Observation of Elite Gymnastic Performance: Processes and Perceived Functions of Observation

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Abstract

Objectives: The purpose of the study was firstly to examine the nature of the information individuals extract from observations of their own performance and the reasons they give for choosing this information. Second, we aimed to investigate how individuals treat observed information and the strategies they use. Identification of the reasons for the use of each of the strategies was also discerned.

Method: Ten French female elite gymnasts were invited to "think-aloud" as they viewed a video sequence of their own performance.

Results: Findings revealed that the gymnasts paid attention mainly to spatial information and rarely reported kinematics information. The participants reported four main reasons for observing their own performance: (i) to improve self-assessment; (ii) to increase performance of technical execution; (iii) to increase imagery; and (iv) to increase visual perceptions. Gymnasts used different strategies to code the information, such as imagery, self-talk, imagery associated with self-talk, observing others and listening to the coach's feedback. These strategies of retention were perceived to be a means to improve performance.

Conclusions: The results are discussed in relation to Bandura's (1986, 1997) social cognitive theory of observational learning.

Keywords: observational learning, nature of the information, strategies of retention, functions, elite gymnasts.

Introduction

In all aspects of life humans spend a considerable amount of time observing others in order to understand their behavior (Decety, Chaminade, Grèzes, & Meltzoff, 2002) and in some cases, to imitate that behavior (Meltzoff & Moore, 1977, 1997). Imitation, which refers "to copying by an observer of a feature of the body movement of a model" (Heyes, 2001, p.254), represents a fundamental part of human behavior used to acquire new skills and establish contact with other individuals (Meltzoff & Moore, 1977).

Observing others', or one's own, performance is a commonly used strategy in teaching and coaching in the sport domain since it can facilitate the execution of a new motor performance (see Dowrick, 1999; McCullagh & Weiss, 2001 for a review). To assess the acquisition and production of modelled tasks in the physical or sporting domain, Bandura's (1986, 1997) social cognitive theory of observational learning has been the theoretical approach most commonly used (Horn, Williams, & Scott, 2002; Williams, Davids, & Williams, 1999). This cognitive orientation posits that visible and actual action is not required for the acquisition of social behaviors, and that observing a model may be sufficient to replicate these behaviors. Bandura (1986, 1997) suggested that there are four sub-processes involved in observational learning: attention, retention, ability, and motivation.

The first, attention, requires the individual to extract relevant information from the model. What is obtained from the observed demonstration depends upon observer characteristics (e.g., cognitive capabilities, arousal level, expectations) and on the characteristics of the modelled event (e.g., complexity, saliency, affective valence). The second sub-process, retention, includes the observer's ability to encode and retain what has been observed. Encoding refers to the transformation of modelled information into visual or verbal abstract representations. A reminder of the coded information may be accomplished via cognitive rehearsals (Bandura, 1997). Motor rehearsal could also be used to refine the cognitive representations (Carroll & Bandura, 1985).

The third sub-process, ability, allows the symbolic/cognitive (i.e., visual or verbal) representations to be translated into actions or behaviors. The final sub-process refers to motivational processes. These may involve external, vicarious, and self-reinforcements. Individuals are more likely to execute a modelled behavior if they are adequately motivated and the motivation is goal directed.

Even though Bandura's (1986, 1997) theory was originally developed to explain the acquisition of social behaviors, research has shown the sub-process of attention via the manipulation of the model and motor demonstration characteristics to be important (see McCullagh & Weiss, 2001 for a review). Indeed, model skill level, coping and mastery models, model status, model similarity, self-modeling, practice variables, and feedback have been shown to influence attention and, therefore, motor behaviors. For instance, Starek and McCullagh (1999) showed that watching oneself led to better swimming performance than watching someone else and allowed the athletes to appraise their motor skill more realistically than athletes instructed to observe others. Weiss, McCullagh, Smith, and Berlant (1998) have stated that observing a coping model was equally as effective as observation of a mastery model for children fearful of water performing swimming skills. A coping model is a model in which gradual learning, negative to positive attitude statements, and lower to higher ability and confidence statements are displayed. A mastery model shows errorless performances, positive attitude statements, and high ability and confidence statements (Weiss et al., 1998). More recently, Baudry, Leroy, Seifert, and Chollet (2005) have shown that providing video feedback with expert- and self-model demonstrations allowed gymnasts to correct complex sports movements. Similarly, Lee, Swinnen, and Serrien (1994) and Darden (1997) have explained the benefits of using unskilled or learning models. They suggested that it encourages the observer to explore task solutions, to correct errors in the learning process, and to make cognitive efforts.

Observing a model also has an influence on psychological responses, such as coping with fear and anxiety (e.g., Weiss et al., 1998) and self-efficacy (e.g., Gould & Weiss, 1981; Weiss et al., 1998). For example, Weiss et al. (1998) have shown that peer mastery models and peer coping models generated higher self-efficacy and lower fear compared to irrelevant models (i.e., models in which cartoons were viewed). The results revealed that coping models produced higher self-efficacy than mastery models in children fearful of water.

Research has also addressed the type of strategies that facilitate motor performance after the observation of performance and before attempting to replicate it. This may constitute the retention sub-process (e.g., Sainte-Marie, Clark, & Latimer, 2002). Different memory strategies have been identified: (a) enactive mediation (i.e., the observer moves synchronously whilst she or he is exposed to the demonstration; e.g., Williams, 1987); (b) lip movements whilst the demonstration is observed (Bouffard & Dunn, 1993); (c) verbal rehearsal (i.e., labelling or naming cues) (e.g., Cadopi, Chatillon, & Baldy, 1995; Carroll & Bandura, 1990; Meaney, 1994); (d) imagery rehearsal (e.g., Cadopi, et al., 1995; Gerst, 1971; Housner, 1984); (e) association of verbal and imagery rehearsal (Hall, Moore, Annett, & Rodgers, 1997); and (f) miming (Bouffard & Dunn, 1993).

