFI, TLI, SRMR, and RMSEA were only found for winning athletes. The group of winning athletes scored significantly higher on all nine flow dimensions, except time transformation, than losing athletes, showing statistically significant differences for challenge-skills balance, clear goals, sense of control, and autotelic experience. Significant correlation coefficients were found between flow state and subjective performance assessments. The binary logistic regression revealed concentration on the task and sense of control to be significant predictors of performance outcome. The predictor variables explained 13% of the variance in games won.**

Conclusion. **The study showed that athletes who win or lose perceived flow state differently. Studies using retrospective assessments need to be aware that subjective experience could be biased by performance outcomes. Pinpointing psychological variables and their impact on ecologically valid measures, such as performance results, would support the development of effective intervention studies to increase performance in sport competition.**

Key words: Athletic performance - Models, psychological - Adolescent.

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Athletes performing at their best in competitions have characterised their optimal performance state as being completely absorbed in and focused on the task at hand, feeling in control, while their body works effortlessly and automatically.[1-4] This state of optimal experience is called flow.[1, 5] Flow is a state of positive experience characterised by intrinsic motivation, total immersion in the activity and a high levels of enjoyment that increases athletes' effort and perseverance in their sport. Therefore, flow state plays an important role in competition as the experience helps athletes to get the most out of themselves and perform above average, which could make a difference between winning and losing.

Several definitions have been proposed for peak performance. Peak performance has been viewed as "behavior which exceeds one's average performance",[6] "superior functioning",[7] or as a "prototype of superior use of human potential".[8] The result of a peak performance may be objectively quantifiable (*e.g.*, observations, performance scores), whereas flow has a strong subjective component that cannot be directly evaluated by others.[9] Even though there are conceptual differences between peak performance and flow, flow is tangentially related to peak performance, indicating that both states can occur at the same time.[10]

To address the relationship between feeling and performance in sport, an early study found various characteristics, such as absorption, involvement, and joy, to be common qualities of flow and peak performance.[7] Following, the proposed experience model aimed to describe the link between athletes' experience and the resulting performance taking into account two orthogonal dimensions that incorporate several feeling and performance states.[11, 12] The model indicated that performance levels gradually increase as feeling states increase from negative (misery, worry, boredom) to positive (enjoyment, joy, ecstasy) experiences. Performance levels were differentiated between unsuccessful (total failure, inadequacy, inefficiency) and successful (effectiveness, high performance, personal best) performances. According to the experience model, feelings of worry and boredom are counterproductive to superior performances, as both experiences are related to performances that are below average. Enjoyment, on the other hand, which is also a key aspect of flow, would signify performances that are above standard. Testing the experience model, differences in feeling states were found at various performance levels.[12] Athletes characterised peak performances as fulfilment, focus, play, and self in progress, whereas average performances revealed a lack of fulfilment and focus, but a higher importance of play and sociability, and failing performances demonstrated most strongly an absence of fulfilment, focus, sociability, and self in progress. Even though the results confirmed the hypothesised positive link between feeling and performance, the model has rarely been used in following years and research on the nexus between feelings and performance has mainly emerged as a concomitant of flow research.

Close resemblance between the experience model [11, 12] and the flow model [1, 3, 5] can be found for various feeling states, as worry and boredom are viewed as debilitative having a negative impact on performance and flow, respectively, whereas enjoyment facilitates both flow and performance. An important flow construct that conjoins both aspects of subjective experience and performance is the challenge-skills balance. The challenge-skills balance is a crucial precondition to get into flow as athletes need to achieve a balance between situational challenges and personal skills.[1, 3] When an athlete with low skills is facing a highly challenging task, this situation would provoke states of anxiety. The situation is perceived as threatening, or, at least, not enjoyable, because challenges go beyond personal skills, which are inadequate or insufficient to successfully manage the situation. Situations in which performers' skills exceed current challenges lead to states of relaxation or boredom, because the demands are relatively low and easy to master. Low-challenge/low-skill situations induce feelings of apathy as the situation is neither stimulating nor does the individual have the skills or expertise to master it, creating little or no interest. To get into flow, athletes need to face performance situations that are challenging above average performance levels, and concurrently athletes need to be confident that their skills can match the performance requirements.[3] Athletes in flow experience one or several of the following characteristics termed action awareness merging, clear goals, unambiguous feedback, concentration on the task, sense of control, loss of self-consciousness, time transformation, and autotelic experience.[3, 5]

