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Artigo Original

AQUISIÇÃO DE HABILIDADE MOTORA DISCRETA: EFEITO DO NÚMERO DE DEMONSTRAÇÕES

DISCRETE MOTOR SKILL ACQUISITION: EFFECT OF NUMBER OF VISUAL DEMONSTRATIONS

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RESUMO
Este experimento investigou os efeitos do número de demonstrações na aquisição de uma habilidade motora discreta. Setenta e quatro universitários, de ambos os sexos, participaram desse estudo. Os participantes observaram um modelo duas ou dez vezes. Na fase de aquisição, os participantes foram requisitados a lançar um dardo por meio de um movimento antero-posterior em um alvo circular até atingir um desempenho critério. Não foram identificadas diferenças na aprendizagem entre os grupos na análise do escore. Contudo, dez demonstrações estimularam melhor do que duas demonstrações no que diz respeito ao desempenho do padrão correto e ao número de sujeitos que atingiram o desempenho critério. Os resultados indicam um efeito similar de ambos os números de demonstrações no desempenho e aprenizagem do arremesso de dardo de salão e que ambas as condições estimularam a capacidade dos aprendizes de detectarem informações relevantes para desempenhar a tarefa.
Palavras-chave: Aprendizagem Motora. Modelação. Arremesso de Dardo. Habilidade Motora.

ABSTRACT
This experiment investigated the effect of number of visual demonstrations on the acquisition of discrete motor skill. Seventy-four college students of both sex participated in this study. The participants observed a visual model twice or ten times. In the acquisition phase, the participants were asked to throw a dart with postero-anterior movement into a circle target until reach a learning criterion. In transfer tests no difference between groups was found in the analysis of score. However, ten demonstrations were more effective than twice as regards performance of the correct pattern of movement and the number of subjects who reached the performance criterion. The results indicate a similar effect of the both number of demonstrations in the performance and dart throwing learning and both conditions influence subject's capacity to detect relevant information to perform the task.
Keywords: Motor Learning. Modeling. Dart Throwing. Motor Skill.

Introduction

The visual demonstration improves the acquisition of motor skills. Although sometimes demonstration is combined with instructions[1], demonstration supplies information on the pattern of movement to be used in the performance of that task, and facilitates the creation of a cognitive structure about this action[2-5]. This cognitive structure will later be responsible for the production of movement, and will also be the pattern of reference for estimation, detection and correction of errors regarding the movement performed[6,7].

Bandura[2] and especially Carrol and Bandura[8] investigated the information processing during demonstration and proposed a theoretical model according to which four mental processes generate the cognitive structure of movement is. The first process, selective attention, enables the individual to retrieve the most relevant information about the action demonstrated. The second process, retention, allows the individual to formulate the mental structure of the action based on the information selected. The third process refers to the production of movement, in which the cognitive structure coordinates the motor units responsible for the movement. Finally, the comparison between mental structure and proprioceptive feedback of the action performed comprises the fourth process.

Other researchers have concentrated efforts on investigations about which information is acquired from the observation of a model[9-11]. Most of the designs proposed for that purpose investigated the observation of real models on video as compared with the effects of point light models. In general, it is possible to conclude that both types of modeling provided information on global and specific characteristics of the pattern of movement in a similar way, suggesting that both types allowed the learner to reproduce the movement in a way that was close to that of the model.

Demonstration can also provide information on the parametrization of the action, in such a way that a learner may adjust the speed of movement in a throwing task according to the distance from the target the object will be thrown at. Considering throwing actions in particular, the consistency and precision of the final part of the movement are essential, and the point where the most information can be gathered[12]. Apparently, learners begin to select more specific information after they have extracted more general information about the movement, that is, they begin to gather information of the movement in absolute terms such as, for example, how fast the limb or limbs moved[10].

