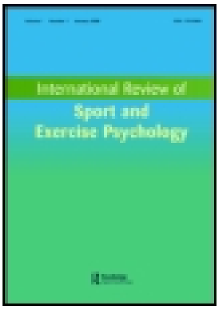

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Observation interventions for motor skill learning and performance: an applied model for the use of observation

Diane M. Ste-Marie [a], Barbi Law [b], Amanda M. Rymal [a], O Jenny [c], Craig Hall [d] & Penny McCullagh [c]

[a] School of Human Kinetics, University of Ottawa, Ottawa, Ontario, Canada

[b] School of Physical and Health Education, Nipissing University, North Bay, Canada

[c] Department of Kinesiology, California State University East Bay, Hayward, USA

[d] Kinesiology, The University of Western Ontario, London, Ontario, Canada

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Observation interventions for motor skill learning and performance: an applied model for the use of observation

Diane M. Ste-Marie[a]*, Barbi Law[b], Amanda M. Rymal[a], Jenny O[c], Craig Hall[d] and Penny McCullagh[c]

[a]*School of Human Kinetics, University of Ottawa, Ottawa, Ontario, Canada;* [b]*School of Physical and Health Education, Nipissing University, North Bay, Canada;* [c]*Department of Kinesiology, California State University East Bay, Hayward, USA;* [d]*Kinesiology, The University of Western Ontario, London, Ontario, Canada*

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Using the 5 Ws and 1 H journalistic approach of Beveridge Mackie (2011), we reviewed the observation intervention research that targeted sport skills or daily movement tasks. Through this review, it became apparent that while there is much research that examines observation of a live or video (what), skilled model (who) for enhanced skill learning (why) in laboratory settings (where), there is a need for not only a wider scope of research, but also a deeper one. Following the review of literature, an applied model for the use of observation is advanced. Through this applied model, we propose that practitioners should first assess the observer's characteristics and the task characteristics for which any observation intervention is being created. The practitioner should then gain an understanding of the context and the desired outcomes of the learner and use this advance information to vary the characteristics of: (1) who is observed; (2) what is observed and what instructional features will accompany the intervention; (3) when it is observed; and (4) how the observed information should be delivered. Future research directions are also forwarded with regard to identified gaps in the literature.

Keywords: observational learning; skill acquisition; performance enhancement; review

Introduction

The fact that we repeat and learn the behaviors of those we have observed is a longstanding finding that is not disputed. What might be disputed, however, is how to label this factual evidence. Indeed, a wide variety of terms, such as imitation, emulation, observational learning, and modeling, to name a few, have been used in the context of such findings (Williams, Davids, & Williams, 1999). It is our intention to speak to the use of observation for both motor skill acquisition and performance. Specifically, we are interested in how observation of others, or the self, can be optimized to assist the learning of motor skills, as well as to improve motor skill performance, such as in sport competition. In the motor skill acquisition context there is the typical tenet that observation can result in the adoption of new motor behaviors not in the individual's existing repertoire (Horn & Williams, 2004). Thus, usage of the term observational *learning* is most appropriate in this context.

*Corresponding author. Email: dstmarie@uottawa.ca

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Observational learning, however, does not apply so well to the situation where a person is using observation to enhance the performance of skills that are already learned (i.e., within their repertoire). For this reason, we chose to remove the word 'learning' and instead refer only to the use of observation so as to reflect both the potential learning and performance enhancement components that can occur through observation.

Horn and Williams (2004) argued that many studies have used novel tasks at the expense of ecological validity while examining the use of observation. Our goal was to review research that involved tasks relevant to practitioners who would be interested in using observation for skill acquisition and performance. Therefore, laboratory-based tasks (e.g., Bachman ladder, computer keyboard, knock-down barrier, stabilometer tasks, etc.) were excluded. The research paradigm also had to include observation being used as an intervention to improve motor skill acquisition or performance, with the exception of descriptive studies that examined the functions of observational learning. While some studies were located that employed modeling interventions using only auditory models, we chose to focus on the delivery of visual information, and thus these were excluded for the purposes of this review. Appendix 1 (see online supplementary data) provides an overview of the intervention articles reviewed.

With a focus on intervention-based experiments, it is important to note that the neuroscientific research paradigm within observation is not a major theme in this review. Such research typically examines neural structures activated as an action is being observed (e.g., Calmels, Hars, Jerry, & Stamm, 2010; Clark, Trembley, & Ste-Marie, 2003; Grezes, Costes, & Decety, 1998) and it certainly informs our understanding of the contributions of observation to learning and performance. The key discovery of mirror neurons by Rizzolatti and his group in the early 1990s (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992) is a clear example of its importance. The research design in such experimentation, however, does not introduce interventions that may enhance the execution of the action and thus they are not captured to any great extent in this review. Readers are encouraged to read the varied reviews that link the mirror neuron system and observation with such topics as education (van Gog, Paas, Marcus, Ayres, & Sweller, 2009), cognitive science (Obhi & Hogeveen, 2010) and sport (Holmes & Calmels, 2008).

Actually, Holmes and Calmels' (2008) neuroscientific review of observation also includes literature related to imagery use in sport, a mental process tightly coupled with observation, with both being shown to have similar neural involvement (e.g., Clark et al., 2003; Macuga & Frey, 2011). Indeed, if one considers Bandura's (1986) work, imaginal coding of observed information is an important step in the process of building a cognitive representation, and thus it is not surprising that imagery and observation are often examined together in research, although McCullagh, Law, and Ste-Marie (in press) have commented on how this coupling is often not made explicit. As noted by Holmes and Calmels, however, these processes are also distinct, with imagery described as a top-down, conscious, knowledge-driven process and observation as more of a bottom-up, unconscious, percept-driven process. Such distinctions support our interest in focusing this review on observation interventions, although some of the combined observation and imagery interventions are given mention.

The review is divided into three sections: (1) current state of knowledge; (2) an applied model for the use of observation; and (3) future research directions. The first section concerns the current state of knowledge concerning observation interventions with sport and activities of daily living tasks. Borrowing from the journalism field, we use the 5 Ws (Where, Why, Who, What, When) and 1 H (How) method to convey this information as it is argued to be a factual gathering process that enables the presentation of all the essential elements on a topic (Beveridge Mackie, 2011).

This structure of the 5 Ws and 1 H is also used in the second section, which concerns a proposed applied model that can be used to guide practitioners in the use of observation. Approaching the research from this structure also exposed us to the many research questions that are yet unanswered, thus allowing us to conclude with recommendations for further research on the use of observation.

Current state of knowledge

Where

There is the opportunity for observation of motor skills to occur in a number of situations (i.e., training, competition or rehabilitation), but most investigations of observation interventions (>90%) have been in training sessions (see Appendix 1, online supplementary data, for overview of settings). Less than 5% of the research has taken place in rehabilitation, and even less has occurred in sport competitions. With respect to training, the large majority of studies (>80%) have employed a laboratory setting, with the other studies being undertaken in either a sport club or a physical education setting.

Why (functions)

Researchers interested in the use of observation have just recently begun to take a learner-focused view and study the specific reasons learners engage in observation. Cumming, Clark, Ste-Marie, McCullagh, and Hall (2005) were the first to explicitly examine the functions that observational learning may serve for the athlete. The term 'function' refers to the reasons *why* athletes, learners, coaches or other individuals engage in observational learning; it is the underlying *intent* or purpose for observing the demonstration. Cumming et al. investigated these reasons through their development of the Functions of Observational Learning Questionnaire (FOLQ). They found that athletes use observation for motor skill acquisition and execution (i.e., the skill function), to develop and execute sport strategies (i.e., the strategy function), and to reach optimal arousal levels and mental states for physical performance (i.e., the performance function). This and subsequent research employing the FOLQ has consistently shown that athletes of all skill levels (i.e., novices through to experts) employ the skill function most frequently, followed by the strategy and performance functions (Cumming et al., 2005; Hall et al., 2009; Hancock, Rymal, & Ste-Marie, 2011; Law & Hall, 2009a, b; Wesch, Law, & Hall, 2007). Fairly reliable sport type differences exist, with individual and independent sport athletes reporting greater use of the skill and performance functions, and team and interactive sport athletes reporting greater use of the strategy function (Cumming et al., 2005; Hall et al., 2009; Wesch et al., 2007). Hancock et al. (2011) extended the populations studied with the FOLQ to include officials and coaches, and replicated the Skill > Strategy > Performance function pattern of previous research. Yet some differences among the sport populations were found. Coaches employed more of the skill function than the other two groups, while officials employed more of the performance function than coaches.

