

Technology-enabled reflection enhances coaching behavior in youth tennis coachess

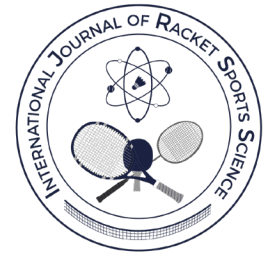
La reflexión mediada por la tecnología mejora el comportamiento de los entrenadores de tenis juvenil

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Abstract

Sports coaches have an important role to play in the development of their participants. One way that coaches can do this effectively is to ensure their behavior is appropriate for the people they coach. Previous research has highlighted that coaches are unaware of their behavior and how this impacts their participants. This study aimed to investigate the effectiveness of technology on reflection in sports coaches and explore the influence of enhanced critical reflection on coaching behavior. The study was underpinned by theoretical frameworks on reflection. In this study, experienced and qualified tennis coaches (n=3) were video- and audio-recorded three times over nine weeks delivering sessions to youth participants (n=7). Coaches had their behavior coded using the Arizona State University Observation Inventory. After each session, coaches reflected on recordings and sent reflections to researchers. Follow-up interviews were conducted with each coach. The results showed increased self-awareness of behavior, increased quality of reflection, and enhanced coaching behavior. The study findings suggest that technology is effective in aiding reflection and coaching behavior in youth tennis coaches. From this, it is recommended that National Governing Bodies, clubs and coach developers use similar interventions to enhance the quality of coaching.

Keywords: Behavior, coaching, intervention, racket sport, technology.

Resumen

Los entrenadores deportivos desempeñan un papel importante en el desarrollo de sus deportistas. Una forma en que los entrenadores pueden hacer esto de manera efectiva es asegurándose de que su comportamiento sea apropiado para las personas a las que entrenan. Investigaciones anteriores han encontrado que los entrenadores no son conscientes de su comportamiento y de cómo este afecta a sus deportistas. El objetivo de este estudio fue investigar la eficacia de la tecnología en la reflexión de los entrenadores deportivos y explorar la influencia de una mayor reflexión crítica en el comportamiento de los entrenadores. El estudio se basó en marcos teóricos sobre la reflexión. En este estudio se grabaron en video y audio tres veces durante nueve semanas a entrenadores de tenis experimentados y cualificados (n = 3) impartiendo sesiones a deportistas jóvenes (n = 7). Se codificó el comportamiento de los entrenadores utilizando el Instrumento de Observación de la Universidad Estatal de Arizona (ASUOI). Después de cada sesión, los entrenadores reflexionaron sobre las grabaciones y enviaron sus reflexiones a los investigadores. Se realizaron entrevistas de seguimiento con cada entrenador. Los resultados mostraron una mayor conciencia de la conducta, una mayor calidad de la reflexión y una mejora en la conducta de entrenamiento. Los resultados del estudio sugieren que la tecnología es eficaz para ayudar a la reflexión y a la conducta de entrenamiento en los entrenadores de tenis juvenil. A partir de esto, se recomienda que los órganos rectores nacionales, los clubes y los formadores de entrenadores utilicen intervenciones similares para mejorar la calidad del entrenamiento.

Palabras clave: conducta, entrenamiento, intervención, deportes de raqueta, tecnología.

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INTRODUCTION

Sports coaching has become increasingly professionalized in recent decades, reflected in the growing emphasis on learning and development (Cope et al., 2022). Common methods that have been employed to help coaches learn and develop have included reflection, mentorship, coach education qualifications, networking, and continuous professional development (CPD) (Stodter & Cushion, 2019). An additional method that has been used for decades with coaches is systematic observation, which is a process in which an observer codes behavior that a coach exhibits during their practice using an inventory of behaviors for reference (e.g., Lacy & Darst, 1984; Partington et al., 2015). Systematic observation comes with benefits for coaches, observers and researchers such as increased awareness of behavior and providing quantitative data for comparison between various contexts. However systematic observation also comes with a significant limitation – results provide little on the quality, or effectiveness, of the coaching behavior observed (Cushion et al., 2012). To address this issue, mixed methods approaches have been applied when studying coach behavior. Researchers employ quantitative methods (e.g., systematic observation using an observation schedule) (e.g., Cope et al., 2021) and follow-up with qualitative methods such as interviews and video and audio recordings of the coach during the session (e.g., Glen et al., 2020), which allows for behavior, and the underlying reasons for the behavior, to be studied and better understood.

One of the most influential factors in all levels of sport is coaching behavior. How a coach behaves with the athletes under their tuition can have a significant influence on the participation, retention, skill acquisition and, for many the pinnacle, the performance of their athletes (Berntsen & Kristiansen, 2019). The desired and required behavior of sports coaches varies and is affected by a range of factors and contexts. These factors include, but are not limited to, age, gender, ability level and cultural influences such as nationality (Henderson et al., 2022). A coach who can adapt their behavior to meet the athletes' needs and desires to maximize participation and performance benefits for their athletes. For a coach to align their behavior with the needs and desires of their athletes, they need to be aware of the factors discussed. Coaches can only align their behavior if they are aware of how they normally behave when interacting with their athletes. This may seem like a statement that lacks influence, but there is often misalignment between how a coach thinks they behave and how they actually behave, or, more importantly, how they are perceived by their athletes (Partington et al., 2015). Without an increase in coach self-awareness, some suggest that coach education can be effectively futile (Cope et al., 2022). One of the main implications of this misalignment is that increasing awareness of one's own behavior can be highly beneficial to improving

coaching behavior in future sessions (Partington et al., 2015).

A growing body of literature has suggested ways to improve the awareness of coaching behavior and how to integrate it into coach education programs and NGB structures. One way to do this is through the incorporation of technology into coaching practice. When integrating technology into coaching behavior interventions, the apparatus and delivery method used must be up-to-date and fit-for-purpose as failure to do so may result in disengagement from coaches because of issues such as time and technical difficulties (Schenk & Miltenberger, 2019). This is becoming less of an issue, as technology within the context of sport and coaching is becoming ever more accessible (Lavalley et al., 2020). Technology to aid coaching awareness has been studied (e.g., Cope et al., 2021; Partington et al., 2015), but it is still used more for athletes than coaches. Further integration should enhance self-awareness and monitor changes over time. Systematic observation, alongside video technology, has been recommended to be integrated into coach education and practice (Cope et al., 2022), with researchers encouraged to use it as a tool to aid the learning and development of the coaching participants within studies.

Reflective practice is an area that has been investigated in numerous fields for various practitioners, including sports coaching, for decades. It is crucial for the development of expertise and improved practice of coaching (Silva et al., 2020). The work of Gilbert and Trudel (2001) within a sports coaching environment was informed by the reflective framework proposed by Schön (1983) that highlighted that professional development is accelerated by practitioners reflecting 'in practice' (during the event) and reflecting 'on practice' (after the event). Gilbert and Trudel (2001) developed this model further in their observational research with youth soccer and ice-hockey coaches to investigate how coaches reflect in their environment. They proposed in their adapted reflective framework that there are three distinct ways that accomplished coaches learn through reflection: reflection in-action (*during the action of coaching*); reflection on-action (*within the action, but not actively coaching it*); and retrospective reflection on-action (*away from the action of coaching*) (Gilbert & Trudel, 2001).