Among the studies that have examined memory strategies and observational learning, few of these studies have used sport-related tasks (e.g., Cadopi et al., 1995). The majority have been basic laboratory tasks, such as a throwing task (Williams, 1987), movement patterns on a pantograph (Hall et al., 1997), or hand movements drawn from the sign language for the deaf (Gerst, 1971; Bouffard & Dunn, 1993), do not allow the results to be of direct use in a sport setting (Williams, 1993). In many of these studies, participants were instructed to use particular and specific memory strategies. They could not use spontaneous rehearsal strategies that they might develop through their natural learning experiences (Bouffard & Dunn, 1993).

It should be recognized that Bandura's (1986, 1997) theory is limited regarding the nature of the information extracted from the model (Horn et al., 2002; Scully & Newell, 1985; Williams et al., 1999). Bandura (1986, 1997) highlighted the stages of encoding and memorisation of modelled features. However, there was limited advice regarding the information picked up by the observer and what exactly was perceived. To overcome this problem, Scully and Newell (1985) proposed a different approach for observational learning based on a Gibsonian model and the results of research conducted in visual perception of biological motion (e.g., Cutting, 1978; Johansson, 1973, 1975; Runeson & Frykholm, 1981). They stated that the visual system is designed to directly perceive invariant movement information about the relationship between different parts of the human body and unable to distinguish the specific movement characteristics being displayed. They also questioned the role of information processing between perception of actions and their reproduction, and suggested that motion was a vital component for perception and that static displays provide little information.

Research in visual perception which has employed the point-light technique (Marey, 1895/1972) to study biological motion has supported the work of Scully and Newell (1985). This technique consists of removing all the structural information, such as familiar cues from clothing, hairstyle etc.., by fixing dots of light on the major joints of the human body. Results have shown that individuals, exposed to a point-light display demonstration, were able to: recognise different patterns of movement, such as walking, running, dancing, (e.g., Johansson, 1973, 1975); specify gender of the model (e.g., Mather & Murdoch, 1994); discern aesthetic quality in gymnastics (e.g., Scully, 1986); depicted emotions in dance (Dittrich, Trosciansko, Lea, & Morgan, 1996); and estimate the dynamic properties, such as the weight of a box (e.g., Runeson & Frykolm, 1981). However, as recognised by Horn et al. (2002), Scully and Newell's (1985) approach provided scant new information about which visual cues were picked up during movement observation.

Studies in observational learning have examined the processing of information derived from self-observed movement. Little research has focussed on the *nature* of the extracted information ("What") (Scully & Newell, 1985; Williams et al., 1999). Knowledge concerning the way individuals learn by themselves and regulate freely their learning, that is, the way they pay attention to information, focus on instructions, organise, code, and rehearse information, and use social resources (e.g., Karoly, 1993), is poorly documented (Bouffard & Dunn, 1993). The reasons for acting in these ways during this process of self-regulation are also unknown. To our knowledge, only Cumming, Clark, Ste-Marie, McCullagh, and Hall (2005) have examined the reasons *why* athletes observe models. Cumming et al. (2005) have developed a questionnaire (FOLQ: Functions of Observational Learning Questionnaire) which revealed that athletes watched models to: improve skill acquisition and performance (skill function); execute and develop strategies (strategy function); and optimize performance through the regulation of arousal levels and mental states (performance function).

Given that self-regulation of learning has had a major impact on observational learning (Druckman & Bjork, 1991), it would be of interest to consider how individuals self-regulate their learning after observing demonstrations and why they make particular and specific choices in this process. In the sport literature, observational learning research has been concerned with simple tasks (McCullagh, Weiss, & Ross, 1989; Williams, 1993). Therefore, it is of interest to consider more complex motor skills in realistic sport settings.

The purpose of the present study was twofold. First, to examine the nature of the information individuals obtain when seeing their own performance during a learning phase, and the reasons for obtaining this information. Second, to investigate how individuals treated the information and which strategies were used to retain the information. Analysis was also implemented to identify the reasons for the use of each strategy (i.e., what functions these strategies served). Since the investigation was exploratory in nature, no a priori hypotheses were offered. A qualitative approach, through a protocol inspired by Ericsson and Simon's (1993) Think-Aloud Procedure, was used to gain an in-depth understanding of how individuals self-regulated their learning. The discipline of gymnastics, and more particularly the asymmetric bars exercises, was chosen because its routines offer diverse elements which can be described as complex motor skills and since they are executed by the whole body around longitudinal, transversal, and/or lateral axes.

Method

Participants

The participants were 10 French female elite gymnasts aged between 14 and 16 years (*M* age = 14.8, *SD* = 0.87 years) at the time of the study. All the gymnasts were at national level and had participated in either the World Championships in Anaheim (2003), the European Championships in Amsterdam (2004) and in Debrecen (2005), or/and in the Olympic Games in Athens (2004). The French team came in sixth in the team competition, one of the participant won the gold medal at the uneven bars at the Olympic Games and at the European Championship in 2005, and another one won the European Championship in the all-around event in 2005. All the gymnasts participated in 25 hours of physical training each week and voluntarily applied for the study. Written informed consent was obtained from the participants. Separate parental consent was also obtained, since all the participants were under the age of 18. The study was approved by the local ethics committee. All the participants were required to learn a new, complex movement in order to perform it in the forthcoming major competitions. To guarantee anonymity, a coding system was used to identify the participants (G1 to G10).

Pilot Study

A pilot study was performed to refine the procedures described below. Two pilot protocols were conducted with two previous international gymnasts. The pilot study allowed for refining of questions in order not to influence the direction of the answers. This addressed the behavior of participants who may have lapsed into silence after having verbalized their behaviors and thoughts.