Using the basis of these functions of observation, we now turn to experimental findings to demonstrate how the functions have been explored within observation research. It is quite difficult to discuss these functions without discussing outcomes from the use of observation. In fact, we would argue that these two should be paired. That is, the measured outcomes within an experiment arise as a result of the specific function(s) that the researchers targeted in their intervention. Basically, the functions can be considered the *intended* focus or *desired* outcome of the modeling experience, whereas the outcome can be considered as the *actual* effects of the observation experience on key performance variables (i.e., the physical and/or psychological *effects* of the modeling experience on the learner's cognitions, affect and behavior). From this perspective, we have chosen to review research that has directly examined each of the functions, and highlight the corresponding outcomes.

Skill function and related outcomes

Within the larger body of observation intervention research, the emphasis has been on examining the effectiveness of skill-based modeling experiences on motor skill learning (i.e., 'skill' function; see Appendix 1, online supplementary data). Aside from the research using the FOLQ described above, only one published study was identified on how athletes employ the skill function. Hars and Calmels (2007) conducted a qualitative study of elite gymnasts' use of observation within practice and reported that gymnasts used the self-observation of their bar performance to help improve self-assessment, to increase performance of their technical execution, to increase their imagery use and to increase their visual perceptions. With the skill improvement context of the study, these four reasons may be considered sub-functions of the skill function, suggesting that athletes have very particular goals in mind when observing the self on video.

Research on observation use has examined and demonstrated significant outcomes related to skill learning in terms of both short-term (i.e., acquisition phase) and long-term (i.e., retention or transfer phase) effects (e.g., Hayes, Hodges, Huys, & Williams, 2007; McCullagh & Meyer, 1997; Wrisberg & Pein, 2002; Wulf, Raupach, & Pfeiffer, 2005; Zetou, Fragouli, & Tzetzis, 1999). These physical performance tests have demonstrated modeling benefits for movement outcomes (e.g., Al-Abood, Davids, & Bennett, 2001; Weiss, McCullagh, Smith, & Berlant, 1998) as well as movement dynamics, or the quality and coordination of movements (e.g., Horn, Williams, & Scott, 2002; Magill & Schoenfelder-Zohdi, 1996). Two meta-analyses have been conducted on this literature and have demonstrated that in terms of skill-related *outcomes*, the use of observation appears to produce greater changes in movement dynamics than movement outcomes (Ashford, Bennett, & Davids, 2006). However effects for movement dynamics are greater for adults than children, while effects for movement outcome appear to be greater for children than adults (Ashford, Davids, & Bennett, 2007). While these meta-analyses included a wide range of gross motor tasks, including many sport skills, some of the laboratory tasks included are those that were excluded from the current review. Due to space limitations, readers are referred to these meta-analyses, as well as reviews by McCullagh et al. (in press; see also McCullagh, Ste-Marie, & Law, in press) for further reading.

Consistent with Bandura's (1986) conceptualization of the modeling process, researchers have shown that the use of observation improves cognitive representations of the movement, as measured by recall and recognition tests. Findings on the use of observation are also consistent with the direct perception perspective (Scully & Newell, 1985), whereby observers pick up relative motion information from a demonstration and use this information to produce novel or unfamiliar coordination patterns (Williams et al., 1999). These benefits have been shown for serial as well as continuous and discrete tasks (see Ashford et al., 2006). This illustrates the universality of observation as a tool within the motor skill domain.

Outside of sport skills, only scant attention has been paid to the use of observation for improvement in motor skills and their performance in the injury and chronic disease rehabilitation environment (Maddison, Prapavessis, & Clatworthy, 2006; Ng, Tam, Yew, & Lam, 1999), highlighting the need for continued research in this setting. One notable exception is the work of Dowrick and colleagues (Dowrick & Dove, 1980; Dowrick & Raeburn, 1995), who have successfully employed self-modeling techniques in therapeutic settings to assist children with physical disabilities in the acquisition of motor skills, such as swimming, walking and other activities of daily living.

Strategy function and related outcomes

Specific research on how athletes gain information to use and modify strategies through observation (strategy function) is limited. One example is Granados and Wulf's (2007) examination of the difference between observing and just discussing strategies that can be used in speed cup stacking. Their results showed that observing the strategy for optimal performance produced greater performance benefits than simple discussion. Research with scarf juggling has also shown that observation of learning and peer models resulted in greater strategy uses than non-peer and skilled models (Meaney, Griffin, & Hart, 2005), suggesting that the type of model may be an important variable for this function. From the lack of research explicitly examining the strategic function of observation and its outcomes, it is clear that this is an area in need of future research before further conclusions can be made about how to effectively focus observation interventions on strategy learning.

Performance function and related outcomes

As the majority of observation research has derived from the motor learning rather than sport psychology domain, the fact that we were unable to find any studies that specifically designed a modeling experience to target psychological factors (i.e., used the performance function) alone is not unexpected. Rather, researchers often assess the impact of their skill-based modeling experiences using psychological factors (e.g., self-efficacy) as well as physical performance. Research that has measured changes in psychological variables generally supports positive modeling effects on self-efficacy, motivation and other self-regulatory variables in both sport (Clark & Ste-Marie, 2007; Kitsantas, Zimmerman, & Cleary, 2000) and rehabilitation settings (Maddison et al., 2006).

Bandura (1986, 1997) placed much emphasis on the mediating role that self-efficacy plays in the observation–behavior change relationship. Therefore, it is not surprising that much research has examined the effects of observation on self-efficacy. In research with undergraduate students, both self-modeling/self-observation (Feltz, Short, & Singleton, 2008) and participant modeling (Feltz, Landers, & Raeder, 1979) have produced improvements in self-efficacy. However, other studies have shown no such observation effects (Law & Ste-Marie, 2005; Ram & McCullagh, 2003; Soo Hoo, Takemoto, & McCullagh, 2004; Starek & McCullagh, 1999). Research examining these relationships among children has also shown equivocal findings (Weiss et al., 1998; Winfrey & Weeks, 1993; Zetou, Kourtesis, Getsiou, Michalopoulou, & Kioumourtzoglou, 2008). One of the reasons for the range of findings could be that the observation interventions used were all designed to improve skill performance and did not include design elements that would target self-efficacy beliefs, such as positive affirmations made by models, indications of improvement, or mastery. Furthermore, learners' perceptions of what makes a model effective for building self-efficacy have not been examined in depth.

In terms of other psychological processes, Weiss et al.'s data (1998) suggested that a coping or mastery model may help reduce the fear of water among children early in the swimming skills learning process. The effectiveness of self and other modeling on self-efficacy and anxiety among novice adult swimmers was examined by Starek and McCullagh (1999), but no effect was found for this age group. Interventions designed specifically to examine effects on arousal and anxiety through the use of observation are needed before clear recommendations can be made regarding the effectiveness of this technique for modifying these responses.

More recently, Ste-Marie et al. (e.g., Clark & Ste-Marie, 2007; Rymal, Martini, & Ste-Marie, 2010; Ste-Marie, Rymal, Vertes, & Martini, 2011; Ste-Marie, Vertes, Rymal, & Martini, 2011) have pushed current bounds on observation research to examine its effects on self-regulatory variables, thus extending the examination of the performance function in the motor skill learning and performance contexts. This research is framed within Zimmerman's self-regulation of learning framework (2000) and has demonstrated that, particularly for children, self-modeling produces favorable changes in self-satisfaction, self-reactions and intrinsic interest in a motor task being learned (Clark & Ste-Marie, 2007), and, in competition, is combined with other self-regulatory strategies such as strategic planning and self-evaluation (Rymal et al., 2010; Ste-Marie, Rymal et al., 2011).