This work has informed several more recent studies into the area which have been systematically reviewed (Silva et al., 2020) and has also had a direct impact on the work of coaches and those associated with coaches and coaching (Cope et al., 2022). In the United Kingdom, NGBs have realized the importance of reflective practice and many embed this as a key component in their higher-level coaching badges. Initially this was conducted through real life 'scenario' type coaching sessions under assessment conditions (Nelson & Cushion, 2006); however, within more

recent research there have been attempts made to incorporate modern technology, such as video, audio and online reflective journals, alongside this reflection to improve the validity and accessibility of these reflections (Silva et al., 2020). This work can have practical implications for the future of sports coaching and sports coaching education.

This study aimed to investigate the effectiveness of technology on reflection in sports coaches employing the framework proposed by Gilbert and Trudel (2001). We also aimed to explore the impact of enhanced critical reflection on coaching behavior. Our study focused on longitudinal behavior change in tennis integrating video and audio resources available to aid reflection, with a focus on retrospective reflection on-action (Gilbert and Trudel, 2001). The study used audio and video technology, alongside measures to code coaching behavior using the Arizona State University Observation Inventory (ASUOI) and qualitative measures (semi-structured interviews) post-observation to gain an understanding as to why, or why not, behaviors changed.

MATERIAL AND METHODS

Participants

Coaches. Three tennis coaches took part in this study. This is typical of observation-based research in the field of sports coaching (cf. Partington et al., 2015; Guzmán & Calpe-Gomez, 2012). The coaches recruited had a minimum of Lawn Tennis Association (LTA) Level 2 coaching qualification and one was working towards their LTA Level 3 during this study. The coaches each had a minimum of two years coaching experience at the time of recording and all continue to play competitively. Coaching participants received a participant information sheet and participation was entirely voluntary. The study received institutional ethical approval and informed consent was attained from coaches prior to any data collection. Two of the coaches participated in a previous study by the researchers (Glen et al., 2020). They were contacted by a research advertisement within the club sent via email. The other participant joined as a result of the research advertisement in the club. Each coach was at a different stage in their coaching pathway: Coach 1 (Female, LTA Level 5, 32 years of experience, national level coach); Coach 2 (Male, LTA Level 3, 4 years of experience, regional and club level coach); and Coach 3 (Female, LTA Level 2, 2 years of experience, regional and club level coach).

Players. Players (N=7) were between the ages of 7-12 years old and were a mixture of male (N=6) and female (N=1). Playing participants who took part in the study competed at a range of regional and national level and therefore had experience being coached and

playing competitively. Each player had participated in coaching sessions delivered by the associated coach prior to the commencement of this study and therefore had a pre-existing relationship with the coach. Parental informed consent and player informed assent were attained before any data collection. These forms were emailed to parents by the coach before the sessions. They were then handed in to the researchers by both email and hard copies. These were stored under the ethics protocol and data management plan approved by the university.

Procedure

Quantitative. Sessions were all recorded at an outdoor artificial clay court at a tennis club in a major city in Scotland. No sessions were postponed because of the weather, but conditions were variable, with wind and rain affecting several sessions. The sessions took place between the months of May and July. This was in order to have the best possible chance of consistent weather in a climate that is very changeable (James et al., 2019). This also aligned with the sessions put on by the club and availability of court times. Each coach was recorded on three separate occasions similar to Cope et al. (2021) with a minimum of two weeks and a maximum of four weeks between each session per coach to allow for in-depth reflection between sessions. Two coaches (Coach 1 & 2) were filmed delivering individual sessions, while one coach (Coach 3) was filmed delivering group sessions. This was based on their timetable and availability and allowed consistency between sessions. The time gap between sessions also allowed the researchers time to upload, combine and share the relevant audio and video files. The average time per coaching session was 40 minutes and 24 seconds and sessions ranged between 31-48 minutes across all coaches.

Video Collection Procedure. A Panasonic Model SD90-04 was used to record each session and was mounted on a tripod and placed in an elevated position at the back of the court for each session. This allowed for the entire court to be observed throughout the session. The only movement of the camera was zooming in and out at appropriate times throughout the session. Upon completion of each session the files were saved into MP4 format for integration with audio files.

Audio Collection Procedure. A wireless microphone (Fifine Technology model K031) was used to collect audio recordings from the coach. The microphone was clipped onto to a t-shirt or tracksuit top between 10-20cm from the mouth of the coach. Audacity technology was used on the first author's laptop with the receiver USB drive attached. This allowed for the quality of sound and pitch of the recordings to be checked as they were taking place. The first author was also listening as recordings were taking place. Upon completion of each session the files were saved into MP3 format for integration with video files.

Procedure for Sharing Files. Video and audio files were combined to allow for ease of use for the coaching participants. This was achieved by using Adobe Acrobat Pro. The audio from the MP3 files was uploaded into the MP4 (video) files with the audio from the original MP4 (video) files being removed. This allowed the researchers to overlay the higher quality audio collected by the wireless microphone over the lesser quality audio collected by the camera. The integrated file was uploaded to a private YouTube channel and the link was shared with the relevant coach.

Coding of Behavior. The apparatus used for quantitative data collection was the ASUOI; [Lacy & Darst, 1984](#)). The ASUOI has 15 categories of behavior which are distinct and well defined (see [Table 1](#)). The ASUOI is among the most commonly used method of measuring and coding coaching behavior ([Cope et al., 2017](#)). Coaching behavior in tennis has been measured using the ASUOI in both face-to-face (e.g., [Claxton, 1988](#)) and online (e.g., [Glen et al., 2020](#)) environments, enhancing the rationale for the choice of this method. The first author observed the coaching sessions live and coded coaching behaviors via the ASUOI afterwards using the audio and video available to ensure accurate recording. The first author made field notes for each session to give context around factors, such as weather and incidents, that may have affected the session. After each session, the results of the ASUOI and the combined audio/video file were made available to the coach for reflection to take place. This was conducted in accordance with previous studies (e.g., [Potrac et al., 2007](#); [Glen et al., 2020](#)).

Upon completion of all sessions, data from each coaching session was presented in a Figure ([Figures](#)

[2, 3 and 4](#)) where the data was presented in total number of behaviors, rates of behaviors exhibited per minute (RPM) and total percentage of behavior. The 'Use of first name' was treated as an independent category (cf., [Lacy & Darst, 1984](#)). This was presented for each coach individually. Overall results were also shared with the relevant coach prior to the interview at the end of the study. Because of the small sample size, no statistical tests were conducted to check for statistically significant differences and effect sizes.

