Examining coach–athlete interactions using state space grids: An observational analysis in competitive youth sport

Karl Erickson [a,*], Jean Côté [a], Tom Hollenstein [b], Janice Deakin [a]

[a] School of Kinesiology & Health Studies, Queen's University, Kingston, Ontario, Canada
[b] Department of Psychology, Queen's University, Kingston, Ontario, Canada

A B S T R A C T

Objective: The purpose of this study was to compare the coach–athlete interaction structures of two competitive youth synchronized swimming teams differentiated on the basis of level of success.
Design: This comparison was a pilot test of the state space grid (SSG) observational methodology (Hollenstein, 2007) in sport settings.
Method: Two teams (two head coaches and 17 athletes in total) were observed over five training sessions. Coach and athlete behaviour was coded continuously for the duration of each training session. Measures of coach–athlete interaction were derived from these coded behaviours and compared between teams.
Results: Results revealed significant differences between the teams on measures of interaction variability, behavioural content patterns, and the sequencing of coach behaviours. The more successful team was characterized by less variable, more patterned interactions between coaches and athletes. The sequencing of coach behaviours for the more successful team emphasized the pairing of technical correction and positive reinforcement.
Conclusions: The findings suggest that positive environments characterized by a deliberate pattern of coach–athlete interaction may be associated with youth sport settings producing more satisfied and successful athletes. These results support the utility of SSGs for the analysis of interpersonal interactions in sport and highlight the unique insights made available through use of this methodology.

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The role of sport coaches in fostering positive outcomes for youth through their behaviour and interactions with their athletes has been stressed for over 30 years. In perhaps the most notable line of research on youth sport coaching, Smith, Smoll, and colleagues (see Smith & Smoll, 2007 for a review) made use of observational techniques (i.e., the Coaching Behavior Assessment System [CBAS]; Smith, Smoll, & Hunt, 1977a) to elucidate the relationship between specific coaching behaviours and positive youth sport experiences. In general, Smith, Smoll, and colleagues concluded that youth sport coaches who exhibited high levels of supportive and instructional behaviours were rated most positively by their athletes. They also noted that athletes of coaches who demonstrated more supportive and instructive behaviours reported having more fun and liking their teammates more than athletes of coaches who were more punitive in their interactions.

While the CBAS-based findings have reasonable theoretical foundations for translating this content into practice, there remains a dearth of empirical evidence related to these behavioural processes – more specifically, how these behaviours should be enacted over time (e.g., the course of a training session). Smith (2006) made a significant step in this regard through the re-analysis of older CBAS-derived data. By examining intra-individual variability in coaching behaviours in relation to game situation (i.e., winning, tied, losing), Smith was able to generate contextually linked behavioural signatures for individual coaches. While this analysis provided valuable insight into the dynamic, shifting nature of coach behaviour and represents an important step forward conceptually, the data were presented in a primarily theoretical paper and were not linked to athlete outcomes, nor did the analysis take temporal sequencing into account.

Thus, while previous research on coach behaviours in youth sport has provided an excellent account of the general content of coach behaviours (e.g., being supportive and not punitive), little is known about the dynamic structure of that content. The effects of differing consistency (variability) and contingency (sequences) structural characteristics of coaches' behaviour on athlete

* Corresponding author. School of Kinesiology & Health Studies, 28 Division Street, KHS Room 401D, Queen's University, Kingston, Ontario, Canada K7L 3N6. Tel.: +1 613 533 6000x78207; fax: +1 613 533 2009.
E-mail address: 2kte@queensu.ca (K. Erickson).

outcomes remain unexplored. Without this information, we may be: a) missing key determinants of desired athlete outcomes and b) ignoring valuable process detail that could better inform coach education on the practical implementation of behaviour content findings. The present study aimed to address these concerns by taking a structural approach to the analysis of interactive coach behaviour influencing athlete outcomes, targeting the variability and sequencing as well as content of coach behaviours.

Conceptualizations of the coaching process

Most previous research on coaching behaviours has taken a unidirectional view of influence (see Horn, 2008; Kahan, 1999). In this view, the coaching process is done by coaches to athletes, which reduces athletes to non-contributing recipients and ignores the ability of the athlete to influence or contribute to their own development. This unidirectional view also does not offer insight into how the effects of a particular coach behaviour may be influenced by preceding or subsequent athlete behaviours.

In contrast, a multidirectional conceptualization of coach–athlete interactions (Bowes & Jones, 2006; Cushion, Armour, & Jones, 2006) suggests that coaching is, in fact, a complex, reciprocally-influential process based on systems of social interaction. Poczwardowski, Barott, and Jowett (2006) suggested shifting from a focus on the individual to the inter-individual, specifically coach–athlete dyads, as the central unit of study and diversifying methodological approaches in order to best reflect the dyadic unit and its functioning. Work by D'Arripe-Longueville and colleagues (D'Arripe-Longueville, Fournier, & Dubois, 1998; D'Arripe-Longueville, Saury, Fournier, & Durand, 2001) with elite French sport teams has taken a similarly interactive approach, examining the communication and perceptions of both coaches and athletes in a given situation. Notably, their innovative qualitative study of coach–athlete interactions during elite archery competitions (D'Arripe-Longueville et al., 2001) recorded the actions and perceptions of both coaches and athletes through self-confrontation interviews while each viewed video-recorded competition situations and then aligned the two data streams temporally. In doing so, the researchers revealed the give-and-take nature of these interactions over time, whereby interactive behaviour by the coach or athlete influenced subsequent behaviours by the other and thus the overall path of the interaction.

Thus, the goals and objectives of either actor in isolation do not explain the mutually constructed interactive environment. A full understanding of coach–athlete relationships and interactions must take into account both parties and recognize the interdependent nature of this milieu. The present study adopted this interactive system perspective to examine the structural characteristics of coach–athlete interactions (as opposed to coach behaviour alone) in youth sport. In doing so, a non-traditional methodology was required to quantitatively record and analyze the behaviour of both coaches and athletes.

Methodological considerations

Observational methods

Given the recent view of coach–athlete interactions as a reciprocally-influential system, any method must account for the explicit communicative behaviours exhibited by both parties. While this may be attempted through self report-type methods, the direct observation of interactions provides a more direct account of behaviours as they occur in real time. This is especially important given the findings of Curtis, Smith, and Smoll (1979), who noted

a consistently low correlation between coaches' observed and self-reported behaviour.

The importance of direct observation in coaching research has been recognized for some time (Kahan, 1999). Despite the significant contributions of previous observational coaching research, this body of literature has been heavily focused on the coach as the primary significant contributor to coach–athlete interactions, relying on the unidirectional conceptualization of influence mentioned earlier. The behaviour of athletes in these interactions has been largely ignored.