While few studies have examined modeling within the context of rehabilitation, these studies appears to have taken greater care in targeting psychological factors in the design of the intervention through the use of coping modeling experiences at several time points during recovery. Within injury rehabilitation, research examining the effects of modeling on individuals recovering from anterior cruciate ligament (ACL) reconstructive surgery has shown that a coping model can produce reduced perceptions of pain and increased crutch self-efficacy, but no effect on anxiety (Maddison et al., 2006). Again, these findings may depend on the population, as Ng et al. (1999) did not find any effect of modeling on self-efficacy for chronic obstructive pulmonary disease (COPD) patients who viewed a mastery model. Flint (1999) conducted interviews with athletes who were recovering from ACL injuries after they had viewed several coping model videos. Overall, her findings support the notion that athletes can build confidence in their ability to cope with the recovery process through peer modeling.

While the FOLQ research has produced clear functions that athletes, coaches and officials of sport use, it was developed directly from the sport imagery questionnaire which leads one to question whether other functions for observation have been overlooked. Law (2008), for example, determined through qualitative methods that athletes also reported using observation to learn the norms of the sport group in which they associated. Thus, when researchers are examining the functions of observation, and its related outcomes, they should also consider other means of data collection and the ways in which observation use may be unique from imagery.

Who

When examining the literature related to the use of observation, it is noted that many researchers have been interested in *'who'* is the most beneficial model to observe. Although motor skill performance is also of interest in this review, it is noted that research with this focus has only considered skill acquisition, with no research related to enhanced execution of motor skills in competition. As such, the focus of this section is on motor skill acquisition.

The obvious model types to consider are related to the observation of others or the observation of the self. For observing other individuals, research has grouped these into peer (i.e., matched gender and age between observer and model) and non-peer-models. Within these two model types, there is also the consideration of whether the model is characterized as a skilled model (shows proper execution of skill), an unskilled model (execution of skill contains errors) or a learning model (observer sees individual move from unskilled to skilled performances). Another level of variation is in terms of coping and mastery models. A coping model is seen across a number of trials and moves from verbalizations concerning difficulty performing the skill and feeling a lack of confidence concerning the ability to do the skill to verbalizations that show confidence and ease in performing the skill. Coupled with these verbalizations is a change in the physical execution of the skill from an unskilled to a skilled performance. In contrast, mastery models begin with confident statements in their ability to do the skill and expressing the ease in which they perform the skill and always show a skilled execution. With respect to observing the self as a model, one can view the self from a self-observation (basic video replay) or self-modeling technique (edited video replay techniques; Dowrick, 1999). Research concerning the varied comparisons of these different model types is reviewed next.

Coping and mastery models

With respect to peer coping and peer mastery comparisons, Weiss et al. (1998) investigated the acquisition of swimming skills, fear and self-efficacy of 24 children who were afraid of the water. Children either viewed a peer mastery model, a peer coping model or no model. Their results indicated that both modeling conditions seemed best for skill learning gains but the coping model influenced self-efficacy more than the mastery model and control. Clark and Ste-Marie (2002) extended Weiss et al.'s research and examined the influences of these model types on learning a diving skill (a skill considered to be more fearful than that used by Weiss et al.), self-efficacy and perceived difficulty. Retention scores showed that the peer mastery model group performed the dive better than the peer coping and control groups, though this only approached significance. Perceived task difficulty of those in the peer coping model group decreased at retention, reinforcing the finding that a mastery model may be better for physical performance changes, but coping models provide more change to psychological factors.

Research with non-peer mastery and coping models has not shown the same pattern of findings. In Kitsantas et al.'s (2000) research, a dart-throwing task was used to investigate whether a non-peer mastery model or a non-peer coping model, with or without social feedback, would benefit learning. While social feedback did not have an effect on throwing behavior, those viewing the non-peer coping model showed the greatest benefits in terms of throwing scores, followed by those viewing the non-peer mastery model; the control group performed the worst. Moreover, the non-peer coping model participants had better self-efficacy, intrinsic interest and self-reactions than the non-peer mastery model group, which in turn did better than the control group. Thus, in this investigation both the coping and mastery models yielded physical performance behavior change and psychological benefits more than the control, with coping models being superior (see McPherson & Bull, 2003, for similar results).

Overall, there appears to be a distinction in the benefits obtained between peer and non-peer models and whether they show mastery or coping characteristics. For peer models, mastery and coping characteristics may affect physical and psychological measures differentially, whereas non-peer models show a similar pattern for both of these measures. No research to date, however, has combined these different factors in a research design, so it is difficult to tease out why the pattern of findings differs across the different model types.

Skilled, unskilled and learning models

Skilled versus unskilled models are also of interest when attempting to answer *who* is the most beneficial model to observe. In Gould and Weiss's (1981) investigation of these model types, accompanied with positive, negative or irrelevant self-talk, they found that viewing a peer unskilled model improved a leg exercise task significantly more than viewing a non-peer skilled model. Similar results were found for self-efficacy; peer unskilled performed better than non-peer skilled. A follow-up study conducted by George, Feltz, and Chase (1992) removed the self-talk statements but included a peer skilled and non-peer unskilled, resulting in four groups: peer skilled, peer unskilled, non-peer skilled, non-peer unskilled. Their results showed that the ability of the model was more important than model similarity. Specifically, peer skilled and non-peer skilled held their leg up significantly longer than peer unskilled and non-peer unskilled. However, the less skilled model increased self-efficacy for both the peer and non-peer model types. A noted weakness of these studies is that a retention test was not administered and therefore it is difficult to suggest that increases in performance and self-efficacy were in fact retained. Furthermore, these studies were using a task that was already within the learner's repertoire and so its applicability to skill learning is limited. Using more of a learning paradigm, Weir and Leavitt (1990) investigated peer skilled and peer unskilled models, with and without knowledge of results, on a dart-throwing task. No significant difference between the two model types was evident. The low number of participants per group ($n = 5$) and the lack of learning effects for the task, however, are weaknesses in this experiment, indicating that continued research on this topic is needed.

Using learning models, McCullagh and Meyer (1997) compared a group that received only knowledge of results (KR; i.e., no observation provided) to a peer skilled model plus KR, and two peer learning model groups (peer learning model plus KR and peer learning without KR) during the learning of a free weight squat. For free weight squat form, all groups did better over time but the groups with observation plus KR did better than the peer learning without KR. Therefore, the addition of feedback seemed to contribute to the models' effectiveness (see also Weir & Leavitt, 1990). No differences were found for outcome scores. Adams (2001) was also interested in the impact of observation on the learning of an overarm throw when learners were able to view a peer learning model or a peer skilled model, or received verbal instruction only. The results showed that overarm throwing force improved across all groups. A problem for interpretation of the results, however, is that no post hoc analysis was conducted. Thus, differences between groups were not determined.

Meaney et al. (2005) also examined varied model types for learning scarf juggling. Here, a non-peer skilled model giving verbal instructions (i.e., simulated teacher) was accompanied by either a peer skilled, peer learning or non-peer learning model. No significant differences were seen for outcome scores during acquisition, retention or transfer, though it is possible that the initial modeling from the teacher dampened the potential effects of the supplemental modeling. The number of strategies used by participants during the transfer test indicated that the observation of a peer model encouraged a greater number of strategies than observation of a non-peer model. Also, a greater number of strategies were seen in those who viewed a learning model. Overall then, skilled and learning models do not seem to differentiate much on physical performance measures, but the provision of feedback with unskilled and learning models is important. Learning models may also encourage greater strategy use than skilled models.

Self-as-a-model

Of the research projects that have included comparisons of self-as-a-model techniques, the majority of research is related to self-observation techniques, with very few incorporating self-modeling. In relation to self-observation, six papers have compared self-observation with other modeling interventions to investigate which model type is best for motor acquisition. The limited neuroscientific research that has examined influence of behavioral agency does suggest that observation of the self may be a more powerful technique than observation of another because of the heightened functional similarity with that of motor execution (Holmes & Calmels, 2008). Consequently, one would expect observation of the self to be a better model than observation of another. While some studies have shown positive effects for the self-observation video (e.g., Clark & Ste-Marie, 2007; Onate et al., 2005; Van Wieringen, Emmen, Bootsma, Hoogesteger, & Whiting, 1989), one study has shown it to be less effective (Zetou et al., 1999), and one reported no differences between self-observation and other model types (Emmen, Wesseling, Bootsma, Whiting, & Van Wieringen, 1985). This is similar to Rothstein and Arnold's (1976) early review on self-observation studies and speaks to the idea that certain features are important when considering the effectiveness of self-observation.