Qualitative

Reflections on Sessions. Reflective practice, particularly when combined with video footage, has been instrumental to the behavior change of sports coaches ([Partington et al., 2015](#)). After reviewing their session back on the combined video and audio file shared with them, the coaching participant sent their reflections on their session to the researchers. The coaches were given the option of providing their reflections in either written format ([Cronin & Armour, 2017](#)) or audio recording ([Stoszkowski & Collins, 2014](#)). The purpose of this was for the researchers to evidence that the participants were reflecting upon their session in depth and thinking about the implications for future sessions. Nine detailed reflections were provided to the researchers and retained by each participant (three each). These reflections were recorded and transcribed (where audio was provided). This was conducted to allow more depth in their answers regarding specific instances and thoughts that were highlighted in the reflections provided. The researcher then used the reflections to inform the semi-structured interview for each participant.

Table 1
ASUOI Categories and Definitions

Category	Definition
Use of First name	Using first, or nickname when talking to a player
Pre-Instruction	Information given to players prior to desired action to be executed
Concurrent Instruction	Cues or reminders given during the skills or play
Post-Instruction	Correction, re-explanation or instrumental feedback given after drill/play
Questioning	Any question to platers concerning strategies or techniques
Physical Assistance	Physically moving the player's body to proper position or correction motion
Positive Modelling	A demonstration of correct performance/technique
Negative Modelling	A demonstration of incorrect performance/technique
Hustle	Verbal statements designed to intensify the efforts of the player(s)
Praise	Verbal or non-verbal compliments, statements or signs of approval
Scold	Verbal or non-verbal behaviours of displeasure
Management	Verbal statement related to organisational details of practice or games
Uncodable	Any behaviour that cannot be seen/hear or fits into the above categories.
Silence (On-task)	Coach isn't talking but is obviously involved in action of game.
Silence (Off-task)	Coach isn't talking and obviously involved in tasks unrelated to the game

Data Collection. A semi-structured interview was conducted with each coach (three total interviews). The areas for discussion and potential prompts were in accordance with the interview schedule. The mean length of the interview was 34 minutes 27 seconds, with interviews ranging in length between 24 minutes, 4 seconds and 39 minutes, 46 seconds. Each interview was conducted face-to-face in a quiet, private room at the tennis club where the coaches were based to ensure that a suitable location was used and there was less chance of interruption from external sources (Eppich et al., 2019). Each interview was recorded using a Zoom H1 dictaphone which has been used by the researchers in a prior study (Glen & Lavallee, 2019). Interviews were then transcribed verbatim for analysis.

Data Analysis. Upon transcription of the interviews, a thematic analysis was conducted to identify common themes (Braun & Clarke, 2022). The initial coding stages were conducted by the lead author. Following this, both authors collaborated on the remaining stages of the analysis. Consequently, the data from the initial codes was reviewed for potential themes by both authors; this allowed for the authors to recognize perceptions of the coaches involved and understand commonalities between their answers.

RESULTS AND DISCUSSION

The analysis process resulted in the development of seven subthemes and three main themes. The three main themes were termed: Technology Raises Awareness of Behavior; Increased Awareness of Behavior Leads to Enhanced Reflection; and Enhanced Reflection Can Lead to More Effective Coaching Behavior. Consistent with conceptualizing reflection as a process involving learning and adaptation through experience, the main themes are not discrete but overlap across three stages, with each stage building on the previous one (Figure 1). The results are presented below in order across this three-stage process, with quotes highlighting relevant subthemes.

Technology Raises Awareness of Behavior

All coaches noted that the video and audio technology was minimally intrusive and had little effect on their behaviors and interactions with their participants. One of the coaching participants (Coach 2) offered insight into this below:

I think after the first like 15 minutes of the first lesson or something I've settled into doing it normally and I think it was good cause

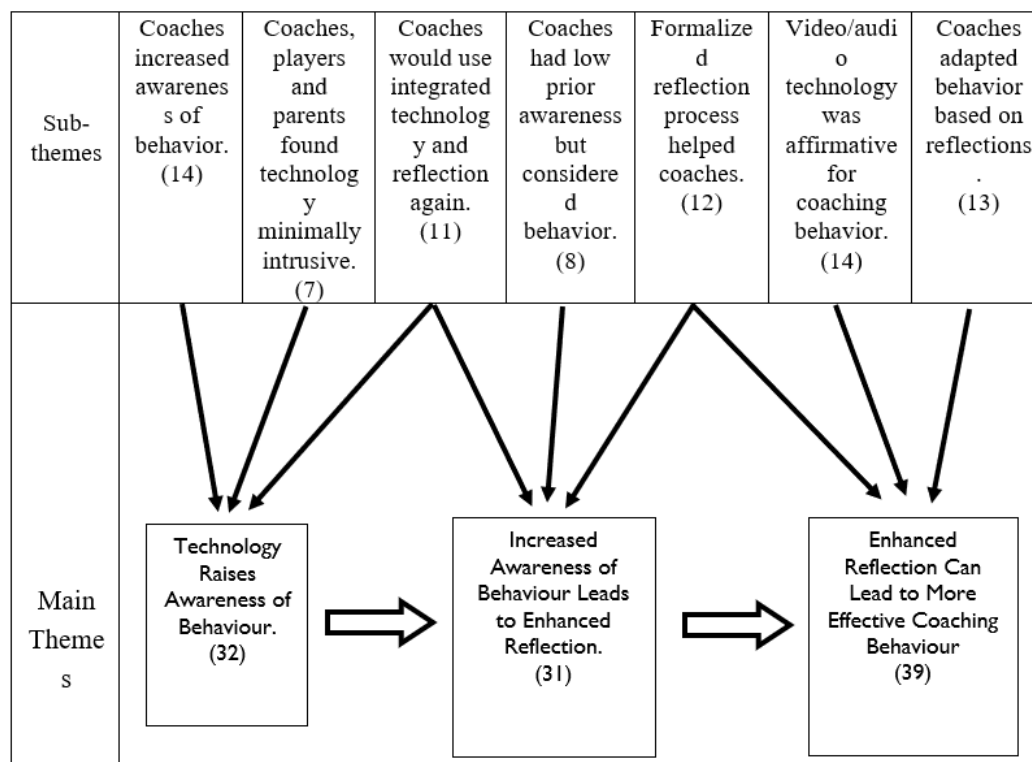


Figure 1.
Thematic Analysis: Sub-themes and Main Themes

Note: Brackets indicate the number of quotes.

even towards the end of the first lesson I was just having normal conversations with the participant that weren't necessarily related to tennis.

The quote from the coach above highlights that the technology used was not obtrusive to their sessions. They did however acknowledge that there was an initial period where they were aware of being observed, this is not unusual and has been noted in other previous studies in the area (Stoszkowski & Collins, 2022). The coaches involved in the present study noted that they got used to the camera and wireless microphone quickly and this period of assimilation was quicker than in Stoszkowski and Collins (2022) where coaches took several sessions to become comfortable. This is perhaps because of the non-intrusive nature of the recording in the present study, sessions were filmed via a fixed camera elevated on a tripod above the level of the court. In a sport where the coach would cover a greater distance during delivery of a session (such as football) the researcher would be more likely to follow the coach with the camera increasing awareness of the presence of the camera and changes in behavior. In Stoszkowski and Collins (2022) the coaches filmed were across various sports, which may explain why the coaches in the present study were more comfortable. Additionally, one of the coaching participants in this study had previous experience being filmed for research (Glen et al., 2020) and the other two participants had previous experience being filmed for their LTA coaching qualifications. This would suggest that they are more comfortable being filmed than the 'average' coach. For this type of intervention to be applied elsewhere may require more time for participants to become comfortable being recorded.