State space grid methodology

In response to traditional observational methodologies which are not well suited to the study of interactive systems with more than one actor, researchers (Hollenstein, 2007; Lewis, Lamey, & Douglas, 1999) have developed the State Space Grid (SSG) method to examine the structural features of interactions. SSGs are designed to account for both the reciprocal nature and structure (as opposed to simply content) of interactions over time. The SSG technique involves constructing a "state space" for the system in question; a grid which characterizes all possible states in which the system could function.

The system, in this case the coach–athlete dyad, is composed of two or more categorical variables representing the elements of the system (i.e., coach interactive behaviour and athlete interactive behaviour). All potential values for one variable (i.e., coach behaviour) comprise the x-axis of the grid while all potential values for the other (i.e., athlete behaviour) comprise the y-axis. The location (or 'state') of the system at any point in time is determined by values of the x (coach)- and y (athlete)-axis variables, which combine to form coordinates specifying a specific cell within the grid. The cell in which the system is functioning is then recorded continuously for the duration of interaction (e.g., a practice session), thus tracking the trajectory of the interaction. As an example, Fig. 1 displays the trajectory of a short (40 s) interaction between a coach and athlete, starting at the hollow circle. The size of the circles represents the length of time the coach–athlete system stayed in a particular cell in that instance of interaction. In observing the location of the system in real time, it is possible to determine the patterns and qualities of the system's functioning. To date, SSGs have been used only within developmental psychology, primarily in laboratory-based settings (see review by Hollenstein, 2007). The use of SSG methodology in the present study allowed the quantitative analysis of the structural characteristics of coach–athlete interactions while accounting for the reciprocality of these interactions.

Purpose of the study

Guided by the dyadic interactive perspective suggested by Poczwardowski et al. (2006), the current work sought to take a structural approach to the study of coach–athlete interactions in relation to athlete outcomes. The specific purpose of the current study was to identify and compare the dynamic coach–athlete interaction structures of two youth sport teams differentiated by athlete performance and personal development outcomes. This comparison served as a first test of the SSG methodology for examining interpersonal interactions in sport. In particular, the current study sought to use SSGs to address the following research questions regarding the nature of dyadic coach–athlete interactions associated with two different teams that varied in terms of athletes' performance and personal development: 1) how variable are these dyadic interactions? 2) to what content patterns do these
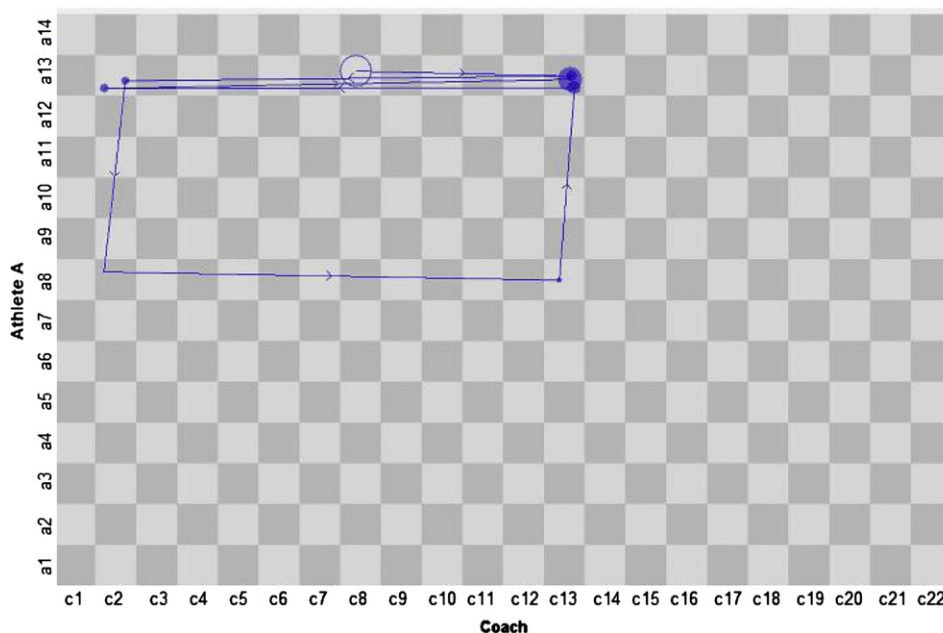
Fig. 1. Standard SSG used in the present study with short (40 s) example trajectory for one coach–athlete dyad during a practice. *Note.* Coach behaviour: c1 = positive reinforcement (team), c2 = positive reinforcement (athlete), c3 = corrective encouragement (team), c4 = corrective encouragement (athlete), c5 = future encouragement (team), c6 = future encouragement (athlete), c7 = corrective technical instruction (team), c8 = corrective technical instruction (athlete), c9 = future technical instruction (team), c10 = future technical instruction (athlete), c11 = organization (team), c12 = organization (athlete), c13 = observation, c14 = general communication (team), c15 = general communication (athlete), c16 = not engaged, c17 = keeping control (team), c18 = keeping control (athlete), c19 = technical error identification (team), c20 = technical error identification (athlete), c21 = negative evaluation (team), c22 = negative evaluation (athlete). Athlete behaviour: a1 = technical talking (team), a2 = technical talking (coach), a3 = technical talking (athlete), a4 = clarification (team), a5 = clarification (coach), a6 = clarification (athlete), a7 = acknowledgement (team), a8 = acknowledgement (coach), a9 = acknowledgement (athlete), a10 = general talking (team), a11 = general talking (coach), a12 = general talking (athlete), a13 = engaged, a14 = disengaged.

dyads tend to be drawn? and 3) are these interactions characterized by particular behavioural sequences?

Methods

Participants

Participants were female head coaches ($n = 2$) and athletes ($n = 17$) from two competitive youth synchronized swimming teams (team A − 10 athletes and team B − seven athletes) in Canada. Athletes were female, 11–17 years of age ($M = 15$ years, $SD = 1.6$), and averaged 6.5 years of previous experience in synchronized swimming ($SD = 1.5$). The teams did not significantly differ on athletes' age or previous experience. All athletes, their parents, and coaches were required to provide written consent prior to participation.