Within these studies, one would think that there would be commonalities to help explain who is a more effective model when comparing self-observation techniques to other modeling techniques. However, no specific feature has surfaced. Although Ashford et al. (2006) suggested that skill classification could moderate observation benefits, a self-observation video was more effective than other modeling techniques for discrete skills such as a jump landing task used in basketball (Onate et al., 2005) and a volleyball serve (Van Wieringen et al., 1989) as well as continuous skills such as swimming (e.g., Clark & Ste-Marie, 2007), so other variables should be considered.

As for research investigating self-modeling, some has found that self-modeling is more effective than other model types for learning swimming skills (Clark & Ste-Marie, 2007; Dowrick & Raeburn, 1995; Starek & McCullagh, 1999) while discrete volleyball skills showed no learning differences from self versus other models (Barzouka, Bergeles, & Hatziharistos, 2007). Such few studies, with a number of different variables, make it difficult to draw any firm conclusions, highlighting the need for continued investigation of advantages related to different model types.

In the reviewed articles, the most popular model used by researchers interested in observation interventions was that of a skilled model, and most often a peer (see Appendix 1, online supplementary data). The use of such a model is likely influenced by Bandura's (1997) notions of the importance of model similarity for the provision of a strong cognitive representation of the skill. Of the papers implementing skilled models, the majority are examined within a laboratory environment intending to influence skill acquisition. That said, there is a clear need to investigate other model types to gain a better understanding of the wide variety of applications of observation in different situations.

What

Any understanding of the crucial elements that lead to learning and performance advantages through the use of observation should include research that has questioned '*what* is observed?' in addition to '*what* instructional features can accompany observation?'. Noteworthy is that these questions have currently only been posed in the context of motor skill acquisition, with no inquiry into how they may affect motor performance enhancement of skills already acquired. Consequently, the next section will focus on the literature pertaining to these two questions for motor learning.

What is observed?

In terms of this first question, Scully and Newell (1985) were the lead researchers critical of the emphasis of research on how observation assisted learning and performance. Instead, in their visual perception perspective of observational learning, they argued that researchers needed to determine the essential information to be conveyed to assist motor skill acquisition. Framed in Gibson's (1950) direct visual perception perspective and Newell's (1985) viewpoint of the hierarchical structure of coordination, control and skill, Scully and Newell contended that observing relative motion (i.e., the motion of all the elements in the configuration relative to each other) provided the necessary information to constrain the emergence of the coordination pattern in the early stages of learning. Thus, observation provides spatial and temporal information concerning the relationship of the limbs and joints involved in the movement. Later in learning, once the coordination pattern is being refined, observation may provide the required dynamic features to assist the learning related to the scaling of the movement pattern.

A corollary to Scully and Newell's perspective is that methods that reduce relative motion information to its essential elements should enhance skill acquisition due to the increased saliency of that information (Runenson, 1984). Point light displays (PLD: a procedure that removes structural and contextual information by only showing moving dots that reflect the motion of key joints of a moving body) is one technique that has demonstrated that a reduced visual display that provides relative motion is sufficient for people to determine varied movement patterns (Johansson, 1973, 1975). Thus, the question as to whether PLD is favorable over video or live models is relevant when considering how to best constrain the information observed. Scully and Carnegie (1998) compared the use of PLD and filmed models for learning ballet sequences. In support of the propositions outlined, participants who observed the PLD were not only able to learn the dance sequences effectively, showing the utility of observing relative motion information, but they did better than those participants who saw a video model.

Subsequent research has not supported the latter finding of PLD being superior to video display, although some research has shown that it is as effective as video display (Al-Abood, Davids, Bennett, Ashford, & Marin, 2001; Breslin, Hodges, Williams, Curran, & Kremer, 2005; Munzert, Hohmann, & Hossner, 2010), even when visual search patterns show that a more effective search strategy is used with PLD (Horn et al., 2002). For example, Breslin et al. had participants learn a cricket bowling task across 60 acquisition trials and examined the learning and retention across four groups, three of which received modeled information either through PLD or video. The results showed that observation groups gained learning and retention benefits, as witnessed by better intra-limb coordination patterns, than the control group, although no differences were seen between the two different displays of modeled information.

In contrast to these findings, using such tasks as ballet skills (Rodrigues, Ferracioli, & Denardi, 2010) and basketball dribbling (Romak & Briggs, 1995), other research has shown PLD to be inferior to video display. Differences in relation to task complexity and novelty of the movement pattern (e.g., Rodrigues et al., 2010) have been introduced as possible reasons for these varied findings. Differences have also emerged as a function of the age of the observer. Hayes, Hodges, Scott, Horn, and Williams (2007) had children and adults learn a bowling task under point light and video model conditions (Experiment 1). While the adults showed no differences between the two observation techniques, children were poorer at reproducing the action when it was observed via PLD compared to video. In Experiment 2, they noted that with perceptual training, the children were able to benefit from PLD. These equivocal findings suggest that if one has access to a video or live model (both assumedly easier to obtain than the creation of a PLD), this modeled information will provide sufficient information to enhance motor skill acquisition, and the effort associated with creating a PLD is likely unnecessary.

The perceptual training benefits noted in Experiment 2 of Hayes, Hodges, Scott et al.'s (2007) work should also be considered. These benefits highlight the importance of visual gaze behaviors for optimizing information gained from modeled information. Visual search research has clearly shown that expert athletes engage in different visual search patterns that provide the relevant information necessary to anticipate and execute movements and that perceptual training can enhance their performance (see Williams & Ward's 2003 review paper). An obvious corollary to this is that individuals could also be trained to be better observers and more quickly detect the necessary critical information. Unfortunately, however, to our knowledge no other studies have specifically trained visual behaviors for relevant information detection of modeled actions. Breslin et al.'s (2005) research does indicate that visual search patterns change across observation sessions, and thus research of this nature is of merit.

Although the research has not strongly supported the argument that reduced contextual and structural information produces more salient relative motion information for observers, stronger support has been found in terms of relative motion information being important in a demonstration. One experimental paradigm used to support this has involved comparing discovery learning methods to the use of observation. For example, Al-Abood, Davids, Bennett, et al. (2001) studied the acquisition of an underarm dart-throwing task. A group provided with a demonstration yielded similar movement dynamics of the task more quickly than those provided with only verbal descriptions or allowed to discover a throwing method (see also Horn, Williams, Scott, & Hodges, 2005; Janelle, Champenoy, Coombes, & Mousseau, 2003 for similar results with other tasks).

A problem with this research, however, is that there has been no manipulation of the availability of relative motion. As noted by Hodges, Williams, Hayes, and Breslin (2007), it is not possible to determine the necessity of relative motion information without manipulating its availability across different experimental groups. To address this, Hodges and colleagues (e.g., Breslin, Hodges, & Williams, 2009; Hayes, Hodges, Huys et al., 2007; Hodges, Hayes, Breslin, & Williams, 2005) used PLD and regulated the availability of relative motion information by removing key markers from joints associated with the movement pattern. A series of experiments were conducted, using a number of different tasks, such as a non-dominant kicking action (Hodges et al., 2006; Hodges, Hayes, Eaves, Horn, & Williams, 2006), a crown green bowling action (Hayes, Hodges, Huys, et al., 2007; Hayes, Hodges, Scott, Horn, & Williams 2006; Hayes, Hodges, Scott et al., 2007) and cricket bowling (Breslin et al., 2009; Breslin et al., 2005; Breslin, Hodges, Williams, Kremer, & Curran, 2006). Assessments of visual gaze, varied coordination measures and movement outcome were collected throughout these experiments and the reader is encouraged to read Hodges et al. (2007) for a more detailed account of each experiment.