Procedure

The procedure comprised three steps: (a) training sessions; (b) data recording and selection of the data to be analysed; and (c) protocol inspired by Ericsson and Simon's (1993) Think-Aloud Procedure.

Training sessions. During three consecutive asymmetric bars training sessions, the participant routines were recorded by a SVHSC camera (Panasonic, NV-VS7) placed on a tripod 7 meters perpendicular to the bars area. Dart Trainer software (Dart Trainer 2-0 Professional Suite) was used. As the gymnasts completed their movement, the coach had the opportunity to speak to them about their performance. The gymnasts then observed their performance. This procedure was chosen to stay as close as possible to the gymnasts' real training sessions. To watch their routine, gymnasts stood in front of a large screen (112 x 150 cm). Correct and incorrect trials were shown at normal speed and with continuous loop. Observation was unguided: Gymnasts were not instructed to direct their attention to a particular aspect of their performance. An unlimited number of viewings of the performance was permitted. At the end of the observation period, they informed the experimenter about the number of times they had observed themselves. They returned to the bars area to prepare. They performed the observed routine. This allowed the gymnasts to become accustomed to: the video and to the protocol which consisted of moving systematically towards the screen to observe the routine immediately after the physical execution.

Data recording and selection of the data to be analysed. The data recording occurred during a fourth training session. This was identical to those previously described. The tapes also included gymnasts' verbal exchanges with the coach and/or the teammates, which might have occurred during this lapse of time. Several video sequences were created.

For each participant, one video sequence was chosen based on the following criteria. First, the time between the observation of the movement and its completion should allow the gymnasts to engage in self-regulatory learning strategies. Second, the selected sequence should be meaningful for the gymnasts, and thus should be a successful or nearly successful performance. Third, social interactions between the gymnast and the coach/teammates should occur during the video sequence to collect the maximum amount of information on learning self-regulation process.

Protocol inspired by Ericsson and Simon's (1993) Think-Aloud Procedure. Gymnasts were invited to "think-aloud" as they viewed the selected video sequence of their own performance. They were instructed to describe accurately their actions, communications, thoughts, and feelings. They were told that they could stop the video tape at any moment they judged was meaningful and to take time to explain their thinking. They were also encouraged to rewind the tape to review a particular situation. When the participants stopped talking, the experimenter checked the content of the verbalizations and, if necessary, asked questions to obtain additional information about the nature of the information. To help the gymnasts to remember the selected sequence and to recontextualize it, trials, which preceded the selected sequence, were reviewed. Two experienced researchers were present during the protocol. This lasted approximately 30 minutes. One was responsible for conducting the protocol. She was a researcher with a PhD in Exercise and Sport Psychology. She was experienced in qualitative methods, had 15 years' experience as a gymnast and as a coach, and ten years' experience in sport psychology consultancy. The second researcher, who was experienced in qualitative methods, and had previously been an international gymnast, was in charge of stopping the video tape and supported the first researcher when and where necessary. Permission to make an audio recording of the protocol and verbatim transcription was obtained. Participants were assured confidentiality and anonymity of their remarks and appointments were made to check the researchers' transcripts and their interpretation.

Instrument

Gymnasts reviewed their movement in real time, after its completion, on a large screen. Dart Trainer/Dartfish video analysis software (Dart Trainer 2-0 Professional Suite) was used. It allowed transfer of video footage from the camera, to a laptop, and to the screen via a data projector. A SVHSC video camera (Panasonic, NV-VS7) was also used to collect the data during the fourth training session.

Data analysis

The data were transcribed from the selected video sequences and from the audio tape to 150 single-spaced pages organized in a two columns table. The first column was composed of the verbatim transcription of the gymnasts' actions and communications which had occurred during their training session and which had been filmed and selected for the adapted think-aloud procedure. The second column was the verbatim transcription of the gymnasts' verbalizations during the adapted think-aloud procedure. Participants' action and communication re-transcriptions were organized to match chronologically their verbalizations as they watched their filmed performance.

After the transcription stage, the data were analysed using the procedures of grounded theory (Strauss & Corbin, 1990). First, data transcripts were divided into meaningful pieces of information called « meaning units » (MU). Secondly, these MU were compared and grouped together according to common features into increasingly more complex categories (Tesch, 1990). Three investigators, experienced in qualitative methods, were involved in the data analysis process. An independent coding of the data was performed by the two researchers who conducted the protocol. Comparison and discussion of the codes (i.e., MU) occurred until a consensus was reached. A third investigator, considered as a "disinterested peer" (Lincoln & Guba, 1985, p.308) was asked to checked the relevance of the categorization process.

Credibility

Data credibility was achieved in three ways (Lincoln & Guba, 1985): (a) the independent coding of the data (i.e., investigators' triangulation); (b) the checking of the categorization process by an experienced researcher in qualitative methods; and (c) the examination by the participants of the researchers' scripts and their interpretation to ensure the information collected was authentic.

Results

The transcripts were analysed on a line-by-line basis by three coders who reached consensus that there were 136 raw data responses (MU) related to the purposes of the study. The results are presented in two parts. The first part of the results describes the nature of and reasons for the information gymnasts gleaned from videotape replays. The second part of the results lists the way gymnasts coded this information; the strategies they used, and the main functions of those strategies.

Nature of the information and reasons for its selection

There were 18 MU for the nature of the information and 34 MU for the reasons why those were chosen. Because observation was unguided, all the gymnasts observed their performance once and eight saw it twice. Results concerning the nature of the information were organized into two parts (see Figure 1). The first depicted the nature of the information during the first observation. The second characterized it during the second observation. For the reasons of picking up information, the 34 MU were assembled together to make 8 categories and 4 major categories. A final level of analysis consisted of matching the nature of the information with the reason(s) for selecting them.