The amount of information presented is fundamental for the acquisition of the movement pattern by means of observation of a model, perhaps even more important than the kind of information itself[13]. Such proposition is in line with the results of Laguna[3], who postulated that a higher number of demonstrations led to a more accurate cognitive representation of the task, providing more security in the reproduction of the movement being learnt and also favoring possible corrections in its performance.

Many investigations have detected the effectiveness of demonstration in the learning of motor skills and associated it with two perspectives. The first one regards the capacity to gather information and reproduce it in the form of movement, while the second regards the sufficiency of information provided by the model. One way to make sure enough information is provided through demonstration is related to the number of times it is presented[14].Newell, Morris and Scully[15], Feltz[16], and Carroll and Bandura[8] suggest it is fundamental to make observers notice the crucial aspects of action so that they have a reference to produce the movement. Therefore, repeated opportunities to watch a teacher or even a learner perform a movement may increase the selectivity of information regarding pattern of movement and retention of the cognitive reference that helps in the process of producing and correcting the movement[11] . Generally speaking, results corroborate the hypothesis of the greater effectiveness of a higher number of demonstrations [8, 10, 12 and 20] when compared with smaller numbers [0, 1, 2 and 5] in the learning of motor skills. Even with the empirical confirmation of the hypothesis, in most cases obtained in studies involving laboratory tasks[8,16-18] and sports and dance tasks[5; 19], the effects of different numbers of demonstration in the learning of discrete motor skills, as well as its effect on the time spent on learning and on how much different amounts of instruction suit the different characteristics of the individuals involved in these motor learning conditions, should be investigated. We expect that the higher number of demonstrations will improve the movement pattern.

Metods

Participants

Seventy-four undergraduate physical education students of both genders, 18 to 40 years old [*Mean*= 25,1; *SD* = 4,8] participated in this study. Each participant provided an informed consent form. All participants were self-declared right-handed and had normal or corrected-to-normal vision. The Ethics Committee of the Federal University of Minas Gerais approved this study [ETIC 300/05] and was in accordance to the ethical standards laid down in the 1964 Declaration of Helsinki amended in 1989.

Task and Apparatus

The task consisted of throwing a dart with the dominant, right arm. Their goal in the task was to score as many points as possible by throwing a dart into a target dartboard placed parallel to the floor [see Figure 1]. The task was novel to all participants and was based on the dart-throwing task used by Al-Abood et al.[20]. The dart weighed 30 g and was 15 cm long. The target was also a standard dartboard modified for the experiment. It contained 10 concentric circles, with the center circle having 2.25 cm diameter and each of the other circles increasing by 2.25 cm in radius. A hit on the center circle was awarded 10 points and the score for each concentric circle out of the center circle decreased by one point so that the outermost circle was worth only one point.

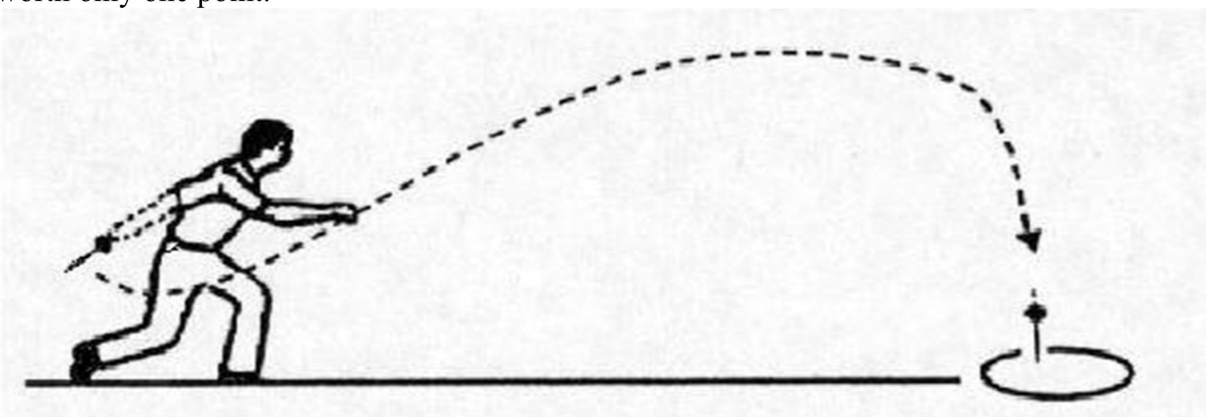

Figure 1. Saloon throwing dart task
Source: Al-Abood et al.[20]