A few main points emerged from this extensive experimentation. One key point was that relative motion information was not always required for observation to generate improvements in coordination patterns. End-point effector information, for example point light emission of only the toe in a kicking action (e.g., Hodges et al., 2006) or only the wrist in a bowling action (Hayes, Hodges, Scott et al., 2007), was sufficient to enable movement coordination benefits from observed information, although movement outcome advantages were not evidenced. Furthermore, the addition of goal-directed constraints, such as the requirement to kick the ball over a barrier (Hodges et al., 2006), resulted in greater approximations to the observed coordination patterns on the part of the learners than when the learner was just attempting to reproduce the action. Removal of relative motion information, however, for a more complex, full-body task, like that of cricket bowling, did result in negative consequences (Breslin et al., 2005). Moreover, in a follow-up experiment that involved fewer practice trials (Breslin et al., 2006) the benefits of inter-limb coordination information via a PLD that was found in Breslin et al.'s (2005) research were not replicated. Taken together, these findings clearly imply that task characteristics (e.g., single limb versus multi-limb tasks), task constraints (e.g., goal-directed versus action-directed) and experience (e.g., number of practice trials) all interact when using observation.

Variation in modeled information is not only through PLD and video. There have also been comparisons between whether the model is on video, live, animated or presented as a virtual model. The research at this level indicates that there is not much difference between these displays. For example, no differences were seen between a live model showing a handstand and one that was animated (Kampiotis & Theodorakou, 2006), or between a live model and a virtual model for the acquisition of flycasting (Kernodle, McKethan, & Rabinowitz, 2008). Similarly, no differences were shown between live models and video models (Feltz et al., 1979).

What instructional features accompany observation?

The mere observation of a motor skill does not automatically lead to the learning of that task. From Bandura's (1986, 1997) perspective, for example, attention and retention processes need to be engaged to form a cognitive representation that is later used in behavior reproduction. Neuroscientific research has also shown that the nature of instructions prior to observation modifies the neural structures employed during action observation (e.g., Grezes et al., 1998). Consequently, research considering the factors that can supplement the observation experience to optimize its effectiveness is important.

Rosen et al. (2010) described a framework in which to understand how instructional features can accompany observation. This framework consisted of five categories that were embedded in three different levels of decision points. The first level concerned whether the instructional feature involved providing the learner with information (passive feature) versus giving the learner an activity to supplement the observation (active feature). Rosen et al. only applied the second level to the active category and it involved whether the activity was to be done before, during or after the demonstration. We would argue, however, that this level could also be applied to the passive category. For example, a therapist could video a client and provide information to that client while the video is being watched, thus fitting with the passive category situated in the 'during' phase of observation. Finally, the third level of categorization in Rosen et al.'s framework only applied to those activities that were provided after observation. Within this level, the distinction was whether the activity was retrospective in nature and encouraged retention of the observed information versus being prospective such that it encouraged transfer to the next attempts at the task. In the remainder of this section, research that has examined the influence of instructional features accompanying observation will be considered within Rosen et al.'s framework.

Both passive and active categories of instructional features with observation have been manipulated in the research. This has been done separately in some research and in a combined fashion in others, always with the purpose of evaluating whether these additional features enhance motor skill instruction. In terms of the passive category, the dominant design has been to add verbal cues to the modeled information. Verbal cues are described as succinct statements, typically of just one or two words, that are used to direct a learner's attention to relevant features of a skill or to trigger key movement pattern elements of a motor skill (Landin, 1994). In the context of the use of observation, the verbal cues have been used for the former function with the logic that there is often too much information to attend to in the demonstration and the observer needs guidance to detect the relevant features in the display.

Much of this research has shown that the benefits obtained from verbal cues depend on a variety of factors, such as age and task characteristics. For example, verbal cues augmented observation benefits for children younger than 6 years of age, but had no effect for children between 7 and 9 years old when they were learning a motor sequencing task (Wiess, 1983; see also Kowalski & Sherrill, 1992; Meaney, 1994). However, Wiese-Bjornstal and Weiss (1992) showed that children between 7 and 9 years old showed dramatic changes in some kinematic variables related to an underhand softball pitch once verbal cues were added to the observation intervention, highlighting that task characteristics may interact with age when evaluating whether to add verbal cues. In addition, verbal cueing seems to influence qualitative aspects of performance as compared to quantitative aspects (McCullagh, Stiehl, & Weiss, 1990; Weiss, Ebbeck, & Rose, 1992).

Sawada, Mori, and Ishii (2002) also used verbal information coupled with observation for younger and older children learning a five-step dance sequence, but contrasted a group that received the dance term for the different movements in the sequence with a group who received a metaphorical cue (e.g., open like a flower). Both age groups were shown to benefit from the coupling of the metaphorical information, but not from the dance terminology, suggesting that the content of the verbal cueing provided is an important consideration. Another possible factor, however, is that Sawada et al. presented the verbal information before the demonstration, whereas the research by Weiss, McCullagh and colleagues (e.g., McCullagh et al., 1990; Weiss et al., 1992) used concurrent verbal cueing. Ste-Marie, Clark, and Latimer (2002) have proposed that the limited attention processing capacity of children can interfere with them using concurrent verbal cueing information effectively and that such information should be presented prior to or after a demonstration, suggesting that the timing of the verbal cueing is a variable that needs to be more fully understood.

Mixed results have also been obtained for adults who received verbal cues in conjunction with a demonstration. Verbal cues aided adults in the acquisition of scarf juggling (Meaney, 1994), but did not alter the learning of a soccer pass (Janelle et al., 2003). Janelle et al. also added a novel cueing technique, that of visual cueing. For this, directional arrows were superimposed on the video to point at key features of interest in the soccer pass. Those participants who received the visual and verbal cueing techniques showed less error and had more appropriate form than all other groups. Thus, verbal cueing reinforced with visual highlights appears to be an effective technique to enhance the use of observation. The addition of eye-movement recording to tap into visual search patterns would have been useful in this experimentation to determine whether these benefits occurred due to increased focus on the relevant cues in the display. In terms of verbal instruction (full sentences of information), it has been shown that instruction enhances the learning as compared to being provided with the modeling experience alone (Kampiotis & Theodorakou, 2006), although this feature has not been investigated at length.

Coming from a different perspective, Al-Abood, Bennett, Hernandez, Ashford, and Davids (2002) manipulated the type of verbal instructions provided before the video was presented (passive/before). One group was encouraged to observe the movement effects of a basketball shot, whereas the other group was told to pay more attention to the movement dynamics. Their results showed that the movement effects group's outcome scores were better than those of the movement dynamics group. Moreover, visual search data showed that the movement effects group spent less time examining movement dynamics than did the movement dynamics group. The authors used this data as support for the idea that by focusing on movement effects, that group was able to free up the movement dynamics required and allowed the basketball shot to self-organize. Problematic with this interpretation, however, is the lack of data concerning the movement dynamics adopted by the two groups. Moreover, despite the instructions, the movement effects group still spent a greater proportion of their time watching movement dynamic information in the visual display (75–80%) rather than movement effect information (20–25%), thus it is difficult to eliminate the possibility that movement dynamic information was contributing to the benefits attained from observation. Regardless, the combined data do show that cueing through verbal or visual means can influence observation benefits positively in adults.

The active category for instructional features is represented mostly by the addition of different verbal rehearsal strategies, such as symbolic coding (Bandura & Jeffery, 1973), imagery (e.g., Fery & Morizot, 2000; Gray, 1990; Gray & Fernandez, 1989; Ram, Riggs, Skaling, Landers, & McCullagh, 2007) and repetition of movement names (Kowalski & Sherrill, 1992; McCullagh et al., 1990; Weiss, 1983; Weiss et al., 1992; Weiss & Klint, 1987) that occur after the modeled information is provided (active/after). In line with social cognitive theory (Bandura, 1986), these strategies focus more on the retention process associated with observation by promoting increased information processing or self-regulatory processing of the observed information. Similar to the verbal cueing and observation literature, findings differ across the different experiments with factors such as age, stage of learning and task characteristics being forwarded as explanatory variables for the incongruences. For example, adults have profited from such strategies when learning hand movement sequences (Bandura & Jeffery, 1973), but not scarf juggling (Meaney, 1994). Similarly, some studies show children benefiting from rehearsal strategies regardless of age (Weiss & Klint, 1987), or between the ages of 7 and 9 years (Kowalski & Sherrill, 1992), with others showing only younger children (5–7 years) benefiting and not older (8–10 years) (Weiss et al., 1992), and yet others showing no benefits for children at any age (McCullagh et al., 1990).