Differentiation between teams by athlete outcomes

Team A and B, while competing in the same division, were differentiated by team performance and athlete personal development. Performance was based on the head coach's description of the team's typical competitive ranking within the last three competitive seasons. A general measure over a span of recent years was chosen rather than a precise account of competition results in the current season in order to tap into a more consistent impression of the typical performance environment within the team. Team A has been highly competitive both provincially and nationally, having won an age-group national championship the previous season. Team B, while competitive in the same division, has not had quite the same level of recent team success, typically finishing in the middle of the pack at the provincial level during this time period. Personal development was compared through scores on the Youth Experience Survey 2.0 (YES 2.0; Hansen & Larson, 2005). The

YES 2.0 is a 70-item questionnaire that provides measures of positive and negative developmental experience within a specific organized activity. The 11 positive and negative experience subscales have been found to be reliable (Cronbach's alphas between .75 and .94) and have been cross validated with observations from adult leaders (Hansen & Larson, 2005).While no differences between teams on any subscales reached statistical significance (set at $p = .003$ after a Bonferroni correction for multiple comparisons), meaningful trends on the YES 2.0's 4-point Likert scale were noted for several subscales. In particular, team A reported trends towards higher perceptions of problem solving experiences ($M = 3.33$, $SD = .77$ versus $M = 2.62$, $SD = .49$ for team B; $t(15) = 2.17$, $p = .014$, $d = 1.10$) and lower perceptions of social exclusion ($M = 1.70$, $SD = .46$ versus $M = 2.10$, $SD = .50$ for team B; $t(15) = -1.70$, $p = .110$, $d = .83$) and inappropriate adult behaviour ($M = 1.50$, $SD = .50$ versus $M = 2.00$, $SD = .60$ for team B; $t(15) = -1.88$, $p = .080$, $d = .91$). That these differences did not reach statistical significance may be due in part to the small sample size in each group. However, consideration of the resulting effect sizes (Cohen's d: Cohen, 1992) suggests that the noted differences were substantial, with all three classified as large effects ($>.80$). Thus, while athletes' experiences on team B were not excessively negative, team A may represent a more positive personal development environment.

Procedure

Five training sessions within two weeks for each of the two teams were videotaped, with each coach wearing an omni-directional wireless microphone to capture both their own and their athletes' verbalizations. The recorded training sessions occurred at a similar point in the competitive season for both teams, with roughly equal time till the next upcoming competition.

Both teams trained in similar pools and training sessions, while composed of differing specific activities, followed a generally similar organization for both teams: warm-up and conditioning drills, followed by individual skill drills, finishing with practice of team routines. The first session served to acclimate coaches and athletes to the presence of the researcher and to the recording process in an effort to minimize reactivity (Smith, Smoll, & Hunt, 1977b). The fifth session was used to provide material for coder training, also serving as a backup in case any of the videos for session two, three, or four were unusable. The video for each of the middle three training sessions was then used to code coach and athlete behaviours in accordance with SSG methodology. Two 30-min segments representative of the training session were selected from each of the three videos designated for analysis, resulting in a total of six hours of observation time spread over 12 video segments. All procedures for this study were approved by the general research ethics board (GREB) at the researchers' university prior to initial contact with participants.

Coach–athlete interaction measure

Coding of video data involved the development of a new, contextually-based coding system following a number of Brewer and Jones' (2002) recommendations for contextually valid systematic observation instruments in sport psychology. The newly developed Coach–Athlete Interaction Coding System (CAICS) is intended for observation of in-pool training in a synchronized swimming team environment. The CAICS provides an exhaustive categorization of coach and athlete behaviour. All categories are mutually exclusive. The selection of behavioural categories is discussed below; for detailed descriptions of each category refer to the coding manual (available from corresponding author upon request).

Coach behaviour

The process of developing the CAICS began with the modification of the Coaching Behavior Assessment System (CBAS; Smith et al., 1977a) to capture coach behaviour. The CBAS is one of the most widely used instruments for the observation of coaching behaviours (Kahan, 1999) and the behavioural categories have been shown to differentiate between different psychosocial outcomes in young athletes (see Smith & Smoll, 2007).

Modification of the CBAS were necessary in order to more accurately represent a female youth synchronized swimming context during training and provide the continuous, duration-based coding required for full SSG analysis. These modifications resulted in a final total of 12 behavioural categories to classify coach behaviour: 1) positive reinforcement, 2) corrective encouragement, 3) future encouragement, 4) corrective technical instruction, 5) future technical instruction, 6) organization, 7) observation, 8) general communication, 9) not engaged, 10) keeping control, 11) technical error identification (without corrective information, e.g., "You messed up the leg lift"), and 12) negative evaluation (containing no technical information, e.g., "That was horrible"). The recipient of each of these behaviours (i.e., the whole team or individual athletes) is also recorded, with the exception of the observation and not engaged categories. The specific target of observation could not be reliably distinguished and was thus always coded as whole team, while not engaged is not an interactive behaviour and thus has no recipient. An 'uncodable' category was also included for any instances where the coach was out of the camera view.

Athlete behaviour

Based on observational systems used in physical education settings that code student behaviour (e.g., CAFIAS: Cheffers &

Mancini, 1989) and exploratory qualitative interviews with four youth sport coaches, a complete range of athlete reactive (in response to a coach behaviour) and spontaneous (athlete initiated) interactive behaviours were identified and defined. This process resulted in six categories of interactive athlete behaviour content: 1) technical talking, 2) clarification, 3) acknowledgement, 4) general talking, 5) engaged, and 6) disengaged. These athlete behaviours are coded as directed at the coach, a group of athletes, or other individual athletes (with the exception of the engaged and disengaged categories that have no recipient). An 'uncodable' category was also included for any instances where the athlete was out of the camera view.

Coder training and reliability

Two independent coders not involved in study design or data collection were trained over a period of three weeks on use of the CAICS coding system and tested for reliability before coding data to be analyzed. After initial familiarization and training, the coders used the CAICS to code several 10-min test video segments. The resulting coded data for these test video segments was compared to a 'gold standard' coding of each segment completed by the primary researcher. The coders' data was compared to the gold standard data for inter-rater reliability of both frequency and duration of behaviours in terms of percentage agreement. For each comparison, frequency agreement referred to the total number of occurrences of both coders (the target coder and the gold standard coder) activating the same specific behavioural category within a three second window. Duration agreement referred to the total number of seconds of coded video in which both coders (the target coder and the gold standard coder) had the same specific behavioural code active for each participant. Coders were required to meet a minimum agreement with the gold standard coding of 70% on frequency and 90% on duration reliability checks for two consecutive 10-min test video segments before being allowed to code video to be used in study analysis. After initiating coding for analysis, two full 30-min segments were randomly selected to be coded by both coders, after which the coded data for these segments was compared to each other in a further inter-rater reliability check to guard against observer drift. Again, percentage agreement for both frequency and duration of behaviours was calculated (freq. = 70%, 72%, dur. = 99%, 97%, respectively, for the two segments).