Nature of the information. The nature of the information has been described through three kinds of characteristics that have emerged from the analysis: (a) epochs of the movement, which were observed; (b) parts of the body which were seen; and (c) kinematic parameters. One epoch of the movement, several epochs of the movement, and all the epochs of the movement were identified as part of the movement epochs. One part of the body, several parts of the body, and the whole body constituted parts of the body which were taken into account by the gymnasts. The presence of kinematic parameters, such as speed, rhythm, was the last characteristic. Ten categories emerged through the combination of these three characteristics (see Figure 1).

Reasons for the selection of information. Reasons identified for picking information during the first and second observation were very similar: "improve self-assessment"; "increase performance of technical execution"; and "increase imagery ability" were cited. Whereas "increase visual perception" was only mentioned during the second observation (see Figure 1).

Details of the reasons for the selection of information were provided in Figure1. For example, the observation of one epoch of the movement and one part of the body allowed gymnasts 8 and 1 to increase performance of technical execution and, more specifically, to detect and correct technical errors (G1, G8) and to make the coach's feedback more explicit (G8). It also helped gymnast 1 to improve self-assessment, namely to check whether self-assessment matched the coach's analysis.

Strategies used to code the information and their functions

There were 53 MU for the strategies used by the gymnasts to code the information picked up when observing their own performance. These 53 MU were assembled together to make seven categories. There were 31 MU for the functions of these strategies which coalesced into nine categories and four major categories (see Figure 2). A final level of analysis consisted of matching the strategies with the reason(s) for using them.

The gymnasts used seven different strategies to treat the information gleaned from video replays: (a) performing movements during one's own observation; (b) observing others; (c) imagery; (d) self-talk; (e) imagery associated with a technical self-talk; (e) listening to the coach's feedback; and (f) gazing at the bars (see Figure 2).

Performing movements during one's own observation. Performing movements during one's own observation was the first identified strategy. Movements of head, hands, and head and body were performed, as gymnasts (G2, G3, G5, G8, G10) looked at their performance. Most of the time, these movements seemed automatic and unconsciously controlled (see Figure 2).

Observing others. Observing others was the second strategy. Observing teammates performing a similar movement or a different movement displaying similar key actions was perceived as a means of increasing performance of technical execution by detecting and correcting technical errors. Observing teammates performing a different movement also allowed gymnasts 2 and 3 to increase performance of technical execution by exchanging technical advice with teammates and increased the engagement of gymnast 2 (see Figure 2).

Imagery. Imagery was the third strategy. First, imagery from an internal perspective and with or without kinaesthetic sensations was used by gymnast 4. She reported that simulating mentally all the epochs of the movement in color and with kinaesthetic sensations served to increase performance of technical execution and, more specifically, to detect and correct technical errors. Second, imagery of several epochs of the movement, from an external perspective and without kinaesthetic sensations, was a means to increase self-confidence just before performing the next trial (G3). Finally, a combination of external and internal imagery perspectives seemed to fulfil the same function, as reported previously by gymnast 3 (G2).

Self-talk. Self-talk was the fourth strategy. When gymnasts' self-talk consisted of technical instructions and self-assessment, this strategy was thought to increase performance of technical execution and, more specifically, to feel kinaesthetic sensations for an instructional self-talk (G7), and to detect and correct technical errors for both kinds of self-talk (G1, G2, G3, G5, G6, G7, G8, G10). Instructional self-talk was also perceived to increase engagement and activation (see Figure 2). Finally, when the content of self-talk was made up of positive encouraging statements, self-talk was used to increase engagement and, more specifically, to give a motive to succeed at the next trial for gymnast 2 and to overcome pain for gymnast 8.

Imagery associated with a technical self-talk. Imagery associated with an instructional self-talk was the fifth strategy. Gymnasts 1, 8, and 9 combined self-talk with external imagery to increase performance of technical execution and, more specifically, to detect and correct technical errors. The mental simulation was in color with or without kinaesthetic sensations (see Figure 2).

Listening to the coach's feedback. Listening to the coach's feedback was the sixth strategy. Feedback was about information on one's own performance and on a teammate's performance which was actually a different movement displaying similar key actions.

Gazing at the bars. Gazing at the bars was the seventh strategy. Gymnast 3 felt that it enabled her to increase imagery ability by helping her to trigger imagery.

Discussion

The first purpose of the present study was to examine the nature of the information the gymnasts extracted from observations of their own performance and the reasons for picking such information. Secondly, the study aimed to identify how individuals treat this information and with which strategies. The function these strategies served was also investigated. The discussion was organized into four sections. The first two sections of the discussion consider the goals of the study, the third discusses the strengths and limitations of the study, and the fourth considers the practical implications and the future directions of research.

Nature of the information and reasons for its selection

Nature of the information. The results of the study revealed that the gymnasts paid attention mainly to spatial information (i.e., epoch(s) of the movement, part(s) of the body) and rarely picked up kinematic information (i.e., rhythm and speed) from observations of their own performance. Indeed, rhythm and speed features were selectively attended to only three times. These findings do not seem to support Scully and Newell's (1985) approach and research conducted in visual perception and biological motion (e.g., Mather & Murdoch, 1994; Runeson & Frykholm, 1981). They proposed that observers discerned invariant movement aspects (organization of limb segments) and temporal movement aspects (rhythm of limb movement/action) and not the specific movement characteristics being displayed through a demonstration. Discrepancy in findings may be related to the nature of the task which was studied. In previous research, tasks were relatively simple, whereas, in the present study, the task was a complex motor skill.

Gymnasts' attention was attracted by spatial aspects, such as part(s) of the movement or part(s) of the body. During the first and second observations, participants observed different epochs of the movement and paid attention to diverse parts of the body. It maybe that during a second exposure to their performance, gymnasts preferred to observe more complete information. This suggestion cannot be discussed in the context of any previous research because, to our knowledge, no research has addressed this topic.