Moving into the research that has incorporated other mental skills, this has focused mainly on imagery coupled with observation. One approach in which imagery and observation have been combined is visual motor behavioral rehearsal (VMBR; Suinn, 1984). Hall and Erffmeyer (1983) in their VMBR group had subjects first relax, then view a video of a female basketball player successfully executing 10 foul shots with perfect form before they imaged and then performed the task. A second group did not receive the video but did image, and showed poorer free throwing performance than the VMBR group. Further studies that have included a video with VMBR (Gray, 1990; Gray & Fernandez, 1989) have also shown that the addition of observation assisted in various aspects of performance, suggesting that visual information supported by imagery rehearsal (and vice versa) can enhance learning (see also Onestak, 1997).

Finally, the last aspect related to instructional features concerns an active/before category that implemented a training protocol. Perceptual training provided before the use of PLD modeled information was implemented by Hayes, Hodges, Scott et al. (2007) with children learning a bowling task. This research showed that children were able to gain information from PLD better as a result of learning how to identify different biological motion patterns viewed on a computer screen.

Upon examination of these two factors for the compilation of articles reviewed, it is apparent that most researchers use full body video displays (approximately 80%), followed by a full body live model (15%), with none of the experimenters opting to use PLD. In terms of instructional features, less than 20% added a component to the modeled information. When a feature was added it was typically passive, concurrent information that directed attention to relevant cues in the demonstration. One study also included an active verbal rehearsal strategy in addition to the passive information. In this regard, there is the implication that researchers interested in the use of observation perhaps do not capitalize on potential instructional features that can complement observation experiences.

When

Observation can be provided before a skill is practiced, interspersed throughout practice trials, and/or provided after practice is complete. As can be noted in Appendix 1 (online supplementary data), the majority of studies (approximately 60%) have employed a combination of presenting observation both before and during physical practice. The next largest representation was providing observational learning before physical practice (almost 35%) with fewer studies providing it only during physical practice, or following physical practice (remaining 5%).

In terms of directly manipulating when observation is provided, only two studies were found that incorporated ecologically valid tasks. Anderson, Gebhart, Pease, and Rupnow (1983) had 7- and 9-year old children learning a ball-striking task, whereas Weeks and Anderson (2000) had adults learning a volleyball serve. The basic experimental conditions for both studies involved groups viewing the model either before, after or interspersed throughout practice trials. The results showed that the children were not affected by the temporal placement of the modeling experience, but that the modeling groups performed better than the control. For the adults, service form and outcome were assessed during acquisition, immediate and delayed retention. Multiple pre-practice demonstrations by the model generated better initial form, although there were no significant group differences on either of the retention tests for either dependent measure. A noted weakness in this research was the lack of a control group.

Overall, the most common approach in research studies is to have the model demonstrate both before and during physical practice, and given the positive effects of observation, this appears to be effective. Is it the optimal approach? At this point we really do not know because of the paucity of research examining 'when' a model should demonstrate.

How

Certainly, it may be possible to increase the effectiveness of one's observation use through manipulation of several model presentation characteristics such as the angle at which the model is viewed, the speed of video demonstration and the frequency of model presentation. Despite this, it appears that such characteristics have not been thoroughly examined. This is surprising given the importance placed on *effective implementation* of psychological skills (e.g., Gill & Williams, 2008). It is not enough to simply be using psychological skills; one must use such skills in an effective manner in order to maximize learning and/or performance gains. In the remainder of this section, we highlight certain presentation features that may be of importance and review the research to date on each.

Angle at which a model is viewed

When a learner is viewing a model, from which angle should he or she watch? This is not a new question being asked in the modeling literature (i.e., Fleishman & Gagné, 1954), but the research is limited. Researchers have examined three different viewing angles. The objective view involves placing the learner in front of the model (i.e., facing the model while the model faces the learner). The subjective view requires the learner to be placed behind the model performing the skill to be learned. Lastly, the looking glass view requires the model and learner to be facing each other (as in the objective view), but the model presents a mirrored image of the skill to be learned, relative to the required limb movements (e.g., for a movement sequence where the right arm is abducted simultaneously, the looking glass model would abduct the left arm instead, thus simulating one looking into a mirror).

It has been suggested by some researchers (i.e., Ishikura & Inomata, 1995) that, relative to the subjective view, the additional cognitive processing required in the objective and looking glass model view conditions may force a learner to process movements of a skill at a 'deeper' cognitive level because of the reversal processing needed to flip the visual information, thus leading to greater skill learning due to the development of a more robust memory representation. A second hypothesis has suggested that learners may move through the acquisition phase of skill learning at a faster rate when using a subjective model view (e.g., Ishikura & Inomata, 1998) as reversal processing strategies are not required, but this faster proficiency may lead to a weaker memory representation of the skill to be learned. Taken collectively, these two hypotheses suggest that the objective and looking glass model views may lead to greater learning but will require more time to move a learner through the acquisition phase, while the subjective view will allow a learner to demonstrate skill proficiency sooner, possibly at the cost of a weaker memory representation of the skill being developed.

Ishikura and Inomata (1995) examined the effect of model viewing angle in a sample of 30 undergraduate students who learned a seven-step movement sequence under one of three conditions: (1) an objective model view group; (2) a looking glass model view group; and (3) a subjective model view group. Results indicated that the subjective model view group acquired the movement sequence the fastest and the objective model view group the slowest; however, all three experimental groups demonstrated similar retention test performance. These results suggest that, from a practical perspective, it may be more time-efficient to have learners view modeled skills from a subjective view. Additional support for the faster acquisition rates following subjective model viewing is provided by Roshal (1961) who employed a knot-tying task. However, in a replication of the Roshal experiment, Sambrook (1998) found no difference in the rate of acquisition between subjective and objective model view groups. At this time, the conclusion that a subjective model view is more effective than objective or looking glass model views may be somewhat premature, especially given the sparse number of experiments examining the influence of model viewing angle on acquisition and learning.

Speed of video demonstration

Despite the ever-increasing popularity of the use of slow motion video in sport (e.g., Goldlust, 1987), scientifically rigorous examinations of the influence of video speed on observation effects are scant and appear to be strongly linked to the movement characteristic(s) being examined. For example, Scully and Carnegie (1998) compared the effects of slow motion speed, real time speed and still picture modeling conditions on novices' performance of a ballet jumping skill. Results of biomechanical analyses indicated that the slow motion video group performed significantly better than the other groups in terms of foot placement upon landing, movement form and relative timing. However, the slow motion video group also performed more poorly than the other groups relative to absolute timing and force production. Scully and Carnegie hypothesized that slow motion modeling may be beneficial for aspects of skill performance related to coordination and relative timing but may be detrimental to aspects related to the manipulation of control variables required to produce variations of skill performance (e.g., absolute timing/speed of movement, force production).

This suggestion is supported by results of earlier research (Williams, 1989) which found that the use of slow motion modeling of an overhand throwing motion assisted with acquisition of the correct relative timing of the throw, but did not influence limb displacement. More recent research (i.e., Al-Abood, Davids, Bennett, et al., 2001), however, has found contradictory results, indicating that slow motion video modeling appeared to impede spatial and temporal pattern recognition in limb movement coordination compared to a real time speed video modeling condition.

In reviewing the few studies examining model demonstration speed, it should be noted that tasks of varying complexities have been examined. For example, the ballet jumping skill of Scully and Carnegie (1998) had high spatial and temporal dependency between several movement components as well as the need to constrain all of the limbs, each in a precise manner (i.e., high skill complexity). Conversely, spatial and temporal dependency were less crucial to task success in Al-Abood, Davids, Bennett, et al.'s (2001) three-meter underhand dart throw for accuracy. That task was comprised of relatively few movement components, and less limbs had to be constrained in a precise way. Although speculative, it is possible that with increased complexity of the movement, slow motion assists the learning of the greater spatial/temporal demands.

Frequency of model presentation

The number of times a demonstration is provided, much like viewing angle and speed, has been relatively under-researched in the literature. Of the research investigating this characteristic, Sidaway and Hand (1993) hypothesized that since viewing a correct model still requires a learner to employ error detection and correction strategies, then high frequencies of model viewing relative to the number of the practice trials should not negatively impact learning. Using a four-group experimental design, Sidaway and Hand examined whether the frequency of model presentation would influence retention and transfer test performance of a golf ball hitting task. The 100% group viewed a correct model before each physical practice trial, the 20% group viewed a correct model once in every five physical practice trials, the 10% group viewed a correct model once in every 10 physical practice trials and the control condition received only initial instruction. Results indicated that all groups improved performance significantly over the three practice days. During retention, however, the 100% group performed significantly better than all other groups, and demonstrated a trend towards superior performance during the transfer test.

