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1 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).

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

6 Even though Bandura's (1986, 1997) theory was originally developed to explain the
7 acquisition of social behaviors, research has shown the sub-process of attention via the
8 manipulation of the model and motor demonstration characteristics to be important (see
9 McCullagh & Weiss, 2001 for a review). Indeed, model skill level, coping and mastery models,
10 model status, model similarity, self-modeling, practice variables, and feedback have been shown
11 to influence attention and, therefore, motor behaviors. For instance, Starek and McCullagh
12 (1999) showed that watching oneself led to better swimming performance than watching
13 someone else and allowed the athletes to appraise their motor skill more realistically than
14 athletes instructed to observe others. Weiss, McCullagh, Smith, and Berlant (1998) have stated
15 that observing a coping model was equally as effective as observation of a mastery model for
16 children fearful of water performing swimming skills. A coping model is a model in which
17 gradual learning, negative to positive attitude statements, and lower to higher ability and
18 confidence statements are displayed. A mastery model shows errorless performances, positive
19 attitude statements, and high ability and confidence statements (Weiss et al., 1998). More
20 recently, Baudry, Leroy, Seifert, and Chollet (2005) have shown that providing video feedback
21 with expert- and self-model demonstrations allowed gymnasts to correct complex sports
22 movements. Similarly, Lee, Swinnen, and Serrien (1994) and Darden (1997) have explained the
23 benefits of using unskilled or learning models. They suggested that it encourages the observer to
24 explore task solutions, to correct errors in the learning process, and to make cognitive efforts.

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

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

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

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

14 Research in visual perception which has employed the point-light technique (Marey,
15 1895/1972) to study biological motion has supported the work of Scully and Newell (1985). This
16 technique consists of removing all the structural information, such as familiar cues from
17 clothing, hairstyle etc., by fixing dots of light on the major joints of the human body. Results
18 have shown that individuals, exposed to a point-light display demonstration, were able to:
19 recognise different patterns of movement, such as walking, running, dancing, (e.g., Johansson,
20 1973, 1975); specify gender of the model (e.g., Mather & Murdoch, 1994); discern aesthetic
21 quality in gymnastics (e.g., Scully, 1986); depicted emotions in dance (Dittrich, Trosciansko,
22 Lea, & Morgan, 1996); and estimate the dynamic properties, such as the weight of a box (e.g.,
23 Runeson & Frykholm, 1981). However, as recognised by Horn et al. (2002), Scully and Newell's
24 (1985) approach provided scant new information about which visual cues were picked up during
25 movement observation.

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

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

20 The purpose of the present study was twofold. First, to examine the nature of the
21 information individuals obtain when seeing their own performance during a learning phase, and
22 the reasons for obtaining this information. Second, to investigate how individuals treated the
23 information and which strategies were used to retain the information. Analysis was also
24 implemented to identify the reasons for the use of each strategy (i.e., what functions these
25 strategies served). Since the investigation was exploratory in nature, no a priori hypotheses were

1 offered. A qualitative approach, through a protocol inspired by Ericsson and Simon's (1993)
2 Think-Aloud Procedure, was used to gain an in-depth understanding of how individuals self-
3 regulated their learning. The discipline of gymnastics, and more particularly the asymmetric bars
4 exercises, was chosen because its routines offer diverse elements which can be described as
5 complex motor skills and since they are executed by the whole body around longitudinal,
6 transversal, and/or lateral axes.

7 Method

8 *Participants*

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

22 *Pilot Study*

23 A pilot study was performed to refine the procedures described below. Two pilot
24 protocols were conducted with two previous international gymnasts. The pilot study allowed for
25 refining of questions in order not to influence the direction of the answers. This addressed the

1 behavior of participants who may have lapsed into silence after having verbalized their behaviors
2 and thoughts.