Examining individuals with different backgrounds, such as dancers, white collar workers, and students in order to identify what marks the onset of their flow experience the most frequent answer, given by over 40% of the respondents, was the activity itself.[13] Familiar stimuli or simply the performance of a specific activity could trigger flow.[3, 13] In sport psychology, research on the flow-performance relationship focused on the examination of peak performance,[8, 14] flow state and subjective performance assessment,[15, 16] and on flow state predicting performance outcome.[16] Previous studies found that flow state was more intense in best performances than in competitions in general.[8] Interviews with professional tennis athletes indicated that during a personally outstanding competition performance over 50 percent of the players experienced flow dimensions of concentration, sense of control, action-awareness merging, clear goals, and unambiguous feedback as part of their match performance.[14] Young concluded that flow was related to optimal performance, but that this optimal performance was not necessarily associated with a winning performance.

Jackson et al. examined the relationship between athletes' flow state and perceived performance and real performance results in surf life saving, road cycling, and orienteering.[16] Subjective performance ratings and objective performance results, measured by finishing position and errors in orienteering, were entered as criterion variables into a standard multiple regression equation, with dimensions of flow state as predictor variables. The results revealed that flow dimensions explained 46% of the subjective performance rating, 33% of errors in orienteering, and 13% of the actual performance outcome. Significant predictors of subjective performance were autotelic experience and challenge-skills balance, errors in orienteering were significantly predicted by autotelic experience, clear goals, action awareness merging, and unambiguous feedback, and finishing position was significantly predicted by clear goals, challenge-skills balance, and action-awareness merging. The results of the Jackson *et al.* study demonstrated the important association between flow dimensions and subjective performance, and between flow and ecologically-valid performance outcomes. The performance-outcome variables were particularly meaningful for the various sports, including finishing position and errors in orienteering. Future studies investigating the flow-performance link should examine flow state with regard to crucial, ecologically-valid performance variables, which address core components of the performance.

Most of the flow-performance studies have provided evidence underlining a positive connection between flow state with subjective performance and objective performance outcomes. The associations between flow and performance were tested on heterogeneous samples that included athletes from a range of sports,[8, 15, 16] but rarely focused on a single sport.[14] The current study consists of four aims, that is, to examine a) the validity of the nine-factor flow model in tennis competition, b) differences in flow state between athletes who won or lost their competition match, c) the link between flow state and subjective performance, and d) flow dimensions as predictors of performance outcome.

Materials and methods

Participants

The sample consisted of 188 junior tennis players (115 male, 73 female) between 12 and 18 years of age (M=14.18; SD=1.50). Participants provided complete data for measures of flow state and performance. Demographic information showed that participants had been involved in tennis competitions between half a year and 9 years (M=4.19; SD=1.74), and their training intensity varied between 1 and 27 hours per week (M=8.24; SD=5.65). The estimation of the normal distribution for tennis competition experience (skewness=0.45; kurtosis=-0.21) and training hours per week (skewness=1.29; kurtosis=1.25) revealed acceptable values,[25] indicating a relatively homogeneous sample.

