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Consistently modeling the same movement strategy is more important than model skill level in observational learning contexts

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ABSTRACT

The experiment undertaken was designed to elucidate the impact of model skill level on observational learning processes. The task was bimanual circle tracing with a 90° relative phase lead of one hand over the other hand. Observer groups watched videos of either an instruction model, a discovery model, or a skilled model. The instruction and skilled model always performed the task with the same movement strategy, the right-arm traced clockwise and the left-arm counterclockwise around circle templates with the right-arm leading. The discovery model used several movement strategies (tracing-direction/hand-lead) during practice. Observation of the instruction and skilled model provided a significant benefit compared to the discovery model when performing the 90° relative phase pattern in a post-observation test. The observers of the discovery model had significant room for improvement and benefited from post-observation practice of the 90° pattern. The benefit of a model is found in the consistency with which that model uses the same movement strategy, and not within the skill level of the model. It is the consistency in strategy modeled that allows observers to develop an abstract perceptual representation of the task that can be implemented into a coordinated action. Theoretically, the results show that movement strategy information (relative motion direction, hand lead) and relative phase information can be detected through visual perception processes and be successfully mapped to outgoing motor commands within an observational learning context.

1. Introduction

Extensive research has demonstrated that the initial performance of a motor and/or cognitive skill by a novice is enhanced following observation of a model demonstrating the skill (Ashby, Maddox, & Bohil, 2002; Braaksma, Rijlaarsdam, van den Bergh, & van Hout-Wolters, 2004; Hodges, Williams, Hayes, & Breslin, 2007; McCullagh, Stiehl, & Weiss, 1990; McCullagh, Weiss, & Ross, 1989; Vogt & Thomaschke, 2007). Neuroimaging research shows that many motor areas involved in motor skill planning and production are also active during “action observation” and “action imitation”, demonstrating that watching engages the observer in processes similar to the physical performance of a skill (Calvo-Merino, Grezes, Glaser, Passingham, & Haggard, 2006; Cross, Kraemer, Hamilton, Kelley, & Grafton, 2009; Decety et al., 1997; Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Petrosini et al., 2003). Numerous studies have demonstrated that observing a skilled model facilitates a novice's initial performance of a motor skill (Al-Abood, Davids, & Bennett, 2001; Al-Abood, Davids, Bennett, Ashford, & Marin, 2001; Blandin, Lhuisset, & Proteau, 1999; Hodges, Chua, & Franks, 2003; Martens, Burwitz, & Zuckerman, 1976; McCullagh & Meyer, 1997; McCullagh et al., 1989; Pollock & Lee, 1992). Research has also shown that observers can benefit from watching a novice model learning a new motor skill (Black & Wright, 2000; Blandin et al., 1999; Buchanan & Dean, 2010; Buchanan, Ryu, Zihlman, & Wright, 2008; Buchanan & Wright, 2011; Hayes, Hodges, Huys, & Williams, 2007; McCullagh & Meyer, 1997; Pollock & Lee, 1992). The experiment reported investigated the influence of model skill level on learning a bimanual coordination pattern through observation. Specifically, the impact of variation in a model's performance and its impact on observational learning and training after observation were examined.

Variation in a model's demonstrations can be quantified on two different levels: 1) variation in movement strategies demonstrated and 2) variation in coordination or performance outcome regardless of the movement strategy. Movement strategies in the current context are defined with respect to (a) the relative direction of limb motion and (b) the lead–lag relationship between limbs. Variation in coordination in the current context is linked to the spatio-temporal variable relative phase that defines the accuracy and stability of coordination with respect to the task goal. Skilled models, theoretically, provide an advantage because they demonstrate a single movement strategy linked to high performance outcomes (very accurate and stable), thereby providing an observer with a well-defined reference frame for the modeled performance (Bandura, 1986; Hommel, Musseler, Aschersleben, & Prinz, 2001; Scully & Newell, 1985; Sheffield, 1961). Novice models, on the other hand, are theorized to provide an observer information

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about the success or failure of specific movement strategies (Adams, 1986), which may facilitate the development of error detection and correction processes and enhance initial performance (Black & Wright, 2000; Blandin & Proteau, 2000; McCullagh & Caird, 1990; Pollock & Lee, 1992; Rohbanfard & Proteau, 2011). A study by Mattar and Gribble (2005) videoed one model getting systematically better in reacting to the same arm perturbation and another model attempting to learn to adapt to random arm perturbations. Observers that watched the model getting systematically better benefitted compared to the observers that watched the model exposed to random perturbations. Observers do benefit from watching a novice model when systematic reductions in error can be linked to specific changes in motor performance.

Many studies that have compared the impact of novice versus skilled models on observational motor skill learning have not revealed a consistent advantage of either model type (Andrieux & Proteau, 2013; Bird & Heyes, 2005; Blandin et al., 1999; McCullagh & Meyer, 1997; Pollock & Lee, 1992; Rohbanfard & Proteau, 2011; Weir & Leavitt, 1990). The reason why novice and skilled models may often produce similar outcomes in observer groups is that over practice the novice model often learns the same movement strategy the skilled model used to achieve the action goal (McCullagh & Meyer, 1997; Rohbanfard & Proteau, 2011). Moreover, in many studies movement strategy and performance outcomes are often confounded and do not allow for an examination of whether or not variation in movement strategy usage or variation in performance outcome is more of a factor in observational learning contexts (Bird & Heyes, 2005; McCullagh & Meyer, 1997; Pollock & Lee, 1992; Rohbanfard & Proteau, 2011). The goal of the current study is to separate out variation in strategy usage from variation in performance outcomes and to determine how these factors interact with model skill level in influencing observational learning of motor skills.