3 *Procedure*

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

7 *Training sessions.* During three consecutive asymmetric bars training sessions, the
8 participant routines were recorded by a SVHSC camera (Panasonic, NV-VS7) placed on a tripod
9 7 meters perpendicular to the bars area. Dart Trainer software (Dart Trainer 2-0 Professional
10 Suite) was used. As the gymnasts completed their movement, the coach had the opportunity to
11 speak to them about their performance. The gymnasts then observed their performance. This
12 procedure was chosen to stay as close as possible to the gymnasts' real training sessions. To
13 watch their routine, gymnasts stood in front of a large screen (112 x 150 cm). Correct and
14 incorrect trials were shown at normal speed and with continuous loop. Observation was
15 unguided: Gymnasts were not instructed to direct their attention to a particular aspect of their
16 performance. An unlimited number of viewings of the performance was permitted. At the end of
17 the observation period, they informed the experimenter about the number of times they had
18 observed themselves. They returned to the bars area to prepare. They performed the observed
19 routine. This allowed the gymnasts to become accustomed to: the video and to the protocol
20 which consisted of moving systematically towards the screen to observe the routine immediately
21 after the physical execution.

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

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

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

1 confidentiality and anonymity of their remarks and appointments were made to check the
2 researchers' transcripts and their interpretation.

3 *Instrument*

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

9 *Data analysis*

10 The data were transcribed from the selected video sequences and from the audio tape to
11 150 single-spaced pages organized in a two columns table. The first column was composed of
12 the verbatim transcription of the gymnasts' actions and communications which had occurred
13 during their training session and which had been filmed and selected for the adapted think-aloud
14 procedure. The second column was the verbatim transcription of the gymnasts' verbalizations
15 during the adapted think-aloud procedure. Participants' action and communication re-
16 transcriptions were organized to match chronologically their verbalizations as they watched their
17 filmed performance.

18 After the transcription stage, the data were analysed using the procedures of grounded
19 theory (Strauss & Corbin, 1990). First, data transcripts were divided into meaningful pieces of
20 information called « meaning units » (MU). Secondly, these MU were compared and grouped
21 together according to common features into increasingly more complex categories (Tesch, 1990).
22 Three investigators, experienced in qualitative methods, were involved in the data analysis
23 process. An independent coding of the data was performed by the two researchers who
24 conducted the protocol. Comparison and discussion of the codes (i.e., MU) occurred until a

1 consensus was reached. A third investigator, considered as a “disinterested peer” (Lincoln &
2 Guba, 1985, p.308) was asked to checked the relevance of the categorization process.

3 *Credibility*

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

9 Results

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

16 *Nature of the information and reasons for its selection*

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

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

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

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

19 *Strategies used to code the information and their functions*

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

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

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

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

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

23 *Self-talk.* Self-talk was the fourth strategy. When gymnasts' self-talk consisted of
24 technical instructions and self-assessment, this strategy was thought to increase performance of
25 technical execution and, more specifically, to feel kinaesthetic sensations for an instructional

1 self-talk (G7), and to detect and correct technical errors for both kinds of self-talk (G1, G2, G3,
2 G5, G6, G7, G8, G10). Instructional self-talk was also perceived to increase engagement and
3 activation (see Figure 2). Finally, when the content of self-talk was made up of positive
4 encouraging statements, self-talk was used to increase engagement and, more specifically, to
5 give a motive to succeed at the next trial for gymnast 2 and to overcome pain for gymnast 8.

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

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

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

16 Discussion

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

24 *Nature of the information and reasons for its selection*

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

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

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

1 to increase visual perceptions. The present study also showed that reasons identified during the
2 first and second observations were found to be similar.

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

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

1 not the opportunity to view themselves (Winfrey & Weeks, 1993) or see the performance of
2 others (Starek & McCullagh, 1999).

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

10 *Strategies used to code the information and their functions*

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

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

21 *Imagery, self-talk, and imagery associated with self-talk and their functions.* Imagery,
22 self-talk, and imagery associated with self-talk are well-known strategies used to facilitate
23 retention (Cadopi et al., 1995; Carrol & Bandura, 1990; Gerst, 1971; Hall et al., 1997; Housner,
24 1984; Meaney, 1994). These findings corroborate Bandura's (1986) social cognitive theory of
25 observational learning. Bandura postulated that after a behavior demonstration, visual and/or

1 verbal strategies are implemented to memorize this behavior. The present study takes this a stage
2 further. First, it studied complex motor skills that are only able to be performed by elite athletes.
3 To our knowledge, this has not previously been examined before. Second, details about the
4 characteristics of imagery, such as the perspective (i.e., internal, external), the modality (visual,
5 kinaesthetic), and the content (epoch(s) of the movement and part(s) of the body), and details
6 about the content of self-talk (technical instructions, encouragements, self-assessment) were
7 provided.