Data analysis

Individual coach–athlete dyads were the primary unit of analysis, comprised of the coach and each individual athlete for each team. As such, 17 dyads were analyzed in total, formed by one coach and ten athletes from team A [+] and one coach and seven athletes from team B [−].On the grids used for analysis, each interactive coach behaviour is presented twice on the *x*-axis to differentiate the recipient of the behaviour (i.e., to whole team or individual athletes), while each interactive athlete behaviour is presented three times (i.e., to the coach, a group of athletes, or other individual athletes). Each cell in the grid represents a distinct interactive state defined by the mutual occurrence of specific coach and athlete behaviours (the *x*- and *y*-coordinates). Dyad measures as dependent variables were grouped by team for comparison purposes. Measures of coach–athlete interaction structures were calculated using GridWare software (Version 1.1; Lamey, Hollenstein, Lewis, & Granic, 2004), designed for the SSG method. Measures were calculated for each team based on three structural concepts: 1) variability, 2) content patterns, and 3) transitions and sequences. These measures were derived from SSGs constructed for each coach–athlete dyadic pair (i.e., coach and athlete A, coach and

athlete B, etc) during each practice. Differences between team A [+] and team B [−] on these measures were tested statistically with independent samples *t*-tests, using Bonferroni-corrected alpha values for multiple comparisons within each conceptual grouping. Adjustments were made for violations of homogeneity where necessary, though uncorrected degrees of freedom are reported for comparison purposes. A significant *t*-test is interpreted as a statistically significant difference in mean score between the teams (averaged across all practice sessions and dyads within each team) on the measure in question.

Variability

The variability of the interactions was assessed by two whole grid parameters. The first variability parameter was the number of Cells visited over the course of the interaction with higher numbers of Cells visited indicating a more variable interaction style, less consistent in patterning. The second parameter was the number of Transitions between cells, with more Transitions indicating a more variable interaction. This second parameter provides additional and different information than the first parameter, as an interaction might be characterized by presence in only a low number of cells but frequent Transitions between those cells.

Content patterns

Unlike variability, which was measured across the whole grid, content patterns were identified by computing and comparing parameters for each cell. Content patterns, areas in the state space to which the interaction tends to be drawn, were identified through two parameters. The first is the Total Duration (in seconds) spent in each cell, with longer times indicating a stronger attraction. Mean Duration or duration-per-visit (with visits representing distinct occurrences of the behavioural state) was the second parameter, with stronger patterns reporting longer durations per visit.

Transitions and sequences

Sequences of coach behaviour specifically were analyzed via lagged phase plots, whereby coach behaviour at a given time (*t*) was plotted along the *x*-axis and the subsequent coach behaviour (*t* + 1) plotted along the *y*-axis. Each cell then represented the transition from the *x*-axis category to the *y*-axis category, from one coach behaviour to another, with more events in a particular cell indicating a more frequently occurring transition. The frequently occurring transitions represent 2-step coach behaviour sequences, with the potential for overlapping frequently occurring transitions to be linked in three or more behaviour sequences.

Results

Variability

Team A [+] was characterized by less variability in coach–athlete interaction during practices than team B [−] on both whole grid variability measures (averaged across athletes and practice sessions). Using a corrected alpha value of .025, team A [+] demonstrated a significantly lower mean number of Cells visited ($M = 38.33$, $SD = 9.80$) than those of team B [−] ($M = 43.37$, $SD = 10.24$; $t(96) = -2.44$, $p = .017$, $d = .50$). As well, the mean number of Transitions between cells was significantly lower for team A [+] ($M = 311.53$, $SD = 41.66$) than for team B [−] ($M = 415.42$, $SD = 55.18$; $t(96) = -9.95$, $p < .001$, $d = 2.12$). Thus, the coach–athlete interactions of team A [+] were generally less variable than those of team B [−]. See Fig. 2 for example trajectories of one dyadic coach–athlete interaction for each team summed across training sessions.

Content patterns

The alpha value for content pattern comparisons was set at .002. Based on inspection of all coach–athlete dyad grids, potential content pattern cells and regions of theoretical interest were identified for each team. The Total Duration (in seconds) per practice session spent in each of these cells or regions of cells were then compared between teams, followed by comparison of the Mean Duration per visit.

Athletes engaged in practice activities

All athletes across both teams spent the vast majority of their time engaged in practice activities (represented by the dark horizontal band across the middle of the grids in Fig. 2), not directly interacting with the coach or peers. As such, differences in coach behaviour patterns while the athlete in each dyad was engaged will be presented first. Table 1 displays comparisons of Total Durations per practice session for coach behaviours while athletes were engaged. Note that the coach of team A [+] spent significantly more time observing her athletes and less time organizing practice activities than did the coach of team B [−]. The difference between the two teams on technical feedback (TFB), a composite region comprised of the cells representing corrective TFB to the team, corrective TFB to individual athletes, and future-oriented technical instruction to the team, did not reach statistical significance. However, the trend towards greater duration in TFB for the coach of team B [−] may be accounted for by significantly more time spent giving corrective TFB to the team than the coach of team A [+]. Table 1 also shows that the coaches of the two teams did not significantly differ on the time they spent giving positive reinforcement (PR) overall. A difference lay in the target of this PR, with the coach of team A [+] directing more PR time to individual athletes and the coach of team B [−] directing more to the team as a whole. The coach of team B [−] also spent more time giving negative feedback (encompassing both the technical error identification and negative evaluation categories) than the coach of team A [+]. The relative occurrence of PR and negative feedback differed between the two coaches as well, with the coach of team A [+] spending more time giving PR than negative feedback while the reverse was observed for the coach of team B [−]. Finally, it should be noted that the coach of team B [−] spent significantly more time disengaged from her athletes (i.e., not interacting with and not observing athletes).

With regard to Mean Duration (duration-per-instance of interaction), the coach of team A [+] displayed significantly longer durations per visit to the TFB region ($M = 8.96$, $SD = 2.32$) compared to the coach of team B [−] ($M = 5.53$, $SD = 1.27$; $t(96) = 9.44$, $p < .001$, $d = 1.83$). Mean Duration comparisons between teams did not reach statistical significance for any other coach behaviours while athletes were engaged.

Athletes' interaction

Table 2 displays the Total Durations per practice session for athletes interactive behaviour directed at the coach. The distribution of all variables representing athletes' interaction with their coach was severely positively skewed (i.e., all skewness values > 2, where normal distribution = 0). Thus, while raw means and standard deviations are provided, the reported comparison *t*-tests were conducted on inverse transformations of the raw scores.