Previous research has highlighted a lack of self-awareness regarding coaching behavior (Partington et al., 2014; Partington et al., 2015). An area of interest that emerged from the coaching participants in this study was that using the technology to view and hear the sessions back can help the coaches be aware of the things they are doing well:

I felt it (lack of confidence) in the session, but when I watched it back, it wasn't as bad as I thought. Watching it back made me think 'that was better than you thought it was'. I was very critical of myself (initially)... watching myself back helped my confidence! (Coach 1)

This was expanded upon by two other coaches, the first of whom said that using the technology to watch and listen back to her session made her more aware of how she conducted herself during the sessions: I knew that I looked enthusiastic and positive, but I wasn't really aware of my presence on the court (Coach 3). The other coach (Coach 2) also expressed a similar view and highlighted the areas for development as well as areas he was pleased about with his coaching delivery:

Being able to see yourself back and hear yourself back is a big thing because sometimes your memory serves a bit differently from how the lesson actually went... so it can be positive, it's not all gonna be unflattering.

Viewing and listening back to the sessions improved the confidence of coaches and increased awareness of their behavior; however, it was also beneficial for them to highlight areas of improvement. The quotes above highlight the importance of retrospective reflection on-action (Gilbert & Trudel, 2001) as this helped alleviate their concerns in their initial retrospective reflection in-action. This can be achieved without technology, however the presence of technology and a formal reflection process likely enhanced the likelihood and quality of reflection. Coaches can be unaware how they actually behave, and how they are perceived by others, in their daily lives. Prior research with experienced coaches has highlighted that having the respect of athletes is critical for a coach in maintaining an effective coach-athlete relationship (Potrac et al., 2002). The athletes must have respect for the coach in order for coaches to transfer knowledge effectively to the athletes and to retain their engagement (Potrac et al., 2002). The most experienced and qualified coach in the study (Coach 1) touched on this regarding working with female players:

It made me more aware of gender differences in coaching... the second player was female, in general I have the same issues with girl players. I'm not sure if they're really with you? I just find it easier with boys. They seem more naturally competitive; it's kind of easy to feel they're all out there trying their hardest. I find that more difficult with girls. So, it was probably more an increased awareness of the gender differences.

Gender differences and preferences in coaching are areas that have been extensively researched but with no established conclusion that fits all contexts (Henderson et al., 2022; Partington et al., 2014). This is because how males or females are coached is a highly nuanced area that is affected by several factors (Cope et al., 2022). One positive point in the quote above outlined by the coach is that she became more aware of an area where she would like to improve her coaching practice. Indeed, all coaches interviewed in the study stated that the use of video and audio technology helped them become more aware of the impacts of their behavior and consider their behavior for future sessions:

I think it definitely made me more aware of what I was doing, I think some of the stats like positive feedback because you don't really think about what you're doing. You're just like it's more of a throw away thing that I just do every now and again, the thing is you don't think how much of that is built into the lessons. (Coach 2)

Increasing coach self-awareness of behavior is critical for their development. The coach above never paid much attention to the positive feedback he was giving to his athletes, but by reflecting on the footage, he could see the value that this behavior was bringing to his sessions and to his participant. Another coach (Coach 3) spoke about the benefits of integrating technology into her sessions and highlighted the role of the wireless microphone in aiding awareness:

It picked up my voice very clearly, when I was on the other side of the court, it still picked it up and it really helped to hear everything that I said, not just the encouragements and the shouting, really the conversations between the players, that really helped to hear them back.

The quote above highlights the benefits of adding wireless microphone and audio recording technology to the study. Previous research (Cope et al., 2022; Partington et al., 2015) has highlighted the benefits of video technology in aiding awareness in sports coaches, however in these studies there is little detail in how the audio recordings were obtained. It is possible to pick up audio through the camera, however in-built microphones in cameras are not effective in picking up volume in larger spaces and as a result external microphones can be required (Zoder-Martell et al., 2020). This would likely be made worse when coaches are on the move, meaning that many of the interactions could be missed if the audio from the camera was used. A previous study conducted by Guzmán & Calpe-Gomez (2012) integrated a handheld tape recorder in a pouch wrapped around the waist of their participant in their observation of a coach. This allowed for better quality audio to be obtained than that from a camera as may have been the case in other observational studies in the area. Although this was an improvement, the microphone used in the present study was designed in such a way that it clipped in with minimal intrusion and saved to MP3 format for simple merging with video. This allowed coaches to view video and audio together in one merged file after each session. This is not a criticism of the previous research. This is merely because of advances in wireless audio recording technology over the last decade.

Increased Awareness of Behavior Leads to Enhanced Reflection

From analyzing the interviews with each coaching participant, it became clear that the increased awareness of their behavior, caused by watching and listening back to their sessions, helped them reflect in a more meaningful way. Similar results for this were found by Partington et al. (2015) who found that by sharing the videos with coaches to review in their own time gave them ownership of the process and enhanced their motivation to improve behavior. Despite our coaching participants reflecting on coaching practice before this study, these reflections

were relatively informal. Their only experience of formalized reflection had been during studying for coaching qualifications. None had ever reflected with technology regarding their coaching practice, however all coaches interviewed stated that they would use integrated technology and reflection again within their coaching practice. The most experienced coach (Coach 1) highlighted the benefits of the formalized reflection and added insight about when it should be carried out:

You do it and it's done. The first one, I went away and did it straight away that night... it's better doing it at the time, you watch it and remember it more as opposed to doing it later.

Another example is below where Coach 2 outlines the benefits of doing reflection as soon as possible after watching the videos back as well as touching upon perceived mistakes:

It's obviously good to see the mistakes you're making during the lesson cause you don't always realize until you see them, so I think the footage and audio, seeing and hearing it back is better than even if you just walk straight after lesson then write down points on a sheet of paper. Things have already been shaped quite a lot by how you've remembered them in your mind, or how much you've dwelled on them during the lesson.

The coaches above make an important point about the reflection being carried out as soon as possible after viewing and listening to the session. Studies have previously used video clips in their 'stimulated recall' interviews with participants to help them recall behavior. (e.g., Stodter & Cushion, 2019). In the present study, coaches viewed the clips back before reflecting and in advance of being interviewed. This should reduce the chances of key incidents being forgotten prior to reflecting. This is a significant point raised by Coach 1, as the recall of key events is relatively poor for sports coaches and this is particularly evident in lesser experienced coaches (Coaches 2 and 3), who can recall significantly fewer events than more experienced coaches (Laird & Waters, 2008). The least experienced coach in the study (Coach 3) highlighted some of the benefits that the formalized reflection process provided. Previously she had been less inclined to think about the positive aspects of her coaching sessions, but the formal reflection integrated with the technology helped affirm desirable coaching behavior and helped make her aware of what she was doing well:

It was good. A lot of the time I've got a feeling of how the session went, but putting it into words is sometimes quite hard, and I had to think of stuff that I thought I did well and stuff that I could have done better. And because I'm so hard on myself, the stuff that I did well, it's harder to find! But doing that (reflecting on recordings) really made me notice it.