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

24 *Observing others, listening to the coach's feedback and their functions.* Observing others
25 seems to be a novel strategy which codes information collected as gymnasts watched their

1 performance. Gymnasts observed teammates performing a similar movement, a different
2 movement displaying similar key actions, and a different movement. All these movements are
3 familiar to the gymnasts and are part of their motor repertoire. As discussed previously,
4 modeling literature can explain why participants perceived observing a model as helping
5 increasing performance. One gymnast, who observed a teammate performing a different
6 movement, also reported that it helped her to increase her engagement; she was keen to perform
7 new and complex skills. This is consistent with Cumming et al. (2005) who reported that using
8 OL for motivational functions was not employed very frequently by athletes, but that it did exist
9 as an OL function.

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

14 *Strengths and limitations of the study*

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

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

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

13 *Practical implication and future directions of research*

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

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

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Figure Captions

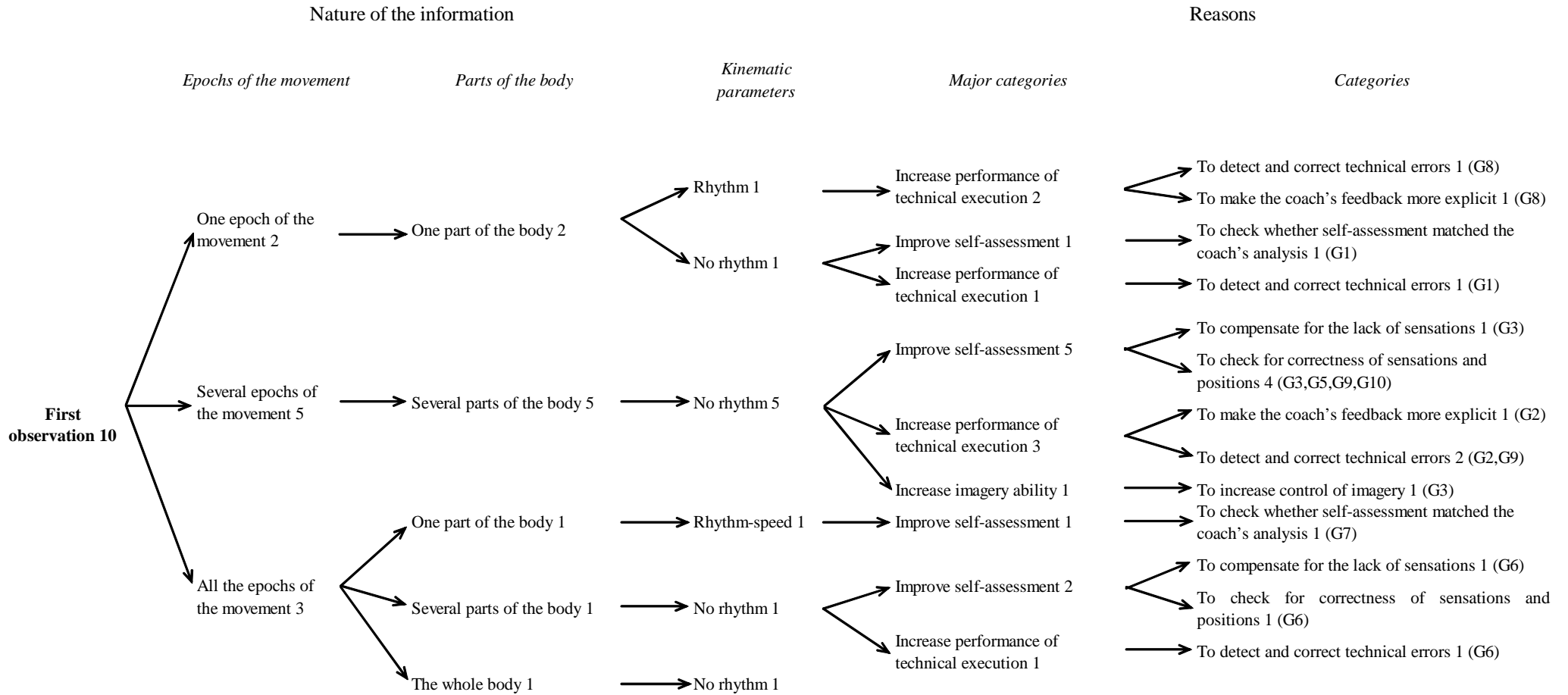
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Figure 1. Nature of the information observed by the gymnasts after viewing their performance and reasons provided.