Reasons for selecting information when seeing one's own performance. As the sport literature provided some evidence that observing a model operates to affect motor performance and psychological indicators (see McCullagh & Weiss, 2001 for a review), little has been done to examine athletes' reasons for observing models (Cumming et al., 2005). The present study identified four major reasons which were reported by the gymnasts: (a) to improve self-assessment; (b) to increase performance of technical execution; (c) to increase imagery; and (d) to increase visual perceptions. The present study also showed that reasons identified during the first and second observations were found to be similar.

These results are partially consistent with Cumming et al.’s (2005) work. One of the four reasons is similar to the functions identified by these authors. Increase performance of technical execution could be matched with the skill function; motor skill acquisition and performance of Cumming et al. (2005). The performance and strategy functions of Cumming et al.’s (2005) observational learning (OL) are not matched in the present study. Improvement of self-assessment and increases of imagery and visual perceptions did not appear in their study. These differences may be explained through factors related to the characteristics of the participants, the sport, and the model that was observed. First, our participants were elite athletes, whereas Cumming et al.’s participants included elite level athletes, but also recreational, provincial, and varsity athletes. Their elite athletes represent a small percentage of their total population. Second, the characteristic of gymnastics, which is a discipline in which form is important, and which requires the display of diverse and complex skills with little margin for error, may explain the differences. Third, in Cumming et al.’s (2005) study, participants were told that OL consisted of watching a teammate or oneself performing a skill. In the present study, participants only observed their own performance.

As noted by Cumming et al. (2005), it is not surprising that observing oneself was perceived by the gymnasts as a means of increasing their performance, since modeling literature has shown the benefit of observing a model in performance improvement (see Dowrick, 1999; McCullagh & Weiss, 2001 for a review) and, more specifically, the benefit of observing learning models (e.g., Baudry et al., 2005; Darden, 1997). It is also not unexpected that observing oneself allowed the gymnasts to improve self-assessment. Indeed, Winfrey and Weeks (1993) and Starek and McCullagh (1999) have pointed out that participants who watched themselves formed a more realistic and exact appraisal of their own performance in comparison to individuals that had not the opportunity to view themselves (Winfrey & Weeks, 1993) or see the performance of others (Starek & McCullagh, 1999).

Finally, increasing imagery ability via the observation of oneself seems logical, since White and Hardy (1995) suggested that observation and external imagery were basically equivalent. This is in line with neuroscience and psychophysiology literature which has clearly identified a functional equivalence between action execution, motor imagery and action observation (e.g., Grèzes & Decety, 2001). The principle of this functional equivalence states that similar brain areas have been found to be activated during mental simulation of an action and observation of the same action (e.g., Grèzes & Decety, 2001).

Strategies used to code the information and their functions

Finally, the results of the present study revealed that gymnasts used six different strategies to code the information gleaned when observing their own performance. Performing movements during one's own observation, imagery, self-talk, and imagery associated with self-talk are strategies that have already been identified in the literature (e.g., Cadopi et al., 1995; Caroll & Bandura, 1990; Hall et al., 1997), in which mainly basic laboratory tasks were studied. Observing others and listening to the coach's feedback are new strategies that have emerged from the analysis.

Performing movements during one's own observation. Performance movements during observation is a strategy which has already been identified by Williams (1987) in throwing actions.

Imagery, self-talk, and imagery associated with self-talk and their functions. Imagery, self-talk, and imagery associated with self-talk are well-known strategies used to facilitate retention (Cadopi et al., 1995; Carrol & Bandura, 1990; Gerst, 1971; Hall et al., 1997; Housner, 1984; Meaney, 1994). These findings corroborate Bandura's (1986) social cognitive theory of observational learning. Bandura postulated that after a behavior demonstration, visual and/or verbal strategies are implemented to memorize this behavior. The present study takes this a stage further. First, it studied complex motor skills that are only able to be performed by elite athletes. To our knowledge, this has not previously been examined before. Second, details about the characteristics of imagery, such as the perspective (i.e., internal, external), the modality (visual, kinaesthetic), and the content (epoch(s) of the movement and part(s) of the body), and details about the content of self-talk (technical instructions, encouragements, self-assessment) were provided.

Participants reported that using imagery and imagery with self-talk served to increase performance of technical execution. Classical literature in sport psychology, which has shown the positive effects of imagery on performance (see Hall, 2001 for a review), can explain why gymnasts' perceived imagery enabled them to increase their performance. Increasing self-confidence and engagement/activation were also two reasons reported by the gymnasts to explain the use of imagery and self-talk after the observation of their performance. These findings are consistent with studies in the sport psychology literature in imagery (e.g., Garza & Feltz, 1998; McKenzie & Howe, 1997) and in self-talk (e.g., Hardy, Gammage, & Hall, 2001). For exemple, Garza and Feltz (1998) and McKenzie and Howe (1997) have shown that mental simulation of a movement increased self-efficacy of competitive figure skaters and of darts players. Hardy et al. (2001) have reported that self-talk could serve different motivational functions, such as a mastery function (e.g., coping in difficult situations), an arousal function (e.g., psyching up), and a drive function (e.g., maintain and increase drive). Nevertheless, interpretation of these results should be made cautiously, since the moment the gymnasts used imagery and self-talk was just after viewing their performance. To our knowledge, this has not been examined before.

Observing others, listening to the coach's feedback and their functions. Observing others seems to be a novel strategy which codes information collected as gymnasts watched their performance. Gymnasts observed teammates performing a similar movement, a different movement displaying similar key actions, and a different movement. All these movements are familiar to the gymnasts and are part of their motor repertoire. As discussed previously, modeling literature can explain why participants perceived observing a model as helping increasing performance. One gymnast, who observed a teammate performing a different movement, also reported that it helped her to increase her engagement; she was keen to perform new and complex skills. This is consistent with Cumming et al. (2005) who reported that using OL for motivational functions was not employed very frequently by athletes, but that it did exist as an OL function.