Measures

The Flow State Scale-2 (FSS-2)[17] assesses the intensity of flow state on one occasion (*e.g.*, one tennis match). The 36-item scale consists of nine subscales, which represent the nine dimensions of flow as described in the introduction. The response format is a 5-point Likert (1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree). The internal consistency alpha coefficients for the nine subscales were between .81 and .90. Confirmatory factor analyses of the FSS-2 demonstrated acceptable fit of the nine first-order factor model of flow state for the original (χ^2=1171.026; df=558; Comparative Fit Index=0.925; Non-Normed Fit Index=0.915; Root Mean Square Error of Approximation=0.053) and the validation (χ^2=1177.558; df=558; CFI=0.939; NNFI=0.931; RMSEA=0.051) sample.[17]

The self-report performance items are based on propositions by the flow model [18] and on qualitative findings on flow in sport [2, 14] to assess athletes' perception of the performance outcome. Participants answered several questions on the competition situation, as well as on their technical performance, including service, groundstroke, and net performance. Descriptions of the subjective performance questionnaires [15, 16] were taken into consideration. Technical performance was assessed on an 11-point bipolar scale anchored by -5 (very poor) and +5 (excellent), with 0 as average. Additional ratings, using a 11-point bipolar scale with extreme ends of -5 and +5, assessed competition importance (anchored by not important at all and extremely important), competition commitment (anchored by very low and very high), competition preparation (anchored by not at all and very much so), perceived certainty about competition outcome (anchored by very uncertain and very certain), and situational and environmental conditions (anchored by very debilitative and very facilitative). Participants in this study evaluated their current competition performance to how they perform generally in competitions.

The objective performance outcome was measured in two ways, 1) by the overall match result (competition match won or lost); and 2) by number of games won and lost. Performance results were obtained from the participants themselves after the competition match and cross-checked with the results of the tournament draws provided by the tournament directors. The competition matches were played as part of tennis tournaments conducted in metropolitan and rural Victoria, Australia. The competition mode provided players to play best-of-three with a tie-breaker at the end of each set. Participants needed to win two sets to claim victory of the competition match. The second performance outcome variable, number of games won and number of games lost, had a possible range between 0 (*i.e.*, straight set loss with no games won) and 20 (i.e., three set victory with two tiebreakers won and one tiebreaker lost).

Statistical analysis

Statistical analysis consisted of five parts, including: 1) descriptive statistics on flow state and demographic information (*e.g.*, age, sex, tennis experience); 2) congeneric model testing of flow state in competition; 3) *t*-tests to examine differences in flow state between successful and unsuccessful athletes; 4) Pearson Product-Moment Correlation Coefficients between flow state and subjective performance, and e) regression analyses with flow dimensions as predictors of performance outcome.

Data was entered into SPSS Version 16.0 to assess means, standard variations, Cronbach's alpha, and correlation coefficients. Congeneric model testing was undertaken using AMOS 16 software. Model estimations were based on maximum likelihood methods.[19] First, we assessed a one-factor congeneric model to examine construct and convergent validity of flow state in competition using fit measures addressing model parsimony (normed chi-square index χ^2/df), model fit (standardized root-mean-square residual, SRMR; RMSEA), and incremental fit (CFI, TLI). A close model fit is achieved when fit index values are between 1 and 2 for normed χ^2, under .06 for SRMR, between .05 and .08 for RMSEA, on a .95 level or higher for CFI and TLI. Fit indices were selected on the basis of best practice determination of model fit as suggested by previous SEM research [20, 21] and multivariate analysis texts.[22, 23]

Regression analyses was carried out with flow dimensions as predictor and performance outcome as criterion variables. Binary logistic regression analysis was applied in conjunction with competition results (match won or lost) as categorical dependent variable, and two separate multiple regression analyses were conducted with games won and games lost as criterion variables.

Procedures

Following approval from the University's Ethics Committee, access was requested from tournament directors of junior tennis tournaments in Australia. Information statement and consent forms were handed out to players and legal guardians. Players, who wanted to join the study as volunteers and who had received consent from their parent/guardian, completed measures of subjective performance and FSS-2 immediately after the end of the competition match.

Results

Descriptive analysis

Acceptable reliability values[24] higher than .70 were found for flow subscales ranging from 0.74 (challenge-skills balance, loss of self-consciousness) to 0.87 (autotelic experience). The FSS-2 subscale scores signified moderate endorsement of the items for the sample. The mean scores for the flow dimensions varied between 3.16 (time transformation) and 3.91 (unambiguous feedback), signifying that a number of participants experienced flow characteristics during competition. The abbreviations of the flow dimension in Table I will be used in the same way for other table formats within the results section. In addition, we assessed if items were problematic based on skewness (>± 3) and kurtosis (>± 7) scores.[25] All items indicated to be normally distributed with skewness ranging from -0.61 to -0.23 and kurtosis from -0.25 to 0.89.