These sentiments were echoed by Coach 2, who became more aware of the importance of the quality of feedback he was giving his participant during the sessions:

I'm guilty of giving poor quality positive feedback like 'good shot'. That's terrible feedback. You're not getting the feedback on the teaching point. Not like, 'good follow through in that shot' it just you know all that 'good one' is about trying to cut that out.

Coach 2 did also raise the issue of contextual factors, notably the changeable Scottish weather, and how this affected his coaching behavior, specifically for his second session conducted:

We were having to battle against the weather. We couldn't keep, you know, trying to shout over them just to keep like, trying to be heard alone, knowing that you're not being heard so well. I mean, you can't give as good feedback during the lesson.

The quotes above highlight that weather conditions for coaching should be considered when discussing coach behavior. Author 1 is a practicing coach in a very similar climate (James et al., 2019) and would echo that the weather does indeed affect the type of coaching behavior one exhibits. This is also supported in other studies, including Partington et al. (2014) when youth football coaches in their interviews stated that they consider contextual factors including cold conditions when deciding how long to speak to athletes and what type of question to ask them. This study was conducted in a similar climate (England) to the present study (Scotland) and is a very interesting insight from Coach 2. Additionally, other contextual factors such as age of athlete and ability level can affect coaching behavior and should be taken into consideration (Cope et al., 2022; Partington et al., 2015).

It is common for coaches to view reflection as a negative experience and to prioritize aspects that did not go well in their practice (Knowles et al., 2006). Although it is acknowledged that in-depth critical reflection is essential for raising awareness and promoting changes in behavior (Partington et al., 2015), this should not mean that coaches only view the negative aspects of their practice. In this study, as part of their critical reflection the coaches were asked to think about what they did well besides what could be improved in future sessions. One coach (Coach 3) in the study was happy to look back on her previous reflections and video clips to aid future development:

I've obviously saved those videos, so I'll just look back on the videos and again reflect on if I do lose my sight of what I'm doing, go back and see what I've done well.

This is another perceived benefit of using technology to aid reflection. The formal reflections have been stored, and the merged file can be reflected

on at any time to remind them of the positive aspects of their coaching in addition to the areas for further development. Coaches are open to different methods of learning to develop (Christensen, 2013), so they could be keen to try out interventions and support similarly to this study or the work of Partington et al. (2015). As well as the benefits of formalized reflection with the technology discussed, the depth of reflection that coaches went through was very thorough. Below, Coach 1 explains the detail that went into this:

I've got to have confidence in what I'm doing, but also, I have to have confidence in that relationship (with the player). I think part of the goal for him just now is to let him have these behaviors in that session, so that we can then work on it in session, or out of session to try and help him when he is competing. Sometimes it's hard to get kids into a stage where they behave like that (frustrated) and if you're only seeing it in matches, it's tricky.... I wouldn't have put up with that in the past. But he keeps trying, if he stopped trying then I wouldn't be able to (put up with that). You can be like that if you want but, if you're able to be in a point 1 minute later, then at least that person is trying.

The quote above from the most experienced coach highlights the development that she has gone through in her 32 years of coaching. In the session she is reflecting on, the player being coached was exhibiting levels of frustration and the coach dealt with it by letting the player release this on the court. A coach with less experience, or who did not have the same relationship with the player, may have reacted in a different way to the player's actions. By reflecting on the session and watching it back, the coach affirmed she made the right choice in her behavior and acknowledged that this would have been something she would have been less likely to tolerate in the past. This shows a high level of self-awareness which is possibly because of her experience of coach education and higher educational background in sport and psychology compared to other coaches in this study. Previous research has shown that coaches who have had similar educational experiences are more likely to carefully consider their behavior and show higher levels of self-awareness (Stodter & Cushion, 2019). Additionally, it is worth considering the motivation of a coach to reflect. Coach 3 was very positive about using the technology enhanced reflection for her own future practice, but did state that this may not be applicable to all coaches:

If the coach wants to improve, they'll do it. If they don't care or they don't want the truth, I guess they're not gonna do it. So it's really up to the coach I think. The coach will find a way, because it's different for people, different people reflect differently, and you have to find your own way to reflect.

The quote above gives an interesting insight. It should be noted that all coaches in the present study were likely highly motivated as they participated voluntarily. It is likely that there are many coaches working in sport who are less motivated to take part in technology enhanced reflection as it may be seen as additional work as suggested by Coach 3 above.

Each coach reflected on each individual session and provided evidence within one week of the session concluding. As the coaches were asked to reflect after each session, this type of reflection would be classed as retrospective reflection on-action (Gilbert and Trudel, 2001), which is one of the most common types of reflection used by sports coaches. All coaches showed that they could highlight key details in their sessions that they would not have had the awareness of without the technology to aid this. Coach 2 discusses the nuance in his questioning with his player:

It was like I think I said at the end 'is everything clear there?' and it's like obviously, they're gonna say 'yes', just out of social awkwardness, but I think the trick's probably to ask a question that they can't dodge. You can even just ask them to teach on it or something then. That way you're actually checking for understanding, not just like ticking a box.

The quote above shows that the coach is trying to use questioning behavior more effectively. Rather than asking closed questions that are simple for athletes to evade, they are trying to ask more open questions to allow the athlete to show greater understanding. This type of questioning has been used by more experienced coaches (Partington et al., 2014) and the fact that the coach in this study is now aware of their previous limitations regarding questioning is positive. It highlights an understandable desire on their part to learn and develop.

Enhanced Reflection Can Lead to More Effective Coaching Behavior

It cannot be overstated how important the behavior of the coach is when dealing with athletes, as it has a significant influence in various contexts and can affect the participation, performance and development of the athletes coached (Partington et al., 2015; Schenk & Miltenberger, 2019). The importance of coach behavior is well known; what is less well known is that for coaches to deliberately behave a certain way requires both self-awareness and motivation to change (Glen & Lavalley, 2019; Partington et al., 2015). Coaches in the current study could articulate the underlying reasons why they changed their behavior when coaching, or why they kept some behaviors consistent. Below is a summary of how each coach behaved throughout the duration of the study and areas where they adapted behavior based on their reflections are discussed. Potential underlying reasons for any changes are

given and quantitative ASUOI results are referred to.

Coach 1. Coach 1 was in individual sessions on all three occasions. However, because of circumstances outside the control of the coach, playing participants or the researchers, she was never observed coaching the same player more than once. Despite this being a limitation of the intervention for her, Coach 1 offered insights into the underlying reasons behind her behavior:

With participant 3 (male), I feel a lot more confident. Therefore I don't feel I have to do as much. I feel like I am confident enough to let things go, even if they walk away from this lesson not liking me because maybe they haven't won the point at the end. With participant 2 (female), I feel like if she felt a bit flat at the end then she might not book a lesson again.... I maybe don't feel like I have the skillset for the girls, but I do for the boys. I feel like lots of praise and hustle is a reflection of my own anxieties. I reflect on this whole process and think I just need to be a bit calmer. You know, it's not up to me, I am not going to make you a better player, my job is to help you help yourself to be a better player. I would like that to be my philosophy. That is most reflected in the session and results with participant 3.