Listening to the coach's feedback seems to be a new retention strategy that has emerged from the analysis. We suggest that delivering some verbal feedback could help individuals memorize their movement or part of it. This question of primary interest should be addressed in future research.

Strengths and limitations of the study

It should be recognized that this study could be argued to have two limitations. First, only ten gymnasts participated in the protocol inspired by Ericsson and Simon's (1993) Think-Aloud Procedure. This weak sample size limits results generalization even if the participants were unique in their performance accomplishments. Second, even if the experience of the gymnasts was significant to them and even if the data collection occurred a few hours later, limitations related to memory loss (Wade, 1990; Young, 2005), and thus the risk of giving a distorted version has to be considered or acknowledged. To correct this limitation, thoughts of individuals could be collected as they complete a task. This procedure is not completely satisfactory since verbalizing thoughts during he completion of a task could effect and alter the normal workflow (Ericsson & Simon, 1993). The think-aloud procedure is also sometimes perceived as a technique that cannot access cognitive processes that do not reach consciousness (Wilson, 1994).

This point suggests that the think-aloud procedure may lead to an incomplete data collection. The retrospective procedure used in the present study (i.e., association of video-observation with audio-data collection) seemed to be an acceptable compromise. Unconscious data at the time of the action could be brought into consciousness as the individuals observe and discuss their performance (Young, 2005).

Despite these limitations, the present study presents methodological strengths. The level of the participants was elite, since two of them had medalled at the Olympics and at the European Championship. At the time of the study, gymnasts were learning complex movements which were presented and performed successfully at major competitions. The pilot work and the care taken to check data credibility also contributed to the robustness of the findings. Finally, the protocol set up in the present study has the virtue of allowing the study of ecological tasks with expert performers.

Practical implication and future directions of research

This study also presents important practical implications for coaches in charge of gymnasts. First, it informs coaches about the nature of the information which is obtained when observing a movement and how this information is treated by the athletes. Second, being aware of the way the gymnasts regulate their learning could enable coaches to support them more efficiently.

Finally, to improve further the support provided to coaches, more research is required. For example, comparing information and strategies used by successful or experienced elite gymnasts with those who are less successful or novices.

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Figure Captions

Figure 1. Nature of the information observed by the gymnasts after viewing their performance and reasons provided.

Figure 2. Strategies used to code the information and their perceived functions.

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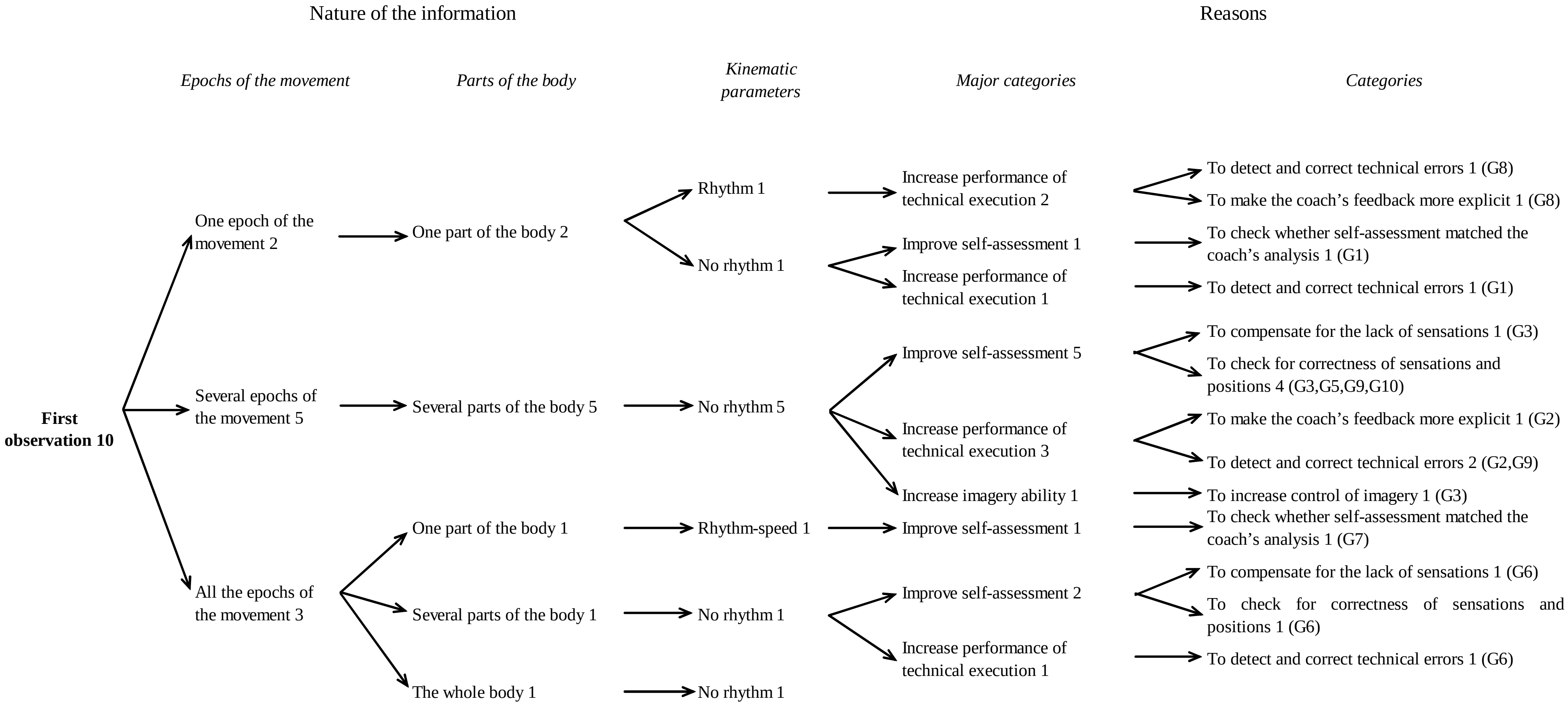