These results show very good support for the effectiveness of frequent model presentation in skill learning situations. However, with regards to effective and *efficient* instructional practices, coaches and other movement practitioners would benefit from a deeper understanding of the dose–response relationship between model viewing frequency and performance or learning effects. Whereas Sidaway and Hand (1993) chose to use pre-determined model presentation frequencies for all of their experimental groups (i.e., 100%, 20% and 10% of physical practice trials), Wrisberg and Pein (2002) allowed one of their three learner groups to dictate how often they viewed a correct model during the acquisition phase for the long serve in badminton. Over three days of practice, one group viewed correct model video performance before each physical practice trial, a second group was only shown correct model video performance when they explicitly asked to view it (self-control group), and a third group served as a no-model control group (only physical practice). For both acquisition and retention form scores, the 100% and self-control groups performed significantly better than the control group, but interestingly did not differ from each other.

The results of Wrisberg and Pein (2002) suggest that 100% model presentation frequency may not be needed to maximize performance and/or learning gains derived from the use of observational learning. In fact, the researchers reported that participants in the self-controlled model view condition only requested to view the correct model during 9.8% of their practice trials, and that most view requests (82%) occurred during the first half of the trials on the first practice day. This finding has recently been replicated by Wulf et al. (2005), who reported that their sample requested to view the correct model during only 5.8% of their practice trials. This notion of allowing learners to self-select when they view a correct model is promising, particularly from an applied perspective, where movement practitioners are constantly seeking to streamline their practice structure in order to maximize efficiency without sacrificing effectiveness. As noted for model viewing angle and speed, however, it is difficult to offer conclusive practical guidelines at this point, given the sparse amount of research examining model presentation frequency.

An applied model for the use of observation

The empirical research reviewed provides both insight and direction in terms of understanding the many factors that must be considered when wanting to use observation interventions effectively. The goal of this section is to present an applied model that can guide practitioners in the use of observation. Given the limitations in the length of the present review, we provide a general overview of the framework in Figure 1 and subsequently describe briefly the basic sequence a practitioner can take to understand how to use this framework.

At the forefront of the model are observer and task characteristics. These two factors emerged clearly as moderator variables that would influence the implementation of an observation intervention. Indeed, in an early review of the literature, McCullagh, Weiss, and Ross (1989) proposed a model that included 'the observer' as a key factor to be considered in the modeling process, and highlighted that age, and consequent cognitive, verbal and motor development as well as motivational orientation, were characteristics of potential importance. Ashford et al.'s (2007) meta-analysis also pointed to the importance of developmental effects in influencing

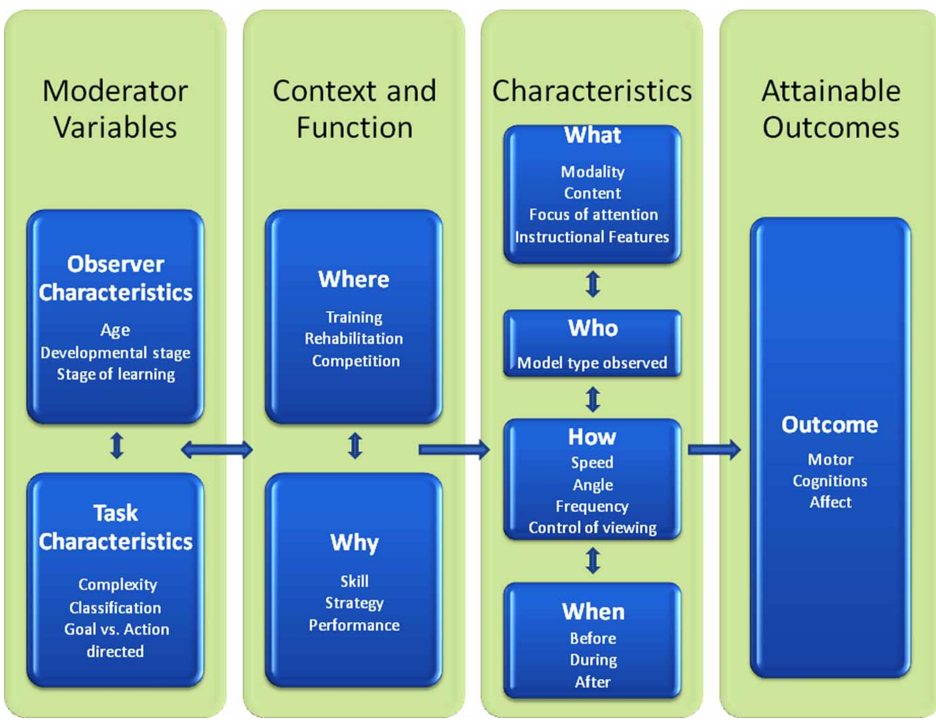

Figure 1. An applied model for the use of observation.

observation benefits. Children and adults benefited differently dependent upon whether the measures considered movement dynamics (i.e., the form of the movement) or movement outcomes (e.g., the accuracy of the movement). Adults showed more gains for movement dynamics whereas children showed more for movement outcome.

Examining the research used in this review, a number of studies had a clear focus on the influence of observer characteristics. The observer characteristic most frequently studied was age. Weiss and colleagues' work (McCullagh et al., 1990; Weiss, 1983; Weiss & Klint, 1987; Weiss, Ebbeck, & Weise-Bjornstal, 1993) was consistent in showing that younger children (5–7 years old) benefited from verbal cueing and verbal rehearsal strategies as compared to older children (8–9 years old). Thus, providing only visual demonstrations was not sufficient for the younger children; they needed a model that also verbalized the task components to help them remember what to do during execution (see Meaney, 1994, for similar results). Sawada et al. (2002), however, have shown that older children can benefit from verbal cuing the same as younger children, but only when it is metaphorical cuing, suggesting that the content of verbal cues is important (see also Bouffard & Dunn, 1993).

Cadopi, Chatillon, and Baldy (1995) also examined the effect of age with observation on varied factors, such as the number of demonstrations requested, coding strategies and performance of 8- and 11-year-olds learning a ballet dance sequence. There were no differences in number of demonstrations requested by 8- or 11-year-olds. When children were asked how they remembered the movements, there was an interaction with age. Younger children reported using more visual coding, whereas older children reported using more verbal coding. These results are in line with the verbal advantages shown by older children (e.g., Bouffard & Dunn, 1993).

While there have been studies that include both male and female participants, many do not use gender as a variable in their analyses (Cadopi et al., 1995; Meaney, 1994; Weiss, 1983). Those that have compared males' and females' responses to observation in more traditional formats involving a teacher–student relationship typically report no gender differences (e.g., Sawada et al., 2002), while some studies have found gender differences (e.g., Weiss & Klint, 1987). In contrast to these traditional formats, gender differences have been noted within dyadic learning. In a series of studies, d'Arripe-Longueville and colleagues (d'Arripe-Longueville, Fleura Winnykamen, 1995; d'Arripe-Longueville, Gernigon, Huet, Cadopi, & Winnykamen, 2002; d'Arripe-Longueville, Gernigon, Huet, Winnykamen, & Cadopi, 2002; Legrain, d'Arripe-Longueville, & Gernigon, 2003) examined males' and females' learning in dyad situations. Legrain et al. (2003) reported that males benefited more from peer tutoring than females and that skill level of the tutor interacted with gender; males benefited more than females when the tutor was skilled, yet females benefited more when tutors were at the novice level (d'Arripe-Longueville, Gernigon, Huet, Cadopi &Winnykamen, 2002; d'Arripe-Longueville, Gernigon, Huet, Winnykamen, & Cadopi, 2002). Differences in psychological outcomes were also reported, with females reporting higher task involvement as compared to the higher ego involvement measured for the males (d'Arripe-Longueville, Gernigon, Huet, Cadopi, & Winnykamen, 2002). These differences between dyad learning and more traditional techniques of observation suggest that different dynamics occur in different learning settings and more attention to gender differences in the use of observation is necessary.