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

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

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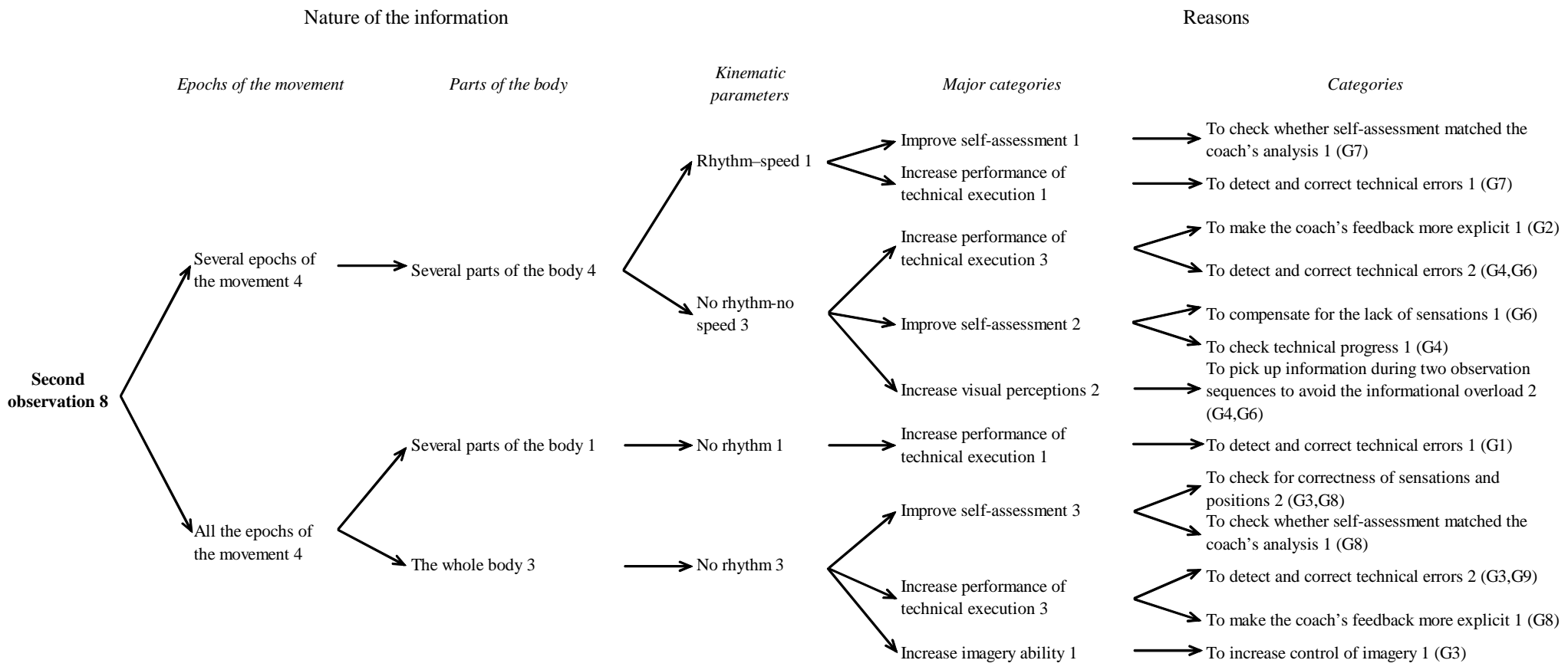