As previously discussed in relation to the first main theme, earlier on in the interview Coach 1 stated that she felt better, and more confident, about the session with the female athlete (participant 2) when watching the footage of and reflecting on the session. This is further reflected in this quote above as she stated she would like to be more relaxed in future deliveries with this participant and other female participants. From analyzing the ASUOI across all three sessions (Figure 2) all participants received a similar amount of instruction, however Participant 2 (female, referred to in the quote above) received very different frequencies of behavior compared to male participants. The female participant received more hustle (4.35% of total behavior) and more praise (21.96% of total behavior) than the male players. Interestingly the female participant also received far less questioning (13.26% of total behavior) compared to the male participants 1 and 3 (22.83% and 20.55% of total behavior respectively) which ties into the quote above. One change that happened with Coach 1 across all sessions was that she exhibited higher levels of silence on-task and gave less concurrent instruction as the sessions progressed. Levels of silence on-task increased: session 1 (3.18%), session 2 (5.65%) and session 3 (17.56% of total behavior respectively). The coach hinted at a possible underlying reason for this:

The highness or frequency (of initial concurrent instruction) kind of highlights a lack of confidence in myself that I'm not sure if they're responding to me. That's how I felt in the session.

Coach 1 earlier stated that watching the sessions back helped her confidence, and this also partially explains the lower levels of silence in the initial session. Contextual factors surrounding a session or athlete can also impact on the behaviors of a coach (Cope et al., 2022; Partington et al., 2015). When discussing the reduced levels of concurrent instruction and increased levels of silence on-task for their third session specifically, the coach offered a further insight:

I think it's about the context of that lesson. It was a pre-tournament session, so we were playing points and things like that.... I think for me reflecting on that kind of session, I felt I had a really good session with him, because we did a task, and he stayed on it for ages. I set up the right task. I think it's a great thing if a child can focus and do something for 20 minutes.

Silence has been a deliberate action taken by coaches (Partington et al., 2014). Changes in silence on-task have been seen before (Partington et al., 2015) when coaches deliberately increase the use of this as they became more aware of their behavior to allow for more observation and increased decision making for players. In order for more silence on-task to occur, other behaviors often reduce in rate, in the case of coach 1, this was concurrent instruction. A similar pattern for Coach 3 emerged in this present study in relation to both silence and levels of instruction.

Coach 2. Coach 2 was observed in individual sessions on all three occasions and coached the same player each time. This allowed for a better understanding of how behavior developed over time than in the sessions conducted by Coach 1. Below Coach 2 explains how he changed the way he played points in-game against the player as sessions progressed:

I was trying to ensure that when we did play the open points, I gave him the ball so that he could then do what we were working on, so

if we were just trying to get lots of volleys, I would force him to come into the net... I think what I was trying to avoid doing was working on something all lesson and getting to the point, and then not having him get a chance to work on it. I felt like that would have been a bit silly. I enjoyed watching that lesson.

The quote above shows a high level of insight and reflection from the coach. In earlier sessions that he reflected on, he showed annoyance at himself for going overly hard on the player during points and not giving them a chance to work on skills the lesson had been designed to work on in-game. Above he highlights that this improved across all three sessions with the same player and he also highlighted his own satisfaction in seeing this. Whilst this is very difficult to quantify on the ASUOI as there are no categories that can adequately quantify such behavior, the first author who observed all sessions would be inclined to agree with this comment. In previous sessions the coach would be more likely to hit winners against a player at a lower skill level than himself and this limited the opportunities in the game for the player to develop the skills worked on prior in drill like scenarios. It again shows critical reflection being acted upon positively.

Aside from in-game tactics, Coach 2 expanded how he developed the use questioning over the duration of the sessions and how he tried to improve his relationship with the player:

I think you heard me say a couple things to the player like 'so tell me, give me a tip on how to hit a backhand' then he can begin to understand that he has to actually volunteer the information. There was one point where he came back with a very confused answer. I was like, 'Oh, I've not made that clear enough'. So that made me realize, I need to go back and clarify that. So, I found that useful, but I also

Behaviour	Freq	% of Total	RPM	Freq	% of Total	RPM	Freq	% of Total	RPM	%Total (1-2)	%Total (2-3)	%Total (1-3)	RPM (1-2)	RPM (2-3)	RPM (1-3)
Use of First Name	8	2.26	0.26	16	3.36	0.36	3	1.35	0.07	1.10	-2.01	-0.91	0.09	-0.28	-0.19
Pre-Instruction	70	20.23	2.28	81	17.61	1.80	36	16.44	0.89	-2.62	-1.17	-3.79	-0.48	-0.91	-1.40
Concurrent Instruction	28	8.09	0.91	25	5.43	0.56	3	1.37	0.07	-2.66	-4.06	-6.72	-0.36	-0.48	-0.84
Post Instruction	21	6.07	0.68	35	7.61	0.78	15	6.85	0.37	1.54	-0.76	0.78	0.09	-0.41	-0.32
Questioning	79	22.83	2.58	61	13.26	1.36	45	20.55	1.11	-9.57	7.29	-2.28	-1.22	-0.25	-1.47
Physical Assistance	0	0.00	0.00	5	1.09	0.11	0	0.00	0.00	1.09	-1.09	0.00	0.11	-0.11	0.00
Positive Modelling	28	8.09	0.91	42	9.13	0.93	3	1.37	0.07	1.04	-7.76	-6.72	0.02	-0.86	-0.84
Negative Modelling	1	0.29	0.03	12	2.61	0.27	0	0.00	0.00	2.32	-2.61	-0.29	0.23	-0.27	-0.03
Hustle	9	2.60	0.29	20	4.35	0.44	6	2.74	0.15	1.75	-1.61	0.14	0.15	-0.30	-0.15
Praise	68	19.65	2.22	101	21.96	2.25	37	16.89	0.91	2.30	-5.06	-2.76	0.03	-1.33	-1.31
Scold	2	0.58	0.07	1	0.22	0.02	2	0.91	0.05	-0.36	0.70	0.34	-0.04	0.03	-0.02
Management	13	3.76	0.42	25	5.43	0.56	18	8.22	0.44	1.68	2.78	4.46	0.13	-0.11	0.02
Uncodable	16	4.62	0.52	26	5.65	0.58	15	6.85	0.37	1.03	1.20	2.23	0.06	-0.21	-0.15
Silence (On-task)	11	3.18	0.36	26	5.65	0.58	38	17.35	0.94	2.47	11.70	14.17	0.22	0.36	0.58
Silence (Off-task)	0	0.00	0.00	0	0.00	0.00	1	0.46	0.02	0.00	0.46	0.46	0.00	0.02	0.02
	354	100%	Time 30m 39s	476	100%	Time 44m 57s	222	100%	Time 40m 38s						

Key: Freq = Frequency, % of Total = % of Total Behaviours Coded, RPM = Rate Per Minute, Green = Increase, Red = Decrease (Dark indicates greater change)

Figure 2
Coach 1 ASUOI Results and Changes in Behavior Between Sessions

found it's really good to be able to just have a chat with the player. I don't want them to feel awkward speaking to me, you want them to go to 'how you doing? How's your day? How's your week?. Before we could only talk about tennis... This has been a positive change from seeing that footage.