Taken as a whole, the studies examining age differences in modeled observation in general produce fairly clear age effects. Younger children appear to need some sort of verbal information or rehearsal beyond mere visual demonstrations for enhanced performance. Older children use their language advantage for developing strategies, whereas younger children may rely more on visual coding of information. Noted, however, is that some of these studies that examined different aged children picked age groups without clear conceptual reasons for the particular ages, whereas others based their samples on previous research or conceptual guidelines that would help to explain the differences. Research that has examined possible male and female differences suggests that different observation experiences may produce varied results, highlighting the importance of gaining a better understanding of interactions between observer and model.

Unlike the fairly substantial research that has examined observer characteristics, few if any studies had the influences of task characteristics as a main research question. Rather, task characteristics were raised more as explanatory features of discrepant findings. An exception to this is the work by Hodges, Williams, and colleagues (e.g., Hayes, Hodges, Huys, et al., 2007; Hodges et al., 2005; Horn et al., 2005). Hodges et al. (2007) noted in their review paper, which questioned what was modeled during observational learning, that task complexity and novelty affected whether observation of relative motion information or end point effector information was most pertinent. For a more complex, whole body task, for example, relative motion information may be necessary, but end point effector information can be sufficient for a single limb task. Ashford et al.'s (2006) meta-analysis also points to the importance of task characteristics in terms of observation benefits. Serial tasks benefited more than continuous tasks, with discrete tasks showing even fewer benefits than continuous ones.

Given these influencing factors of observer and task characteristics, it is important for the practitioner to first gain a clear understanding of the observer and the task. At the second level of the applied model, we propose that the practitioner should then consider the environment in which the observer is situated, and the functions they anticipate the use of observation will serve. Upon acquiring a full appreciation of these four components (observer/task/where/why), the practitioner can better consider the choices involved in manipulating the characteristics concerned with the Who, What, When, and How features of the applied model.

Next we provide two example scenarios of observation interventions, outlining the observer/task characteristics, where and why the intervention is being used and how the intervention may unfold given the situation provided. Although it is obvious that we cannot step through all the permutations and combinations, we hope it is clear that the use of observation is proposed as an effective technique for varied learners/performers (e.g., novice, intermediate or advanced) that have different objectives related to the use of observation (e.g., skill/strategy/performance functions) in a variety of settings (e.g., sport club/physical education class/competition/rehabilitation session) and that the implementation of the observation intervention is adjusted to account for the specific scenario. First, consider the example of a novice dancer, Jessica, who is 6 years old and is learning a dance sequence within a dance class. In this situation, it is likely that she would benefit from a live (or videoed), skilled model of a teacher who provides metaphors for the movements during the dance sessions. It may be best for the teacher to provide an objective view when modeling the dance and to perform the dance in real time. The outcome focus in this situation is on skill learning.

A different scenario, however, would be an advanced dancer (Robert) preparing for a recital. He wants to show strong execution, build confidence and develop strategies for his performance. In this situation, he would likely benefit more from a self-modeling video that the dancer would be provided with in the days leading up to the recital. The dancer would self-control the frequency and the speed of the video. He may use the video to assist with other strategies that can be used to enhance his dance execution at the recital, such as positive self-talk in key components of the dance or imaging the perfect execution seen on video while performing. Under this scenario, the use of observation could assist with the skill function (e.g., viewing the technical execution of the dance), strategy function (e.g., learning to use varied strategies in performance) and the performance function (e.g., increasing self-efficacy for performing in recital).

Future research directions

Although ideas for future research have been mentioned throughout the review, additional ideas are presented here. An examination of Appendix 1 (see online supplementary data) clearly shows that the empirical research on the use of observation has overwhelmingly been concerned with the contributions of a mastery model for the skill function in motor skill acquisition, examined mainly within laboratory settings. Given this limited focus on the use of observation for motor skill learning and performance, it is easy to generate recommendations for future research.

Overall, observation produces desired outcomes related to each of the three functions. However, a major limitation is that we do not know much about how to design observational experiences that target the strategy or performance functions, or what it is, specifically, that helps to create a change in self-efficacy or anxiety versus skill or strategy learning. Consideration toward the design of modeling experiences, particularly with respect to psychological outcomes that fall within the performance function, is strongly recommended. Factors such as model–observer similarity and the use of coping models may play a key role. There may be other factors, such as attentional focus and context provided, to observation experiences that are also important for specific psychological and self-regulatory variables. Most recently, Hancock et al.'s work (2011) has shown that coaches and officials of sport use observation in their sport roles as well. Broadening observation research to include other sport roles is a good direction to take. Given the unique demands of coaching and officiating, examining functions for these groups can be an area for further descriptive and intervention research.

The limited work in the rehabilitation and sport competition contexts is a loud call for more research in these settings. Based on the limited studies in these two contexts, there is a strong suggestion that the mastery model may not be the best to employ. Rather, coping models may capture more of the skill and performance functions that injured populations may want to address. Self-as-a-model techniques may also be effective in the rehabilitation setting, much like that seen in the competitive environment, given their apparent influence on self-efficacy and other self-regulatory processes.

We also advocate for additional examinations of the 'How' factors in the use of observation, such as the angle of viewing the model, manipulation of speed on video and the control over the observational viewing. In particular, more research is needed that incorporates employing tasks of varying complexity and varying degrees of participant skill level relative to the task and those in which the sample reports a reasonable degree of motivation regarding their desire to learn the task.

Recommendations are also forwarded in terms of the methodology used in future observation intervention research, given weaknesses that were noted in the research reviewed. Firstly, the value of using control groups that do not receive the observation intervention is important, as well as including groups that allow one to control for total practice time. Secondly, relevant information concerning how the observation was delivered during the protocol (e.g., frequency, angle of viewing, speed manipulation) should be communicated to enable a full appreciation of the intervention manipulations employed. Thirdly, despite other authors of reviews stating this more than a decade ago (e.g., McCullagh & Weiss, 2001), researchers need to include retention and/or transfer tests. These tests are a necessary component in motor learning and performance research (Schmidt & Bjork, 1992) to capture the relative permanence and adaptability of the motor skills tested.

Another noted factor is that although neuroscientific measures such as transcranial magnetic stimulation (TMS; e.g., Clark et al., 2003), functional magnetic resonance imaging (fMRI; e.g., Macuga & Frey, 2011) and positron emission topography (PET; e.g., Grezes et al., 1998), to name a few, have been used to examine the neural overlap between observation and action execution, none of these studies incorporates interventions (see Holmes & Calmels, 2008, for a review). Employing such methods would certainly be advantageous for our further understanding of the neural mechanisms of observation for learning and performance. Similarly, visual search measures have been used minimally in observation intervention experimentation. Williams and Ward's (2003) review paper noted that perceptual training studies that involved explicit instruction on the most informative areas on which to focus led to improvements in perceptual anticipation. Research that couples similar visual search data with instructions related to relevant information on which to focus during observation of a model would serve to inform us on the importance of added instructional features (see Al-Abood et al., 2002, for an example of this). In addition, Causer, Holmes, and Williams (2011) recently showed that a training program, which included video self-observation, generated more effective gaze behaviors in shotgun shooters, as well as shooting performance. Their training program, however, involved a number of other training methods, and thus contributions specific to the video feedback cannot be specified. Further research in this vein is also recommended.

A final research design recommendation concerns the reliance on the laboratory setting used in observation research to date. While laboratory settings are useful for eliminating confounds and enabling control, there are inherent weaknesses. For example, participants are typically given the task to learn, and thus may not be very interested in learning the task being examined, resulting in lower motivation levels. Indeed, Bandura (1969) has noted that when motivation to learn is low, the effects of practice on skill acquisition and learning will likely be diminished. In addition, it is likely that other contextual factors influence the benefits of an observation intervention. Hence, there is a need for transference of the research into applied settings, such as the physical education classroom, sport club facility or rehabilitation program. Research that integrates observation interventions with ecologically valid tasks and settings will only help to expand our knowledge on the factors that influence its success. Such findings would serve to further develop the proposed applied model for the use of observation, a model that can be used by educators, coaches, therapists and any individual seeking to advance motor skill learning or performance.

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Note

The Appendix is available as online supplementary data for this article, see http://dx.doi.org/10.1080/1750984X.2012.665076

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