Overall, the athletes of the two teams did not differ on the average duration per practice spent talking to their respective head coaches regarding technical, performance related matters or general, non-sport related topics. More specifically, the two teams did not differ on the average amount of time per practice where coaches and athletes were simultaneously talking (i.e.,
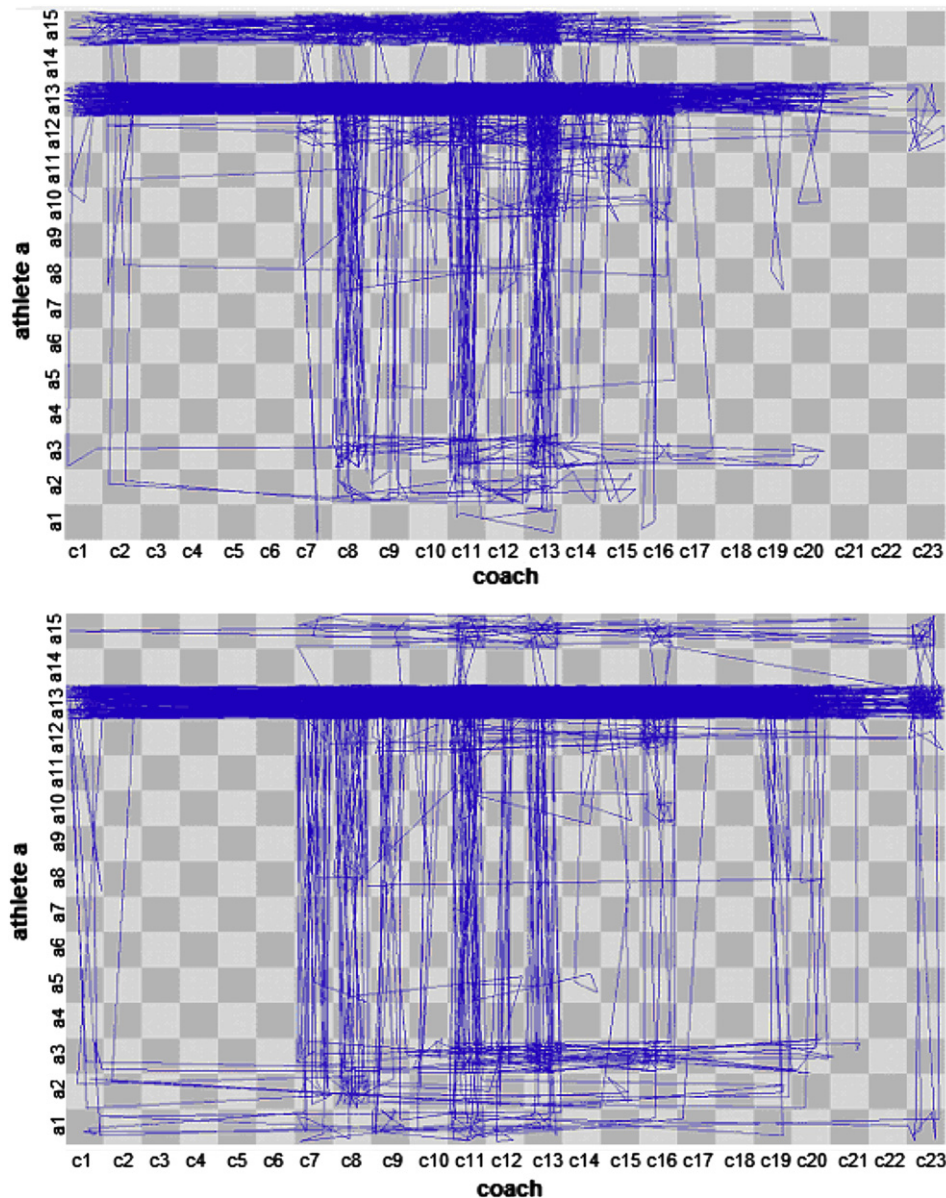
Fig. 2. SSGs for one coach−athlete dyad on team A (top) and team B (bottom) displaying summed trajectories for all practices. *Note*. Coach behaviour: c1 = positive reinforcement (team), c2 = positive reinforcement (athlete), c3 = corrective encouragement (team), c4 = corrective encouragement (athlete), c5 = future encouragement (team), c6 = future encouragement (athlete), c7 = corrective technical instruction (team), c8 = corrective technical instruction (athlete), c9 = future technical instruction (team), c10 = future technical instruction (athlete), c11 = organization (team), c12 = organization (athlete), c13 = observation, c14 = general communication (team), c15 = general communication (athlete), c16 = not engaged, c17 = keeping control (team), c18 = keeping control (athlete), c19 = technical error identification (team), c20 = technical error identification (athlete), c21 = negative evaluation (team), c22 = negative evaluation (athlete), c23 = uncodable. Athlete behaviour: a1 = technical talking (team), a2 = technical talking (coach), a3 = technical talking (athlete), a4 = clarification (team), a5 = clarification (coach), a6 = clarification (athlete), a7 = acknowledgement (team), a8 = acknowledgement (coach), a9 = acknowledgement (athlete), a10 = general talking (team), a11 = general talking (coach), a12 = general talking (athlete), a13 = engaged, a14 = disengaged, a15 = uncodable.

Table 1
Comparison of mean duration (seconds) per practice session for coach behaviours while athletes were engaged in practice activities.

Coach behaviour	Team A [+] M (SD)	Team B [−] M (SD)	t (df)	p (d)
Observation	426.44 (151.89)	264.95 (81.68)	6.82 (96)	<.001 (1.32)
Organization	323.58 (107.11)	428.92 (128.34)	−4.39 (96)	<.001 (.89)
Technical feedback (TFB)	375.99 (84.39)	418.80 (63.13)	−2.86 (96)	.005 (.57)
Team corrective TFB	74.78 (46.19)	129.03 (81.46)	−3.74 (96)	<.001 (.82)
Ind. corrective TFB	155.66 (46.58)	148.86 (51.11)	.68 (96)	.500 (.14)
Team technical instruction	145.56 (45.24)	140.90 (22.19)	.68 (96)	.499 (.13)
Total positive reinforcement (PR)	64.76 (26.53)	67.77 (14.90)	−.72 (96)	.474 (.14)
Team PR.	25.84 (9.47)	43.91 (28.15)	−3.82 (96)	<.001 (.86)
Ind. PR.	38.92 (19.50)	23.86 (19.55)	3.72 (96)	<.001 (.77)
Negative feedback	19.92 (12.12)	105.54 (41.78)	−12.31 (96)	<.001 (2.78)
Not engaged	57.50 (59.92)	192.66 (105.10)	−7.22 (96)	<.001 (1.58)

Table 2
Comparison of mean duration (seconds) per practice session for athlete behaviours directed at coach.