Procedure

Participants were randomly assigned to the two [D2] and ten [D10] demonstration groups. The acquisition phase consisted of up to 120 trials, with the center of the target placed 2.5m away from the participant. This phase was interrupted when the participant reached score band criteria, which was three consecutive trials out of seven and 10 points, obtained by the fixation of the dart on the dartboard. Approximately three minutes later, volunteers carried out the transfer test with 10 trials, with the center of the dartboard positioned 3m away from them. All the twenty subjects in each group had demonstrations before they started the acquisition phase, according to the group they had been assigned to.

Demonstrations were manipulated in a way that both the whole throwing movement and the trajectory of the dart were perceived by the learner. We adopted this procedure because both the final part of the throw and the trajectory of the dart into the target provide complementary information regarding the movement.So, the execution of the model was recorded 90^0 on the right side of the performer for the participants could watch the movement pattern and dart trajectory until reaching the target.

Data collection was performed in a specific room at the School of Physical Education, Physical Therapy and Occupational Therapy of the Federal University of Minas Gerais. The participants reported to the place of data collection, where they were informed on the study protocol and provided written informed consent. Thereafter, each subject received demonstrations from a model classified as expert. The demonstrations were presented by means of a TV monitor (20 inches) and a video cassette recorder, being carried out according to the experimental group.The procedures adopted to choose the action of the model that would serve as a demonstration were the same used by Al-Abood, Davids and Bennett.

After demonstrations were provided, each volunteer received a dart. A voice command of "ready" was the clue for volunteers to adopt the initial throwing position, while the command "go" told them to perform the throw. At the end of the throw, the experimenter provided the volunteer with the knowledge of results (KR) of the score obtained. The KR was provided because, in several attempts, the dart hit the boundary between two scoring ranges. When this was done, the volunteer received another dart for the next trial. We adopted an intertrial interval of approximately five seconds between trials. This procedure was followed during the whole acquisition phase. In order to make sure stability performance had actually happened, we established the criterion of reach of three consecutive trials considering a score band [score obtained by the volunteer reaching the dartboard] of seven to 10 points. We adopted this criterion since it minimizes the effects of motor experiences of the individuals in each group. Some studies also used the same procedure, rather than an identical and specific amount of practice for all subjects[21-24]. At the end of acquisition phase, transfer phase started, with 10 performances of the same throw, with the center of the target placed 3m away from the participant, and no feedback on knowledge of results (KR) provided by the experimenter.

Data Analysis

The data were organized into blocks of five trials: first and last blocks of the acquisition phase plus two transfer test blocks. The variables analyzed were the score and coefficient of variation of the score in acquisition phase and transfer test as well. Accuracy scores were analyzed in 2 (two and ten demonstrations) x 2 (blocks of 5 trials) analyses of variance (two way ANOVA), with repeated measures on the last factor for the acquisition phase, and other accuracy scores were analyzed in 2 (two and ten demonstrations) x 3 (blocks of 5 trials) analyses of variance (two way ANOVA), with repeated measures on the last factor for the last block of the acquisition phase and the two blocks of transfer test. In addition, secondary measures were added for better understanding the effect of number of demonstration, such as number of trials for the volunteers to reach performance criteria, total number of subjects per group, total number of subjects who did not perform the pattern of movement correctly and total number of subjects who did not reach performance criteria. All of them analyzed by the non parametric tests to independent measures (Mann-Whitney's U test), except the secondary measure number of trials for the volunteers to reach performance criteria (One Way ANOVA).