Research examining the impact of strategy variation on observational learning has been minimal, yet some research has revealed that observers are sensitive to the strategy employed by a model. Early work by Martens et al. (1976) demonstrated that observers will imitate a model's strategy, even when the strategy does not result in the optimal performance score. In their experiment 3, Martens et al. had a skilled model demonstrate a correct yet difficult strategy, while another model demonstrated an easier incorrect strategy. The trade-off was that the correct strategy if not executed properly would produce the lowest possible scores, while the incorrect strategy could only produce midrange scores and never produce the maximum score. Observers used the strategy employed by the model (correct or incorrect) they watched more often than any other single strategy. The observers of the incorrect model had a higher average outcome score than the observers of the correct model. A study by Al-Abood, Davids, and Bennett (2001) had three participant groups train on a yard dart task. One group was exposed to a skilled model demonstrating an under arm toss, a second group received verbal instructions on how to perform the underarm toss, and a third group was not exposed to a model or given any instructions on the underarm toss. The main finding was that observers of the model more closely approximated the model's kinematics than did the verbal instruction group. The individuals that were not exposed to the underarm toss all selected an overhand toss of the yard dart. With regard to the outcome, no difference was found between the three groups. In summary, observers will use a modeled strategy employed by a skilled model. However, when taken together, the above research does not reveal if it was the model's skill level or just the consistency in seeing the same strategy employed that most influenced the observers in their strategy selection.

In a more recent study by Buchanan et al. (2008), the task was to learn a 90° relative phase pattern using rhythmic elbow and wrist flexion–extension motions with the forearm supine and the elbow stationary. The 90° relative phase may be achieved with a movement strategy that has the wrist either leading or lagging the elbow in terms of peak flexion and extension. The novice models in the study were not instructed to practice with the wrist lead or lag strategy. Each novice model selected a given strategy (wrist lead or lag) by half-way through day one training and then used that strategy throughout day two training. Each yoked observer selected the wrist-rotation strategy that their novice model used throughout day 2 training. Observers are sensitive to movement strategies demonstrated by novice models, suggesting that this is not a movement feature that only skilled models provide. When combined, the findings from Martens et al. (1976), Al-Abood, Davids, and Bennett (2001), and Buchanan et al. (2008) suggest that the key source of information provided in an observational context is viewing a model consistently using a specific strategy to produce high performance scores or consistently using the same strategy to improve on performance. A way to examine the above idea is to manipulate the use of movement strategies in skilled and novice models and determine if more variation in modeled behavior reduces the rate of performance improvement compared to less variation in modeled behavior.

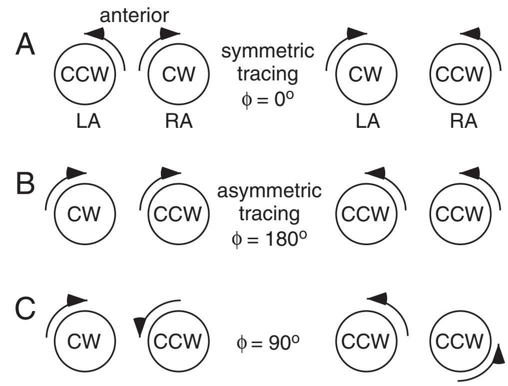

Fig. 1. A–C. Movement strategy is defined with respect to the direction of hand motion around the circle and the body midline for symmetric tracing (A), asymmetric tracing (B), and tracing with a 90° relative phase lead of one hand over the other. Two movement strategies for each defined coordination pattern are depicted. In the examples in C, the right-arm leads by 90° for the example in the left column, and the left-arm leads by 90° for the example in the right column. Other movement strategies are possible for the 90° lead pattern that would produce a 90° relative phase offset from 0° (or 360°) to ±180°. LA—left-arm, RA—right-arm, CCW—counterclockwise motion, and CW—clockwise motion.

In order to address the issue of strategy variation in observational learning, it is necessary to utilize a task whereby different movement strategies can lead to the same level of performance outcome. This was demonstrated in the Buchanan et al. (2008) elbow–wrist coordination task, where the wrist-lead or lag pattern produced equivalent outcomes (see also Buchanan & Wright, 2011). Bimanual circle tracing as a task also offers this possibility with even more variations in movement strategies than the elbow–wrist task (Buchanan & Dean, 2010). For example, both symmetric and asymmetric coordination in bimanual circle tracing can be defined in two ways at the level of hand rotation direction (Fig. 1A, B). For both symmetric and asymmetric patterns, hand rotation direction (i.e., movement strategy) does not influence the accuracy or variability of relative phase (ϕ) when defined as $\phi = 0°$ for symmetric and $\phi = 180°$ for asymmetric coordination (Carson, Thomas, Summers, Walters, & Semjen, 1997). The performance outcome in the current experiment was to achieve a 90° relative phase pattern between the two hands as they trace a pair of circles (Buchanan & Dean, 2010). In general, the 90° relative phase pattern can be defined as one-hand (left or right) leading the other hand by a quarter of a circle trace (Fig. 1C).[1] In the

[1] The relative phase value will of course depend on the actual directions of the two arms, which arm leads, and which arm is defined as the reference and which as the target file. Here, relative phase patterns of −90°, 270°, or −270° are treated as equivalent since each represents an absolute distance of 90° between the values of 0° (or 360°) for symmetric and ±180° for asymmetric coordination.