Athlete behaviour	Team A [+] M (SD)	Team B [−] M (SD)	t (df)	p (d)
Technical (sport) talk total	4.78 (9.34)	8.67 (11.30)	−2.09 (96)	.039 (.38)
General (non-sport) talk total	5.21 (15.94)	2.08 (4.91)	−1.21 (96)	.229 (.27)
Technical (sport) discussion	1.55 (3.63)	3.43 (5.59)	1.98 (96)	.052 (.40)
General (non-sport) discussion	3.21 (11.95)	.89 (2.86)	−.97 (96)	.334 (.27)
Acknowledgement total	3.25 (4.19)	1.09 (1.58)	−3.69 (96)	<.001 (.68)

Note. Alpha value = .002. Discussion refers to instances where athlete and coach both exhibited the same behaviour towards each other in conversation-type interaction.

conversation-type interaction), either about technical, performance related topics or general, non-sport related topics. The athletes of team A [+], however, did spend significantly more time directly acknowledging the receipt of information from the coach (e.g., "Ok, got it") than did the athletes of team B [−].

Transitions and sequences

The lagged phase plot SSG (coach behaviour plotted against subsequent coach behaviour − same categories on each axis) for each coach summed across all practices is presented in Fig. 3. Though not accounting for changes in athlete behaviour, the cells in the lagged phase plot are a rough proxy for the lines connecting cells in the first variability analysis (Fig. 2), the transitions between behaviours. Each cell in the lagged phase plot represents the consecutive pairing of two distinct coach behaviours, a direct first order transition from one behaviour to another. For example, one cell might represent a transition from corrective encouragement (x-axis coordinate) to corrective technical instruction (y-axis coordinate). The lines between cells in the lagged phase plot then represent second order transitions linking these first order transitions between individual behaviours into longer sequences of three or more behaviours.

The transitions of the coach of team A [+] were contained within a significantly lower number of cells (M = 88.50, SD = 6.22) than were the coach of team B [−] (M = 119.17, SD = 12.83; t(10) = −5.27, p < .001, d = 3.04), indicating less variability in the sequencing of interactive behaviours. However, there were no significant differences in the mean total number of first order transitions per practice session, the number of transitions between any two coach behaviours overall (team A [+] M = 425.83, SD = 53.48; team B [−] M = 486.50, SD = 74.95; t(10) = −1.61, ns, d = .93). That is, the coach of team A [+] regularly used a smaller pool of specific behavioural transitions while the coach of team B [−] made use of a greater variety of specific behavioural transitions, though both exhibited an approximately equal number of first order transitions overall.

The nature of this difference in variability between coaches is reflected in measures of frequently occurring specific first order transitions, identified as dark areas on the SSGs in Fig. 3. Both teams shared a similarly high frequency of transitions from the organization and observation categories into the technical feedback categories (TFB) (team A [+] M = 30.00, SD = 8.97; team B [−] M = 33.50, SD = 14.90; t(10) = −.49, ns, d = .28) and the reverse transitions (team A [+] M = 29.50, SD = 8.60; team B [−] M = 34.50, SD = 12.88; t(10) = −.79, ns, d = .46), represented by the dark central portion of both grids. The coaches of the two teams differed, however, in the pattern of most frequently used sequences outside

the organization/observation−TFB pairing. This analysis was targeted at identifying a unique pattern of typical interaction sequences for each coach; thus, the two coaches were compared on which transitions were exhibited most frequently by each rather than on the relative occurrence of specific transitions.
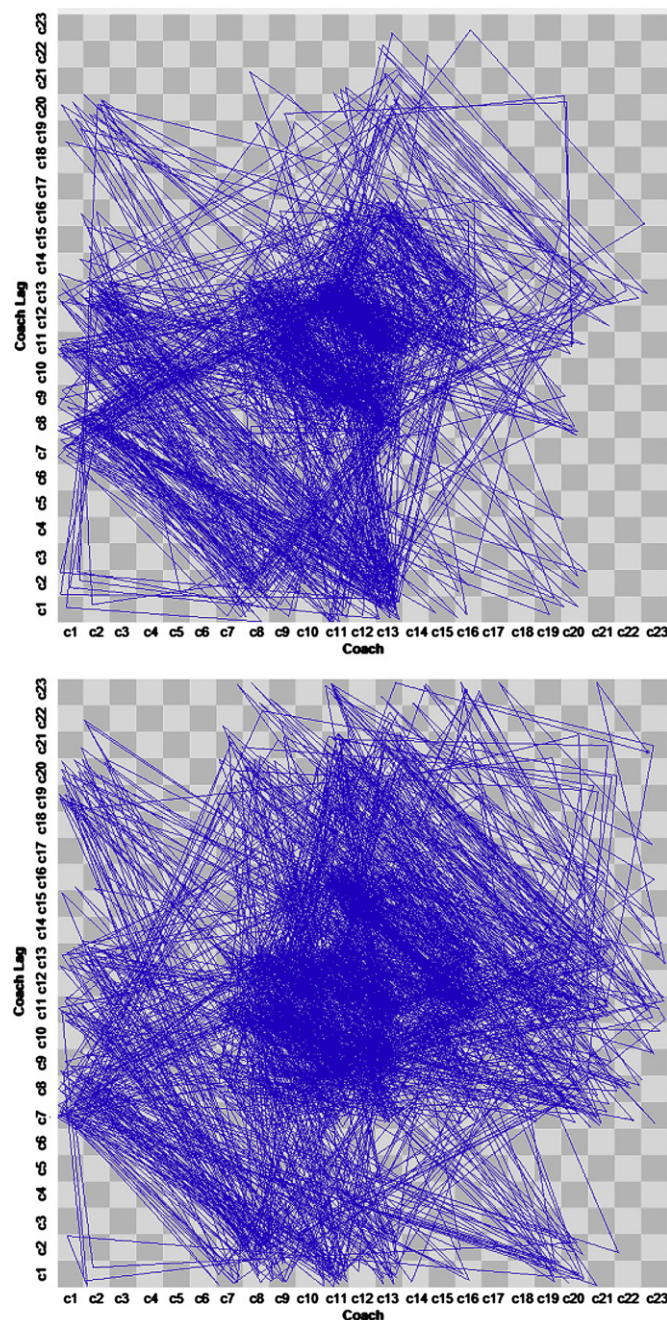