Results

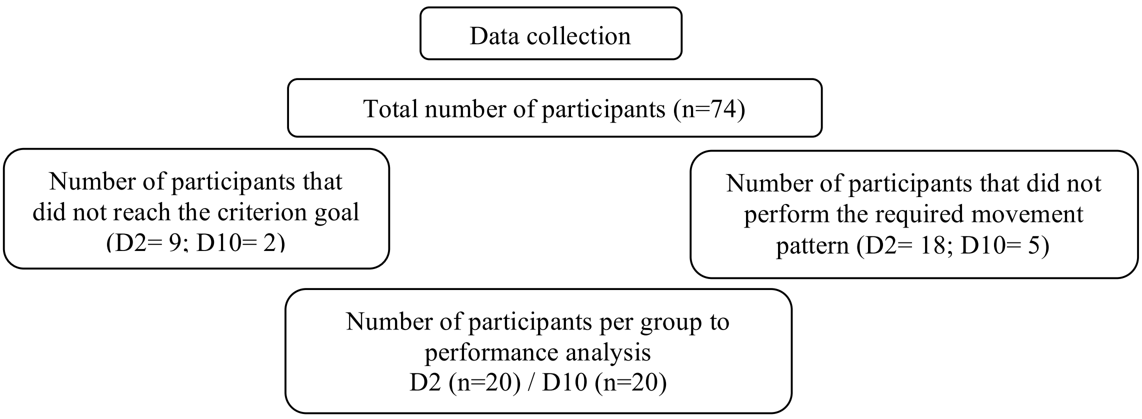

Figure 2. Sample composition fluxogram
Source: Authors

Mean of the Score

In the analysis of the mean score of acquisition phase, the two-way ANOVA for repeated measures on the second factor did not identifysignificant intergroup differences ($F_{1, 38}$=0.246, p = .6), neither did it detect a significant effect in the interaction groups x blocks ($F_{1, 38}$=0.032, p = .8). However, it identified an intragroup difference from the first to the last block of acquisition phase, with a higher score in the last block ($F_{1, 38}$=152.835, p < .01).

In the comparison between the mean score of the last block of trials of the acquisition phase and the mean score of the two blocks of the transfer phase, the two-way ANOVA for repeated measures on the second factor did not detect significant intergroup differences ($F_{1, 38}$=0.497, p = .5), neither a significant effect in the interaction groups x blocks ($F_{2, 76}$=0.008, p = .9). However, the analysis of variance identified an intragroup difference ($F_{2, 6}$=65.113, p < .01). After the analyses mentioned above we performed the Tukey's post hoc test, which identified a significant superiority in the score of the last block over the first block of the acquisition phase (p < .01) and the second block (p < .01) of the transfer test.

In general, the results of the mean scores showed a significant increase in the precision of the throws of both groups during the acquisition phase, which was significantly reduced in the transfer test. The level of precision, however, remained the same in the two blocks (Figure 3).

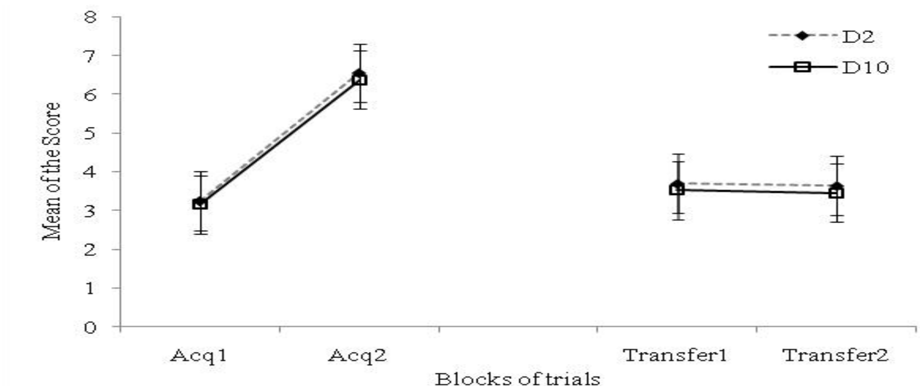

Figure 3. Mean score in the first and last block of acquisition phase and transfer test
Source: Authors