Flow state in tennis competition

The first aim of the study was to examine the experience of flow state in tennis competition.

TABLE I.—*Descriptive statistics for the flow subscales.*

	Abbr.	M	SD	Sk.	Ku.	α
Challenge-skills balance	CSB	3.53	0.80	-0.40	-0.25	0.74
Action-awareness merging	AAM	3.38	0.75	-0.23	0.27	0.76
Clear goals	CG	3.88	0.75	-0.61	0.89	0.76
Unambiguous feedback	UF	3.91	0.75	-0.49	0.04	0.77
Concentration on the task at hand	CTH	3.50	0.89	-0.40	-0.12	0.85
Sense of control	SC	3.55	0.84	-0.60	0.15	0.80
Loss of self-consciousness	LSC	3.59	0.84	-0.40	-0.19	0.75
Time transformation	TT	3.16	0.94	-0.42	0.01	0.79
Autotelic experience	AE	3.63	1.03	-0.60	-0.24	0.87

Abbr.: abbreviation; Sk.: skewness; Ku.: kurtosis

Initially, we assessed whether there are differences in experience of flow between male and female participants. The model for males and females had identical path structures with a higher-order flow factor and nine observed variables representing the nine flow dimensions. Testing for measurement invariance between genders, we investigated if the nine-factor flow model differs for male and female players. Following Byrnes approach, we applied equality constraints on the measurement paths for flow model for male and female participants in order to make the factor loadings invariant across the two groups. The results showed that the solution was non-significant supporting the invariance of the measurement model between males and females (χ^2=79.508, df=62, P=0.066, CFI=0.974, TLI=0.969, SRMR=0.060, RMSEA=0.039). The indices of the model suggested a good fit of model, with a non-significant p value providing support that flow state was experienced similarly across gender. Therefore, further analysis included combined data of male and female participants.

Composite variables (*i.e.*, averaging the number of item responses per subscale) were used to construct nine indicator variables representing the nine flow dimensions. Initially, congeneric and parallel models were tested to examine whether composites and error variances contributed equally to the measurement model, or if some indicators contribute more to the latent variable of flow state than others. In addition, nested model comparisons were estimated to evaluate significance χ^2 differences between congeneric and parallel models. Testing the congeneric model first, Mardia's coefficient to assess normality showed a multivariate kurtosis value of 27.539, indicating significant multivariate non-normality. Hence, results were then interpreted using bootstrapping techniques with 2000 samples and the Bollen-Stine adjusted P-value.

As shown in Table II, acceptable fit was found for the unconstrained congeneric model (Model 1). The Bollen-Stine P was non-significant, which further supports the construct validity of flow state in tennis competition. The factor loadings varied between .23 (time transformation) and .84 (sense of control) with a mean loading of 0.64. Factor loadings have been proposed to be above 0.30, approximately explaining 10% of the variance, to qualify for meaningful interpretation.[26, 27] All factor loadings, except time transformation, loaded stronger on flow state than the suggested cut-off point. The results provided support for the convergent validity of flow state in tennis competition. Testing the model again with composites and error variances constrained to be equal, the parallel model revealed a significant Bollen-Stine P value and was not supported well