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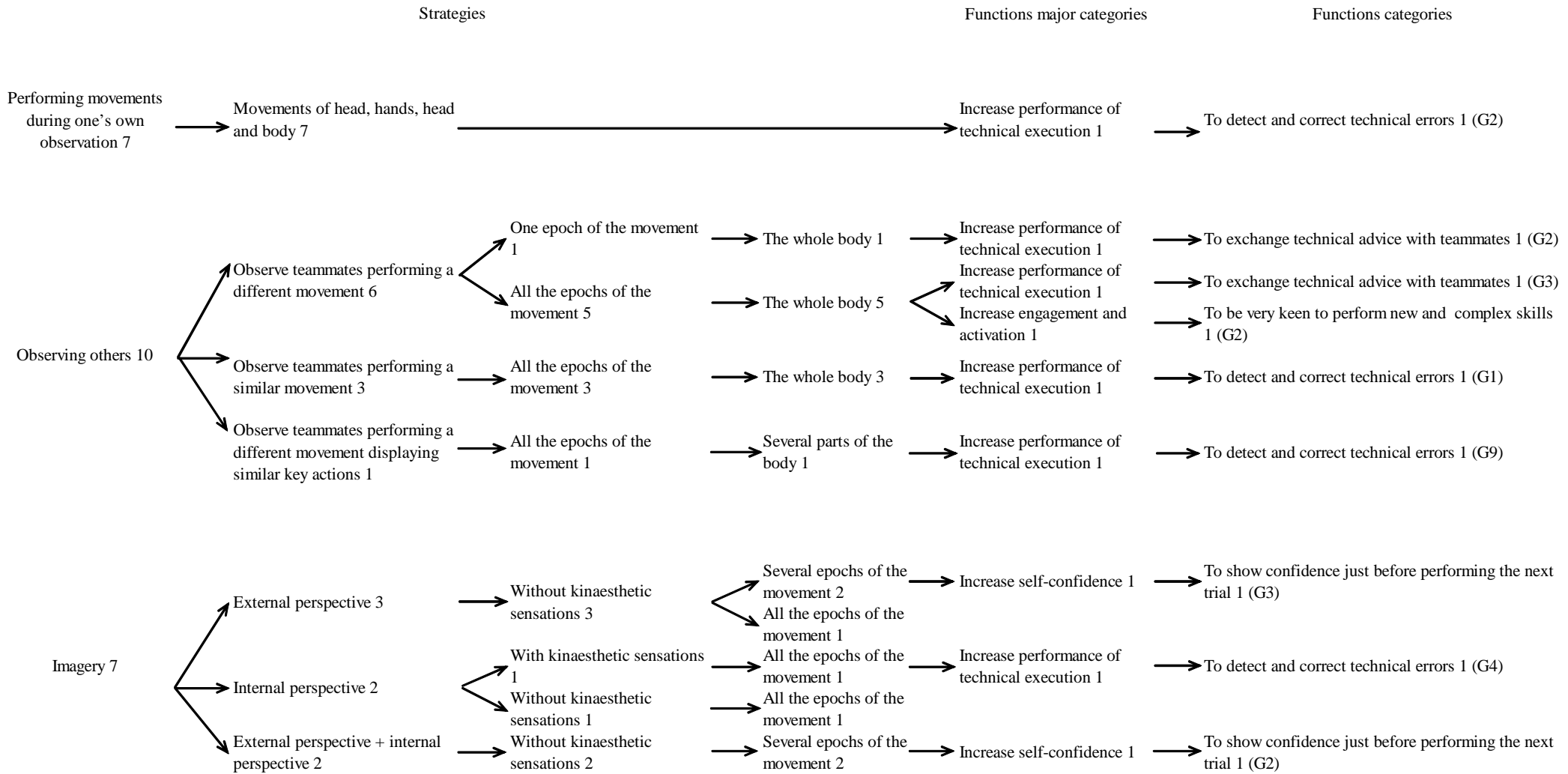