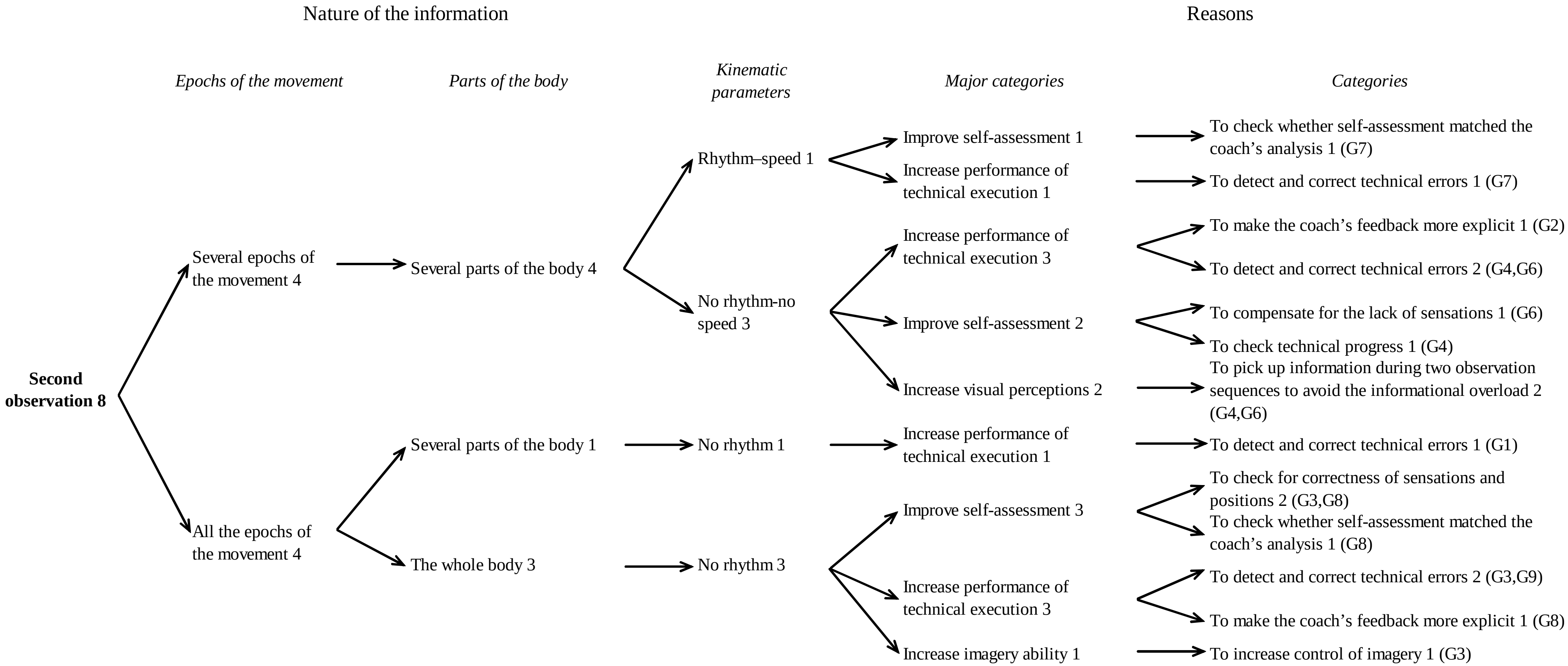

Notes. Numbers mentioned in this figure represent the number of meaning units; G1, G2 to G10: Gymnasts