TABLE II.—*Models of flow state in tennis competition.*

	χ^2	df	χ^2/df	Bollen-Stine p	CFI	TLI	SRMR	RMSEA	*RMSEA* (90% CI)
Model 1 (Congeneric)	53.979	27	1.999	0.241	0.960	0.947	0.043	0.073	0.044-0.101
Model 2 (Parallel)	254.518	43	5.919	0.000	0.687	0.738	0.150	0.162	0.143-0.182
Model 3 (Congeneric Won)	34.564	27	1.280	0.766	0.975	0.967	0.049	0.050	0.000-0.095
Model 4 (Congeneric Lost)	58.018	27	2.149	0.270	0.907	0.876	0.069	0.123	0.079-0.167

by the fit indices (Model 2). The nested model comparison showed a significant difference ($\Delta\chi^2$ (16)=200.538, P<0.001), that is, the congeneric model fits the data significantly better than the parallel model, indicating that one or more flow dimensions vary significantly between models and should not be presumed to be equal. Finally, we tested the model fit of flow state for athletes who won (Model 3) or lost (Model 4) the competition match. Bollen-Stine's P was not significant for both models, indicating adequate fit for both sub-samples. The fit indices, on the other hand, showed strong support for flow state and winning performance, but not for losing performance. Acceptable values were found for CFI, TLI, SRMR, and RMSEA for flow state and winning performances; whereas substantially lower fit indices were found for unsuccessful performances.

The results of the model testing in Table II indicated that flow state varies between successful and unsuccessful athletes. Evidence for the variation of flow state was provided by Model 2, showing that flow factors differed in their contribution to flow, and based on Models 3 and 4 signifying a better fit of the data that reflected a successful performance rather than an unsuccessful one.

Differences in flow state

In the next step, we examined which flow dimensions showed similarities or variations across groups of winning and losing athletes. Group analysis with independent sample *t*-tests were chosen to compare athletes who won (N.=111) and lost (N.=77) their competition match. Winners reported a higher flow experience than losers for all flow dimensions, except time transformation. To examine group differences, a Bonferoni adjusted P value was calculated to account for repeated measurement and to uphold the 5% significance level. Winning athletes scored higher on all flow dimensions, except time transformation, than losing athletes. Based on the adjusted .006 cut-off level, statistically significant differences in flow across groups were found for challenge-skills balance, $t(1.8)=3.31$; P=0.001; $d=0.48$, clear goals, $t(1.8)=2.81$; P=0.006; $d=0.39$, sense of control, $t(1.8)=4.54$; P=0.000; $d=0.67$, and autotelic experience, t(1.8)=4.83; P=0.000; d=0.88. The remaining flow dimensions did not show significant differences between groups for the adjusted p value. The d value, however, indicated moderate differences in flow characteristics between competition winners and losers (action-awareness merging $d=0.32$; unambiguous feedback $d=0.32$; loss of self-consciousness $d=0.36$). No significant differences emerged for concentration on the task and time transformation neither at the adjusted nor at the regular P level.

Flow state and subjective performance

The third aim of the study was to examine the association between flow dimension and subjective performance. As outlined in Table III, Pearson prod-

Table III.—*Correlations between flow subscales and self-assessed performance.*

	CSB	AAM	CG	UF	CTH	SC	LSC	TT	AE
Technical performance									
1st serves	0.34	0.22	0.21	0.21	0.24	0.30	0.23	0.11	0.37
2nd serves	0.28	0.23	0.23	0.18	0.20	0.33	0.25	0.09	0.41
Forehand	0.39	0.42	0.36	0.27	0.29	0.47	0.24	0.16	0.39
Backhand	0.23	0.18	0.29	0.18	0.17	0.29	0.16	0.03	0.28
Volleys	0.26	0.33	0.24	0.19	0.20	0.30	0.06	0.01	0.22
Mean *r*	0.30	0.28	0.26	0.21	0.22	0.34	0.19	0.08	0.34
Competition aspects									
Comp. importance	0.39	0.25	0.28	0.18	0.27	0.26	0.19	0.15	0.39
Comp. commitment	0.52	0.25	0.45	0.35	0.40	0.47	0.29	0.19	0.57
Comp. preparation	0.52	0.25	0.46	0.36	0.45	0.42	0.29	0.16	0.44
Comp. certainty	0.40	0.30	0.31	0.29	0.29	0.42	0.31	0.18	0.35
Ability	0.33	0.21	0.31	0.25	0.19	0.36	0.13	0.03	0.30
Environment	0.11	0.13	0.01	0.11	-0.06	0.10	-0.03	0.25	0.18
Mean *r*	0.38	0.23	0.30	0.26	0.26	0.34	0.20	0.16	0.37