Fig. 3. The lagged phase plot SSGs for the coach of team A (top) and team B (bottom) summed across all practices, with coach behaviour at a given time on the x-axis and the subsequent coach behaviour (lag) on the y-axis. *Note.* Coach behaviour: c1 = positive reinforcement (team), c2 = positive reinforcement (athlete), c3 = corrective encouragement (team), c4 = corrective encouragement (athlete), c5 = future encouragement (team), c6 = future encouragement (athlete), c7 = corrective technical instruction (team), c8 = corrective technical instruction (athlete), c9 = future technical instruction (team), c10 = future technical instruction (athlete), c11 = organization (team), c12 = organization (athlete), c13 = observation, c14 = general communication (team), c15 = general communication (athlete), c16 = not engaged, c17 = keeping control (team), c18 = keeping control (athlete), c19 = technical error identification (team), c20 = technical error identification (athlete), c21 = negative evaluation (team), c22 = negative evaluation (athlete), c23 = uncodable.

In this regard, the coach of team A [+] most often combined observation with subsequent positive reinforcement (PR) to individual athletes ($M = 7.33$, $SD = 1.75$) and PR to individual athletes followed by corrective TFB to individual athletes ($M = 7.17$, $SD = 3.49$) or by observation again ($M = 6.00$, $SD = 3.16$). The coach of team A [+] also commonly used the related sequence of corrective TFB to individual athletes followed by PR to individual athletes ($M = 5.67$, $SD = 1.86$). This pattern indicates the consistent use of positive feedback for the coach of team A [+], either in concert with individualized corrective information regarding skill performance or as a stand-alone communication (as in the transition to and from observation). Such sequences of behaviour are represented by lines connecting two cells, two frequently occurring first order transitions, on the lagged phase plot (Fig. 3).

The coach of team B [−] also used this corrective TFB to individual athletes followed by PR to individual athletes behavioural sequence ($M = 5.83$, $SD = 5.85$), but additionally used sequences including less positive behaviour categories to an equal or greater degree. Specifically, practices of the coach of team B [−] included relatively high frequencies of organization followed by disengagement from athletes' practice activities (i.e., not interacting with or observing athletes; $M = 12.67$, $SD = 13.13$) and the reverse transition ($M = 13.33$, $SD = 10.91$). Also commonly used were the sequences of organization to technical error identification (without corrective TFB, $M = 5.83$, $SD = 4.96$) and the reverse ($M = 5.17$, $SD = 2.48$). In real-world terms, these sequences represent getting athletes started on a drill, then either not paying attention for a period of time before moving the athletes to another drill without providing any feedback (organization–disengagement–organization), or immediately providing only negative feedback without any sustained observation (organization–technical error identification–organization). Again, these sequences of behaviour represent the combination of two first order transitions (two cells in Fig. 3).

Discussion

The purpose of the present study was to compare the coach–athlete interaction structures of two competitive youth synchronized swimming teams, one more successful with regard to performance and aspects of athlete personal development (team A) than the other (team B). The two teams differed on a number of measures of coach–athlete interaction structure, which were effectively identified through the use of SSG analysis. While no explicit causal links between coach–athlete interaction structures and athletes' performance and personal development outcomes can be made based on this differentiation, noted differences will be used to characterize the two different youth sport environments. Finally, reflections on the initial application of SSG methodology to applied sport psychology will be considered.

Variability

The coach–athlete interactions of team A [+] were more consistent and patterned than those of team B [−]. While no previous coaching research has directly measured behavioural variability, the idea of reduced variability as more effective may initially seem to run counter to the conclusions of some recent qualitative and theoretical studies highlighting the complexity of the coaching process (Bowes & Jones, 2006; Jones, 2004). These authors argue that successful coaching is characterized by a high degree of flexibility necessitated by ever-changing situations and circumstances. The results of the current study do not directly negate this characterization but instead provide a more detailed view of how coaches actually respond to the inherent complexity of

contexts in which they work. Two previous studies offer insight that aids the interpretation of the present results. First, D'Arripe-Longueville et al. (2001) qualitatively identified a number of archetypal courses of interaction between coach and athlete, consistently manifested across highly unstable performance conditions in elite level archery competitions. Second, Saury and Durand (1998) concluded that expert sailing coaches' operating (decision-making) modes while running training sessions were enacted as flexible routines and plans based on higher-order general principles. These authors argued that it was this flexible application of larger plans that allowed coaches to accomplish set objectives within complex, aleatory (dependant on unpredictable events/actions) situations. Interpreting the present results in this manner, it might be argued that successful coaches respond to the unpredictability of the coaching context in relatively patterned, predictable ways designed to further their coaching aims. Part of coaches' success may lie in the ability to apply consistent modes of practice to a wide variety of circumstances.

The ability to measure and track interaction variability provided by the SSG methodology offers exciting new avenues for research in sport psychology. By being able to generate and analyze these data, we may be in a better position to understand not only what coaches do, but how they do it. Targeting higher-order qualities of interactions such as variability may allow more process-oriented examination of these critical interpersonal features of sport environments. In doing so, SSGs present a quantitative complement to the primarily qualitative studies of coaching process conducted thus far (e.g., D'Arripe-Longueville et al., 2001; Saury & Durand, 1998), providing a method to quantitatively test the hypotheses generated by such work.

Behaviour content patterns

For both team A [+], and team B [−], the largest duration across all sessions was characterized by athlete engagement in practice activities (on task), as would be expected of traditional sport training sessions. It was the differences in coach behaviours while athletes were on task and in athlete communication to the coach that most effectively discriminated between the two teams.

While athletes were engaged in practice activities, the coach of team A [+] spent the most time of all coaching behaviours silently observing her athletes. In contrast, the coach of team B [−] spent the most time organizing practice activities. Cushion and Jones (2001) argued that not only is observation necessary for optimal analysis of athlete performance, but also an essential part of feedback sequencing such that any presented information is not "diluted by continuous interaction" (p. 369). It appeared that the coach of team B [−] spent more time concerned with the mechanics of running a practice (organization) rather than in-the-moment evaluation of skill acquisition and improvement.

Both coaches spent the second highest amount of time giving technical feedback (TFB), consistent with the conclusions of Douge and Hastie's (1993) comprehensive review of coach behaviour research that effective coaches exhibit high levels of instructive behaviour. Though the two coaches did not differ on the total time spent giving TFB, the coach of team A [+] spent less time giving TFB to the team as a whole unit and more time on each instance of TFB, primarily to individual athletes. One might infer from these results that, given adequately high levels of instruction, the direction (individual versus team) and duration then become salient qualities in determining the efficacy of that TFB.