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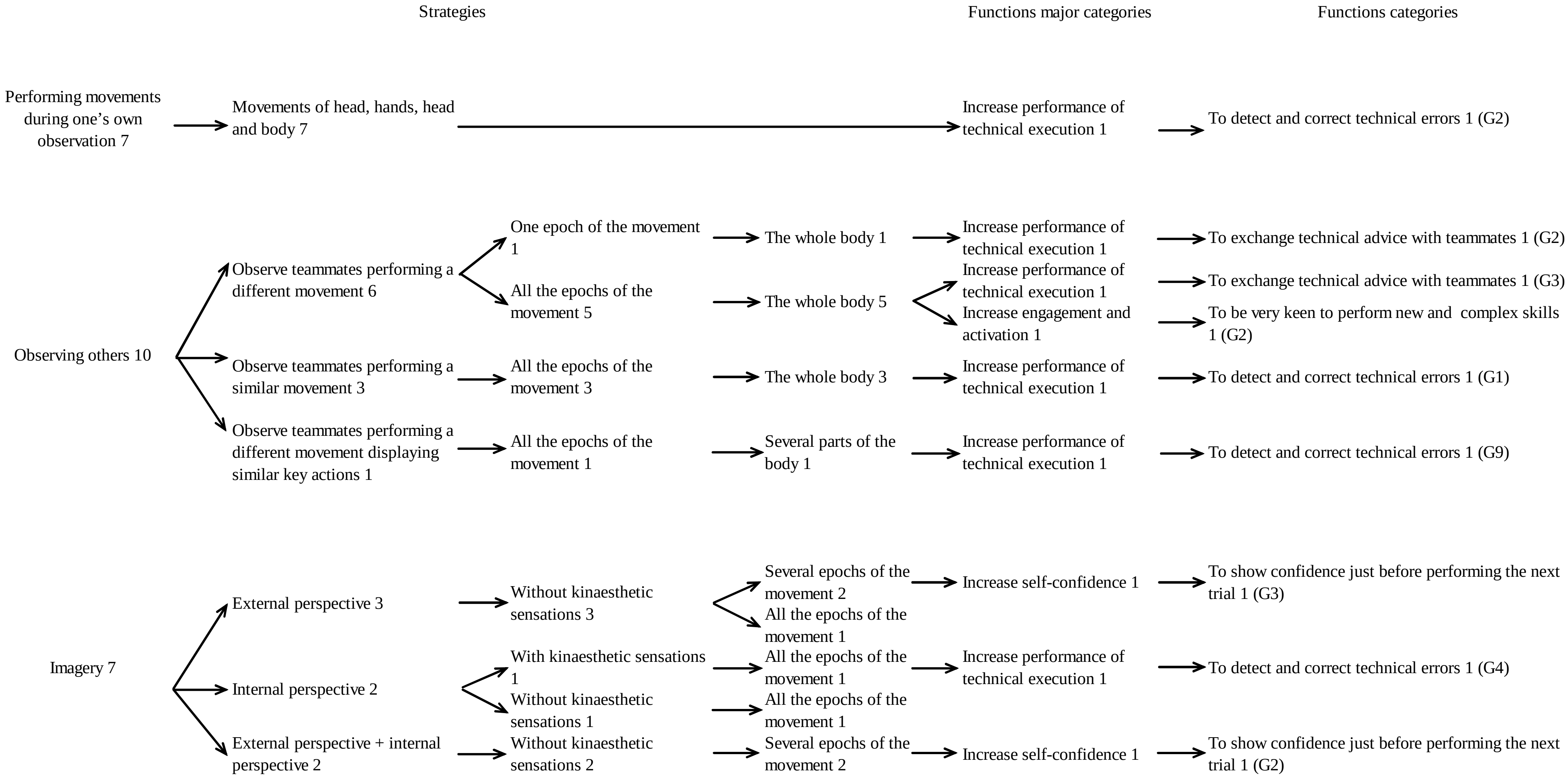

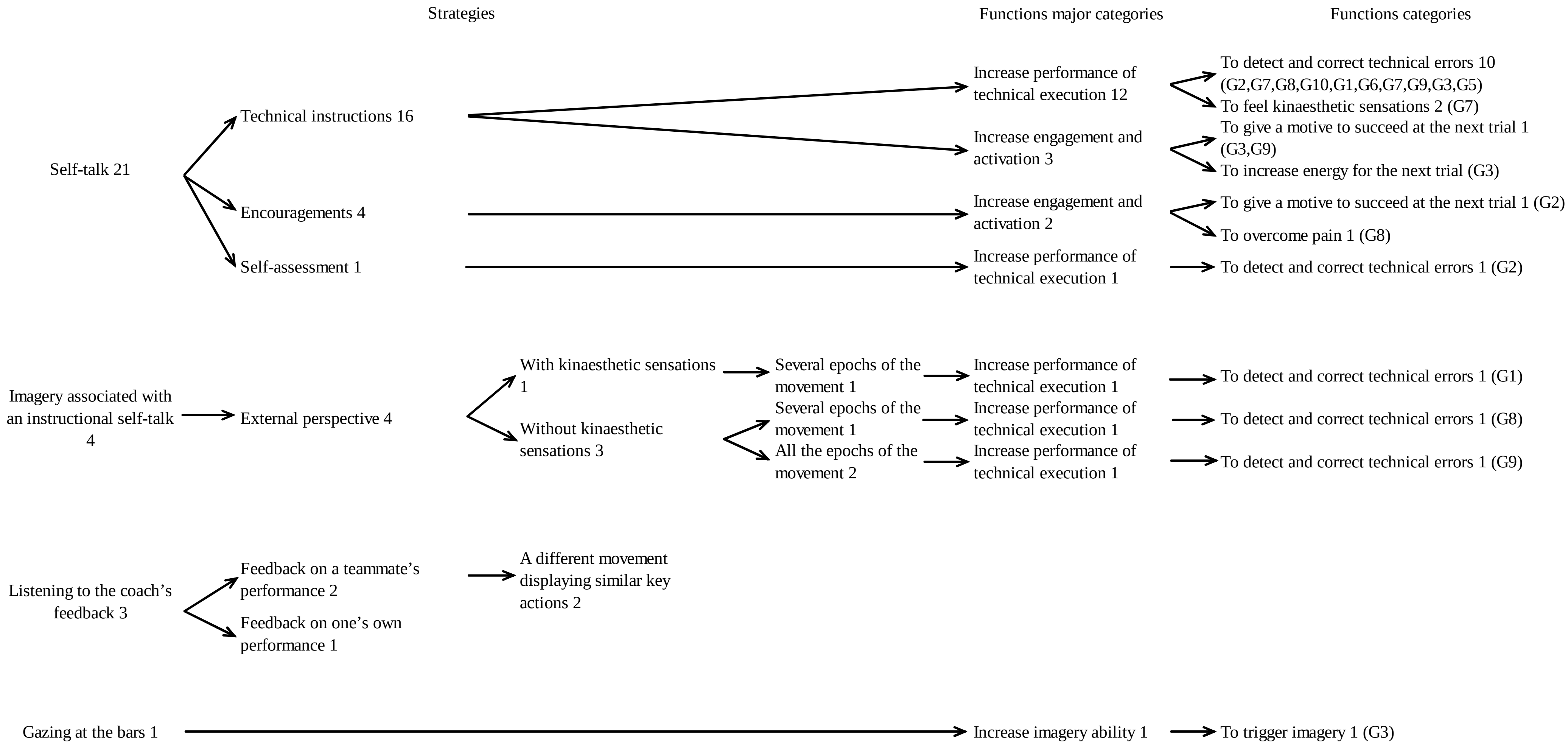

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