The quote above highlights that the coach reflected upon his prior sessions and noticed that he put poor quality questions to the player. Coach 2 also reflected that he asked many 'closed questions' in session 1. This frequency of questioning actually reduced throughout his sessions (14% of total behavior in session 1 to 11.16% in session 3), but what was perhaps more important was that the quality and types of question asked to the player became more open and allowed the player to demonstrate a higher level of understanding. This is a behavior associated with higher level coaches (Partington et al., 2014). This was particularly the case with technical points and tactical decisions such as shot selection. Another point of interest here was that Coach 2 used questioning to further enhance his existing relationship with the player. Coach 2 had worked with the player for several sessions prior to the start of the study, however expressed a desire to improve this relationship. The changes in questioning style were not performance related and could not therefore be coded under the definitions of the ASUOI. It is clear from the explanation above, and from observing the sessions, that this was a deliberate change from the coach. This use of questioning has been a method used by coaches to develop trust and enhance relationships with athletes (Lavalley et al., 2020). The coach also used the first name of the athlete more frequently as sessions progressed (7.61% of total behavior in session 1 to 10.20% in session 3) which has also been shown as an effective way of developing rapport with an athlete (Vinson et al., 2016) and may have been a deliberate strategy from Coach 2

(Figure 3). The quotes above suggest Coach 2 engaged with the process of reflection throughout the duration of the study and tried to change behavior to improve his interpersonal coaching behavior when working for an extended period with the same athlete. This shows a high level of motivation and self-awareness which are essential to changing behavior in sports coaches (Partington et al., 2015). Coach 2 also expressed a desire to continue technology-enhanced reflection post-study.

Coach 3. Coach 3 was observed in small group sessions on all three occasions and each player in the group was coached on more than one occasion. When questioned about which behaviors she was happy with and tried to keep constant Coach 3 offered this insight:

I was honestly quite happy with my explanations. I was quite self-conscious of them before, but when I watched them back, I was quite happy with the way I sounded and the way I explained things. I was clearer than I thought I was.

The above quote from the least experienced coach highlights that she was satisfied with her quality of explanation to her athletes. This ties into the study by Henderson et al. (2022) who found that athletes prefer instruction that is varied and reduces the chance of over-coaching. Whilst she was happy with her explanations and instruction, she found she gave too much feedback during the sessions and talked too much:

I obviously didn't realize that in the first session I talked so much, when I watched it, I obviously toned it down every time. It highlighted points with my session that I never really thought about. Like my, not hustle, but management, or how much I'm talking.

Behaviour	Freq	% of Total	RPM	Freq	% of Total	RPM	Freq	% of Total	RPM	%Total (1-2)	%Total (2-3)	%Total 1-3)	RPM (1-2)	RPM (2-3)	RPM (1-3)
Use of First Name	29	7.61	0.66	35	11.40	0.74	40	10.20	0.85	3.79	-1.20	2.59	0.09	0.10	0.19
Pre-Instruction	35	9.94	0.80	38	13.97	0.81	42	11.93	0.89	4.03	-2.04	1.99	0.01	0.08	0.10
Concurrent Instruction	9	2.56	0.20	4	1.47	0.09	3	0.85	0.06	-1.09	-0.62	-1.70	-0.12	-0.02	-0.14
Post Instruction	34	9.66	0.77	39	14.34	0.83	32	9.09	0.68	4.68	-5.25	-0.57	0.06	-0.15	-0.09
Questioning	52	14.77	1.18	31	11.40	0.66	40	11.36	0.85	-3.38	-0.03	-3.41	-0.52	0.19	-0.33
Physical Assistance	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Positive Modelling	38	10.80	0.86	27	9.93	0.57	36	10.23	0.76	-0.87	0.30	-0.57	-0.29	0.19	-0.10
Negative Modelling	14	3.98	0.32	13	4.78	0.28	25	7.10	0.53	0.80	2.32	3.13	-0.04	0.25	0.21
Hustle	14	3.98	0.32	4	1.47	0.09	12	3.41	0.25	-2.51	1.94	-0.57	-0.23	0.17	-0.06
Praise	64	18.18	1.45	51	18.75	1.09	67	19.03	1.42	0.57	0.28	0.85	-0.37	0.34	-0.03
Scold	4	1.14	0.09	1	0.37	0.02	4	1.14	0.08	-0.77	0.77	0.00	-0.07	0.06	-0.01
Management	38	10.80	0.86	24	8.82	0.51	42	11.93	0.89	-1.97	3.11	1.14	-0.35	0.38	0.03
Uncodable	26	7.39	0.59	20	7.35	0.43	25	7.10	0.53	-0.03	-0.25	-0.28	-0.17	0.11	-0.06
Silence (On-task)	24	6.82	0.55	19	6.99	0.40	22	6.25	0.47	0.17	-0.74	-0.57	-0.14	0.06	-0.08
Silence (Off-task)	0	0.00	0.00	1	0.37	0.02	2	0.57	0.04	0.37	0.20	0.57	0.02	0.02	0.04
	381	100%	Time 44m 0s	307	100%	Time 47m 1s	392	100%	Time 47m 7s						

Key: Freq = Frequency, % of Total = % of Total Behaviours Coded, RPM = Rate Per Minute, Green = Increase, Red = Decrease (Dark indicates greater change)

Figure 3
Coach 2 ASUOI Results and Changes in Behavior Between Sessions

This is something the coach above was very keen to avoid. This was influenced by her experience of being coached as she alluded to below:

When I'm being coached, I don't really like that much talking. I want to get on with it and figure it out on my own.

Furthermore, Coach 3 highlights how she could adapt her behavior based upon the reflections, her beliefs and by considering the session from a player's perspective:

I talked less as the sessions went on, I let the play, the game flow more. On the courses you're told to talk more, at least I was told to talk, talk, talk and give lots of feedback. But after I saw the first session, I thought I actually don't need to give as much feedback. I don't like if the coaches give me too much feedback, so I shouldn't do that to my players. So, I just started talking less and letting them figure it out on their own.

The above quotes are backed up from the ASUOI data for this coach (Figure 4), in session 1 instructional behavior (pre, concurrent and post instruction combined) accounted for 38% of total behavior. This decreased session by session and in the final session only 24.79% could be attributed to instructional behavior. This aligns with previous research that suggests that once coaches become aware of overly high levels of instruction, they try to reduce it (Partington et al., 2015). The coach above also increased her 'silence on task' across all sessions from 5% to 13.41% of total behavior across sessions 1-3. Prior research shows that silence on-task is the most common in-game behavior of elite youth coaches, and this is a deliberate strategy to be more observant and allow players to make decisions (Partington et al., 2014). It is clear then that the coach above has attempted to be quieter, more observant and give less instruction

to help the players find solutions themselves. These changes suggest the coach is motivated to change their behavior and is seeking to develop.