Values of $r \geq 0.19$ are significant at $P \leq 0.01$.

uct-moment correlation coefficients were calculated between flow dimensions and technical performance and situational factors. Most links between flow dimensions and technical performance variables were significant at a .01 level. The findings showed that all correlations were higher for forehand than for backhand performance. No clear pattern emerged for first and second serves. Particularly strong links across technical performance assessments (serves, groundstrokes, and volleys) and flow were found for autotelic experience (mean r=0.34), sense of control (mean r=0.34), and challenge-skills balance (mean r=0.30). Time transformation (mean r=0.08) and loss of self-consciousness (mean r=0.19) showed weaker links.

Additional performance aspects, as shown in the bottom half of Table III, provided substantial support for a positive, significant relationship between flow dimension and subjective performance perceptions. Most correlations were significant at the 0.01 level, except for item environmental and situational conditions. It may be that this item was not specific so that participants were not clear about its meaning, which could have led to a weaker association with flow. Similar to the results on technical performance, strong links were found for the various performance aspects and autotelic experience, sense of control, and challenge-skills balance, whereas time transformation and loss of self-consciousness revealed the smallest mean correlation coefficients.

Flow state predicting performance outcome

The second aim of the study was to investigate which flow dimensions predict performance outcome. We applied standard multiple regression analysis with flow dimensions as predictor variables and performance as criterion variable. To develop a greater understanding of the relationship between flow and performance outcome, separate regression analysis were run with various criterion variables, including a) match outcome, b) number of games won, and c) number of games lost. Match outcome was a dichotomous variable (win, loss) which was analysed through binary logistic regression, whereas number of games won or lost were continuous variables with a possible range between 0 (*i.e.*, straight set loss with no games won) and 20 (*i.e.*, three set win with a tiebreak at the end of each set). The performance outcome variable, number of games won/lost, were standardised to z-scores to facilitate interpretation between regression analyses.

In Table IV, we present the results of the binary logistic regression. The Hosmer-Lemeshow test of overall fit showed that there were no significant differences (χ^2=5.669, *df*=8, P=0.684) between the observed and the predicted observations. The overall fit based on the Negelkerke value revealed an R^2 of 0.227. There were two significant predictors of performance outcome in concentration on the task at hand (Wald=7.510, P=0.006) and sense of control (Wald=6.872, P=0.009). In addition, three predictor variables including loss of self-consciousness, time transformation, and autotelic experience showed significant trends. The predictor variables of flow state correctly explained 83.8% of matches won, but only 46.8% of matches lost.

Finally, we examined the relationship between flow and performance as measured by games won and games lost. The predictor variables explained 13% of the variance in games won. The only significant predictor was found to be autotelic experience (beta=.27). Measuring performance by games lost, sense of control (beta=-0.47) was a

TABLE IV.—*Binary logistic regression analysis between flow dimensions and match outcome.*

Variables	B	SE B	Wald	Sig.	Exp(B)
CSB	-0.068	0.324	0.044	0.833	0.934
AAM	-0.109	0.268	0.167	0.683	0.896
CG	0.528	0.326	2.623	0.105	1.696
UF	-0.203	0.295	0.473	0.492	0.816
CTH	-0.764	0.279	7.510	0.006	0.466
SC	0.874	0.334	6.872	0.009	2.398
LSC	0.394	0.238	2.739	0.098	1.482
TT	-0.372	0.197	3.568	0.059	0.690
AE	0.47	0.251	3.518	0.061	1.600

TABLE V.—*Multiple regression analyses between flow dimensions and games won and lost.*