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Notes. Numbers mentioned in this figure represent the number of meaning units; G1, G2 to G10: Gymnasts

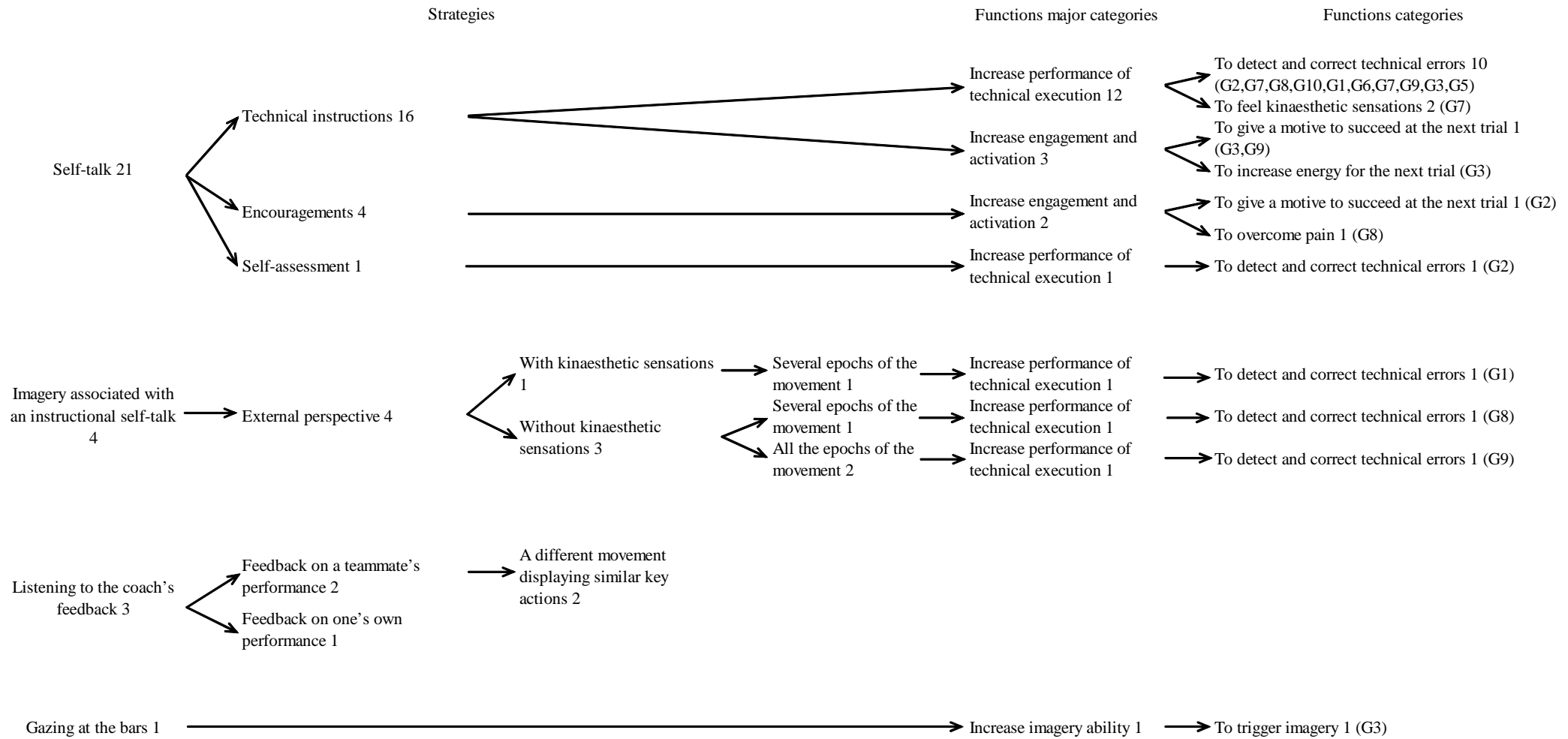
1 *Figure 2. Strategies used to code the information and their perceived functions.*

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