Study Limitations and Future Research

It is important to acknowledge the limitations of the current study. It is clear that the study had a small sample size of both participants and coaches. This means that we cannot be certain that all findings will be able to be universally applied to all coaching contexts. However, when discussing longitudinal research around coaching behaviors, sample sizes are often small due to the amount of data required to be collected and analyzed for each coach (cf. Partington et al., 2015; Guzmán & Calpe-Gomez, 2012). Future research may wish to consider a larger sample size of coaches and participants.

The variance in participants for Coach 1 could also be regarded as a limitation. Coach 2 and 3 both coached the same players in all sessions, however Coach 1 did not. This was the case because the researchers in this study had to work around the availability of the coaches and the participants. For future research it may be recommended that there is consistency amongst both coaches and participants.

Another limitation is that the present study did not consider player perceptions of the session. If further studies are to be conducted in this area, it may be worth considering taking player perspectives into account. The authors acknowledge that player perspectives may differ from that of the coaches.

Finally, it should be noted that the sessions were filmed outdoors, and weather is a factor that can impact coach behavior (Partington et al., 2015; Cope et al., 2022). Whilst efforts were made to make the climate as stable as possible (it was conducted in

Figure 4
Coach 3 ASUOI Results and Changes in Behavior Between Sessions

Behaviour	Freq	% of Total	RPM	Freq	% of Total	RPM	Freq	% of Total	RPM	%Total (1-2)	%Total (2-3)	%Total (1-3)	RPM (1-2)	RPM (2-3)	RPM (1-3)
Use of First Name	56	15.73	1.84	40	10.13	0.81	31	11.19	1.00	-5.60	1.06	-4.54	-1.03	0.19	-0.84
Pre-Instruction	49	16.33	1.61	48	13.52	0.97	11	4.47	0.35	-2.81	-9.05	-11.86	-0.64	-0.61	-1.25
Concurrent Instruction	32	10.67	1.05	37	10.42	0.75	25	10.16	0.81	-0.24	-0.26	-0.50	-0.30	0.06	-0.24
Post Instruction	33	11.00	1.08	30	8.45	0.60	25	10.16	0.81	-2.55	1.71	-0.84	-0.48	0.20	-0.28
Questioning	34	11.33	1.11	23	6.48	0.46	27	10.98	0.87	-4.85	4.50	-0.36	-0.65	0.41	-0.24
Physical Assistance	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Positive Modelling	17	5.67	0.56	16	4.51	0.32	11	4.47	0.35	-1.16	-0.04	-1.20	-0.24	0.03	-0.20
Negative Modelling	0	0.00	0.00	3	0.85	0.06	2	0.81	0.06	0.85	-0.03	0.81	0.06	0.00	0.06
Hustle	10	3.33	0.33	25	7.04	0.50	20	8.13	0.65	3.71	1.09	4.80	0.18	0.14	0.32
Praise	67	22.33	2.20	75	21.13	1.51	53	21.54	1.71	-1.21	0.42	-0.79	-0.69	0.20	-0.49
Scold	0	0.00	0.00	3	0.85	0.06	1	0.41	0.03	0.85	-0.44	0.41	0.06	-0.03	0.03
Management	25	8.33	0.82	42	11.83	0.85	24	9.76	0.77	3.50	-2.07	1.42	0.03	-0.07	-0.05
Uncodable	17	5.67	0.56	14	3.94	0.28	12	4.88	0.39	-1.72	0.93	-0.79	-0.28	0.11	-0.17
Silence (On-task)	15	5.00	0.49	38	10.70	0.77	33	13.41	1.06	5.70	2.71	8.41	0.27	0.30	0.57
Silence (Off-task)	1	0.33	0.03	1	0.28	0.02	2	0.81	0.06	-0.05	0.53	0.48	-0.01	0.04	0.03
		100%	Time		100%	Time		100%	Time						
	356	(115.73)*	30m 32s	395	(110.13%)*	49m 40s	277	(111.19%)*	31m 0s						

Key: Freq = Frequency, % of Total = % of Total Behaviours Coded, RPM = Rate Per Minute, Green = Increase, Red = Decrease (Dark indicates greater change)

summer months), future research may wish to consider conducting the study in an indoor environment. Whilst this is a limitation of the present study, it did yield an interesting insight from one coach in particular (Coach 2) into how his behavior adapted to the conditions and context of the session.

Overall, all the tennis coaches engaged well with the technology and were supportive of its use in future sessions for themselves and others. Subsequently this led to in-depth critical reflection across all coaches. This showed that they were all very keen to engage with technology and apply their reflections to their tennis coaching and interactions with participants. It remains to be seen if these adaptations will become permanent, and a follow-up study could explore this research question. There were no instances of coaches believing that they didn't have to change any aspects of their behavior. This suggests that coaches engaged well with the technology to enhance their reflections and think about the implications of their behavior on their participants. Finally, Coaches 2 and 3 did deliberately begin to change aspects of their behavior because of this reflection process. This was not quantifiable for all aspects of change, due in-part to limitations of the ASUOI, but there were some changes in the results that were very apparent. The increased use of silence on-task for Coaches 1 and 3 was noted and was very apparent from observation of sessions. Whilst there are other methods of systematically observing coaching behavior that are arguably more complex and contain more sub-sections of certain behaviors, there is no distinguished method that is all encompassing and meets the context of all sports and criteria associated (Cope et al., 2017). The rationale for using the ASUOI was clear, it is among the most used systematic observation method in coaching behavior research and has been used in the specific tennis coaching context in prior published studies (Claxton, 1988; Glen et al., 2020).

CONCLUSIONS

The results suggest that technology is effective in aiding reflection and coaching behaviour in youth tennis coaches. Based upon the study findings we recommend the integration of audio and video technology into tennis coach education programmes to help improve coach self-awareness of behaviour. By integrating this technology effectively, it will give coaches a chance to reflect on their behaviour and interactions with athletes. Without this, coaches are more likely to be relatively unaware of their behaviors (both desirable and undesirable) and as a result will have less motivation, or reason, to adapt their behavior accordingly. Additionally, we recommend that tennis clubs should look at using similar types of intervention to work with their coaches in a less formal

setting away from national governing body coach education. Doing so would put the responsibility on clubs to make this standard practice for coaches and allow them to become more familiar with technology and ongoing deliberate reflective practice. This could be further enhanced by using more experienced tennis coaches as mentors to help the younger coaches with the reflection process. Young tennis coaches often find it hard to improve their coaching practice and behavior and many do not know exactly how to, or are not aware of the need to enhance their behavior. By harnessing the technology available and working in conjunction with mentors this could help them improve their tennis coaching and have positive impacts on the overall development of their participants.

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