	Games won				Games lost			
	Unstandardized Coefficients		Standardized Coefficients	*Sig.*	Unstandardized Coefficients		Standardized Coefficients	*Sig.*
	B	SE B	Beta		B	SE B	Beta	
CSB	0.114	0.135	0.091	0.399	0.221	0.133	0.176	0.098
AAM	0.021	0.113	0.016	0.851	0.043	0.111	0.033	0.696
CG	0.086	0.136	0.065	0.525	-0.161	0.133	-0.121	0.228
UF	-0.151	0.127	-0.113	0.235	0.068	0.124	0.051	0.587
CTH	-0.053	0.109	-0.047	0.629	0.359	0.107	0.320	0.001
SC	0.083	0.137	0.069	0.547	-0.566	0.134	-0.473	0.000
LSC	0.030	0.096	0.025	0.755	-0.139	0.094	-0.118	0.139
TT	-0.131	0.078	-0.123	0.094	0.110	0.076	0.103	0.151
AE	0.258	0.107	0.267	0.017	-0.071	0.105	-0.073	0.498

negative predictor of performance, indicating that participants experience a loss of control with an increasing loss of games. On the other hand, with an increase of number of games lost participants reported a more focussed concentration on the task at hand (beta=0.32). The predictors of flow explained 16% of the variance in games lost.

Discussion

This study was designed to examine the relationship between flow state and performance in tennis competition. Initially, we examined various models of flow state. There were no gender differences in the experience of flow in this tennis sample, supporting previous research that showed that flow state is a similar experience for males and females.[9, 16] With regard to the first aim, the results indicated acceptable convergent and construct validity of flow state in tennis competition. Stronger flow dimensions with at least 50% of variance explained were found to be challenge-skills balance, clear goals, concentration on the task at hand, sense of control, and autotelic experience. Overall, the congeneric flow model showed a much better fit of the data than the parallel model, corroborating that flow dimensions contribute in different ways to flow state in tennis competition, and cannot be assumed to be equal. These results confirmed findings by Stavrou and Zervas showing that the factor loading of the flow dimensions can vary considerably. More importantly, model comparisons indicated that the data fit the flow model substantially better for athletes who won, rather than lost, the competition. The findings suggested that flow state, or a state closely representing flow, seem to occur when athletes perform successfully, whereas a competition loss appeared to bear little resemblance with flow.

Taking part in competition play, athletes may perceive that winning and losing are the most important match outcomes. "When winning and outperforming others becomes paramount, the process of experiencing becomes lost and the road to flow becomes more arduous".[3] Several studies underpinned this statement, finding that task orientation, in contrast to outcome orientation, is an antecedent of flow.[8, 15] We found strong evidence that winning athletes experienced most flow characteristics more strongly than losing athletes. In addition, moderate to strong correlations signified that flow state was higher when participants perceived that their performance, in comparison to their general performance, was stronger. The findings supported Privette and Bundrick's theoretical propositions of the experience-performance model, indicating that a better performance entails a more positive experience.

A crucial aim of this study was to examine whether flow state predicted competition outcome. Concentration on the task at hand and sense of control were significant predictors of match won or lost that varied from previous findings,[16] indicating the variability of flow dimensions in predicting objective performance. The importance of flow as predictor of performance could vary based on the sport type[18] and the competition structure.[1] Tennis is an open-skill sport that is mainly based on externally-paced performance in direct competitions. In addition, performance is frequently interrupted by breaks in between points or when players swap ends. In contrast, Jackson et al. examined athletes from three sports (cycling, orienteering, surf life saving), which require closed-skills and are of a continuous nature. The different findings in this and the Jackson et al. study suggested that there is a variation in the importance of flow characteristics for performance outcomes, and that that variation is likely to be influenced by the type of performance flow is measured in.