Similarly, while no differences were noted for total time spent giving PR, the coach of team A [+] spent more of this time directing PR to individual athletes rather than the entire team or groups of individuals. The coach of team B [−] also spent more time giving

negative feedback without any corrective information. The higher degree of negative feedback from the coach of team B [−] is consistent with the findings of Smith, Smoll, and colleagues (see Smith & Smoll, 2007) that increased negative feedback was associated with negative athlete outcomes. However, the lack of differences regarding total PR duration alone, which was postulated as a primary differentiator of athlete outcomes by Smith, Smoll, and colleagues, suggests that the individualization of this PR may be a key aspect of its effectiveness.

In more general terms, the findings of the present study also lend new insight into the nature of coaching behaviours and the critical dimensions that best reflect their differential occurrence. For further depth of understanding, the coach TFB and PR results support the utility of conceptualizing behaviour as a function of direction (to whom?) and duration as well as content, rather than simply an instantaneous occurrence by an isolated actor as in simple frequency counts. While not limited to purely SSG analysis, the continuous coding of the behaviour of multiple actors that is most appropriate for the method allows such duration- and direction-based investigation, both underexplored to date in the study of coach behaviour.

The two teams were very similar in the amount of time athletes spent communicating with their coach, both on technical/performance matters and more general non-sport related conversation. The teams only differed in coach-directed communication in the form of acknowledging receipt of technical information, often a head nod or "Got it", with the athletes of team A [+] exhibiting significantly more of this type of communication. Little, if any, previous research has directly observed the communication from athlete to coach. However, this pattern may reflect aspects of the cooperative focus that Saury and Durand (1998) refer to as the joint process of coaching and similarly Jowett's (2007) notion of behavioural complementarity as central to the quality of coach–athlete relationships according to the 3 + 1 C's model. This finding represents one of the primary advantages of the SSG method: the ability to consider both actors in dyadic interactions. By accounting for the contribution of the athlete to coach–athlete interactions, SSGs offer an empirical strategy for the behavioural dimension of Poczwardowski et al.'s (2006) conceptualization of coaches and athletes as interactive dyads.

Coach behaviour sequences

The lower variability in behavioural sequencing observed for the coach of team A [+] is related to the overall decreased behavioural variability noted earlier. In particular, this finding extends the notion of a more patterned interaction style characterizing the coaching process of team A [+]. In utilizing fewer behavioural options in her interactions with her athletes, this coach also limited the way in which she combined them. In essence, her choices to pair specific behaviours on a regular basis indicate a prescribed pattern of communication.

The content of this consistent pattern of reduced variability can be understood through examination of the most commonly used specific sequences of behaviours and pairings of sequences, linking two frequently occurring first order transitions into a string of three behaviours. The coach of the more successful team relied heavily on pairings of positive reinforcement (PR) with TFB, often beginning and ending interactive sequences with PR. This prototypical 'positive sandwich' was a key component of coach of the more successful team's patterned mode of practice. In contrast, within the significantly increased sequencing variability displayed by the coach of team B [−] were the outlines of a pattern that paints a different picture. Pairings of disengagement–organization and the reverse suggest periods of relative disinterest (or other

competing interests) in the performance and progress of the athletes, so long as they are doing the assigned activity. This is combined with pairings of organization-negative feedback and the reverse, which implies a flurry of information (often purely negative) without any sustained observation. Analysis of the temporal sequencing of these behaviours, another structural quality of coach–athlete interactions, was again made available and accessible through application of SSG methods.

Limitations and future directions

The implications of these findings should be considered in light of the limitations inherent to the study. First, the study was conducted as a comparison of only two youth sport environments, comprised of two head coaches and their athletes (17 dyads analyzed in total). Comparison across a greater number of environments would certainly be beneficial and would strengthen the arguments regarding the nature of coach–athlete interactions most conducive to producing positive athlete outcomes. However, the depth of analysis and the research time and effort required to carry it out necessitated the limiting of the sample to two teams. Given the exploratory and methodological focus of this study, this depth was judged to be of greatest importance. This prioritization of depth of analysis in exploratory phases is consistent with previous research of this sort in sport psychology (e.g., D'Arripe-Longueville et al., 2001; Gernigon, D'Arripe-Longueville, Delignieres, & Ninot, 2004). The direction provided by the resulting findings might now be studied in greater breadth in future research.

Second, a number of athlete individual difference and training content factors may have contributed to the noted differences in coach–athlete interactions structures. For example, the personality of individual athletes on each team was not controlled for and may have influenced how their coaches interacted with them and vice versa. Similarly, while efforts were made to ensure as equivalent a competitive environment for the two teams as possible (i.e., same point in season, same time till next competition, same general organization of training) the nature of the specific training activities was not accounted for. The objective of a given activity (e.g., learning a new skill versus refining a well-learned skill) may necessitate differing coach–athlete interaction patterns. This consideration may be a productive area for more in-depth future examination with SSG methods.

Finally, it is uncertain how generalizable the present findings are to other sports or competitive contexts. It may be that the observed structural qualities are reflective only of the synchronized swimming environment. Even within synchronized swimming, these patterns may not represent good practice in older, more elite or younger, more recreational athletes. It is important to remember, though, that it was not the intention of the study to provide recommendations beyond the competitive youth context. Given the recent recognition of the uniqueness of different coaching contexts (determined by athlete age and competitive level; Côté & Gilbert, 2009), the present study provides justification for a range of previously unconsidered measures that may be useful in the analysis of these different contexts.

Methodological reflections

Overall, the use of an interactive systems framework and SSG methodology allowed us to address Poczwardowski et al.'s (2006) recommendations for the productive study of coach–athlete relationships. Specifically, we were able to focus on the dyad as the central unit of analysis rather than individuals, with a methodology targeted to the research question of interest. In this case, the dynamic and structural characteristics of coach–athlete interaction

were of primary interest, objective measures of which were unavailable from traditional observational methods. Through the first application of SSG methods to applied sport psychology research, we were able for the first time to measure behavioural variability, time-based content patterns, and sequences of coach–athlete interactions. These measures proved informative in differentiating between two youth sport environments characterized by different athlete outcomes, capturing a previously inaccessible level of complexity. This preliminary investigation suggests that the development of SSG methodology opens the door to a host of new research questions in the study of interpersonal interactions in sport, including but certainly not limited to the structural measures identified in the present study.

Acknowledgements

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