Looking at the relationship between flow and performance in more detail, the results showed that some flow dimensions had a positive association with performance, whereas other dimensions revealed a negative link. As expected, autotelic experience showed a significant positive relationship with games won and sense of control a significant negative association with games lost. Interestingly, concentration on the task at hand was a positive predictor for numbers of games lost. Previously, Jackson et al. reported an unexpected result between unambiguous feedback and performance outcome: "The finding of a positive relationship between feedback and errors in this study indicates negative feedback may contribute to further errors (and thus less flow)".[16] A similar mechanism might apply to the findings in this study. Winning athletes have to deal with fewer distractions, as they can follow their game plans, and they are less in demand to readjust their concentration than losing athletes. Distractions could either have an external source, such as an audience or opponent that disrupts the athlete's focus, or an internal source, such as debilitating thoughts or emotions: "When we are anxious or tired, trying not to think about something may paradoxically increase its prominence in our consciousness".[28] Under the stress of facing defeat in a competition, athletes who try to block out thoughts of losing may become preoccupied with it. Wegner described the overpowering of suppressed thoughts over intentional concentration as hyperaccessibility.[29] These counter-productive processes occur when the working memory is overloaded, which would happen when athletes are performing unsuccessfully. The finding of a positive relationship between concentration on the task at hand and games lost indicates that concentration may become a conscious process as athletes try to focus harder to turn the match around and need to avoid disruptive thoughts and debilitative emotions. On the other hand, successful athletes who are in flow might not perceive it as hard work to focus on the task at hand as flow state is signified by effortlessness and transcendence.[3]

One of the main limitations of this study was the use of a retrospective design. Collecting flow and performance data following the competition does not allow for making conclusions on causal, one-directional effects between flow and performance or whether flow and performance are linked by a reciprocal relationship. In addition, the effect of performance outcome on self-report assessments of psychological states could be compromised by methods of retrospective introspection.[30] Filling out the flow questionnaire immediately after losing these competitions could have led to a lower flow assessment. In a study on potential risks of retrospective introspection, Brewer et al.[30] reported that the retrospective evaluation of confidence and task focus, which are also important characteristics of flow state, was confounded by performance outcome. Therefore, knowledge about the performance outcome can influence the evaluation of athletes' experience. To avoid this measurement bias and to shed more light on the connection between flow and performance, a different research approach is required by investigating the flow-performance link through repeated measurements of flow and performance during competition to detect the timely sequence of changes in flow and performance. This way, athletes do not know about the overall performance outcome and, therefore, are less biased in their flow assessment and reflect more genuinely about their competition flow state. This research approach would provide more conclusive results on the association between flow and performance.

Future research should focus on the relationship between flow and performance to increase the understanding of possible causal links between these variables. One research approach could be to investigate the connection between flow state and performance that is directed to untangle the relationship between flow and objective performance. Previous studies, including the current one, measured flow once after the event, which reflects flow as one, non-changing state for a specific entire event. Future research need to acknowledge the fact that flow is a temporary, ephemeral state, which need to be measured repeatedly to obtain a more accurate reflection of the variations in flow state and performance. One approach could apply a pre-post measurement design, in which the first questionnaire is completed prior to performance assessing possible antecedents of flow, such as confidence, concentration, expectations, and competence, and a second questionnaire completed post performance examining flow state.[18] A similar approach in sports that offer time for athletes to complete flow measures during performance, such as tennis, would more clearly pinpoint antecedents of flow and provide more detailed information on the connection and interaction of flow and performance. Multiple measurements of flow and performance are needed to test for causal relationships between flow state and performance. Using the nine-item short form of the flow state scale[31] takes less than a minute to fill out and could be completed repeatedly. In a tennis match, athletes would be able to report on their flow state before and after the match, as well as during the breaks when swapping sides. Patterns in which performance increased after flow increased would provide evidence for a one-directional connection in which flow directly affects performance. The opposite pattern would suggest a one-directional link with performance influencing flow, or a pattern, in which both flow and performance jointly increase or decrease, could emerge, which would indicate reciprocal effects between flow and performance.

Conclusion

The study showed that athletes who win or lose their competition matches perceived flow state differently. Studies using retrospective assessments need to be aware that subjective experience could be biased by performance outcomes. This line of research assessing experiences during competition should compare winning and losing athletes to differentiate performance outcome effects and gain a better understanding of athletes' perceptions. Concentration on the task at hand and sense of control were significant predictors of performance outcome. Pinpointing psychological variables and their impact on ecologically valid measures, such as performance results, would support the development of effective intervention studies to increase performance in sport competition.

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