Coefficient of Variation (CV) of the score

In the analysis of the CV of the score in the acquisition phase, the two way ANOVA for repeated measures on the second factor did not identify intragroup differences ($F_{1, 38}$=1.647, p = .48), neither a significant effect in the interaction blocks x groups ($F_{1, 38}$=0.96, p = .33). However, it detected a significant intragroup difference ($F_{1, 38}$=50.763, p < .01), with the variability being reduced from the first to the last block.

In the comparison between the CV of the score in the last block of the acquisition phase and the CV of the scores in the two blocks of the transfer test, the two way ANOVA for repeated measures did not identify intergroup differences ($F_{1, 38}$=0.454, p = .5), neither a significant effect in the blocks x groups interaction ($F_{2, 76}$=0.474, p = .6). There was a significant intragroup difference ($F_{2, 76}$=18.095, p < .01). The Tukey's post hoc test identified a significant increase in the variability from the last block of the acquisition phase to the first and second blocks of the transfer test (p < .01).

In general, the results showed that both groups increased consistency of performance (Figure 4) from the beginning to the end of the acquisition phase, and in a similar way. In the comparison between the last block of the acquisition phase and the two blocks of the transfer test, on the other hand, the results showed that the new situation of the transfer test led to a significant increase in the variability of both groups in a similar way. Moreover, the results showed no effect of the number of demonstrations manipulated across the experiment on the two measures of performance.

Even though the task used in this study had already been used in other experiments that manipulated the same independent variable, the results of the score were not sensitive enough to identify the effects of the number of demonstrations on learning. Therefore, complementary measures were used to deepen the understanding of the effects of this variable on the acquisition of motor skills. These measures are important since they provide information on the quality of performance.

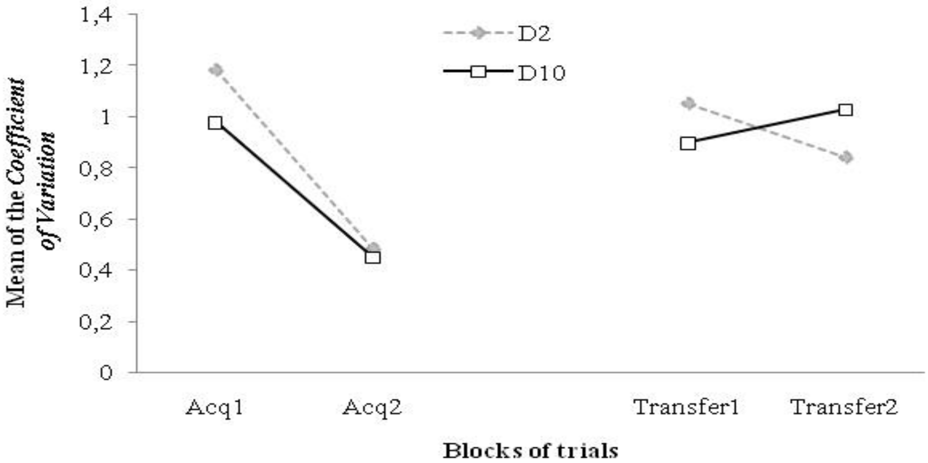

Figure 4. Mean Coefficient of Variation of score of acquisition phase and transfer test
Source: Authors

Number of trials for the volunteers to reach performance criteria

In the present study we opted to use the measure of performance criteria rather than the specific number of trials during the acquisition phase in order to minimize the effects resulting from previous experience and maximize the effects of the manipulated variable. In this way, all the subjects finished the acquisition phase with a similar level of skill in the task proposed. Hence, since the independent variable was manipulated in the acquisition phase, it is possible that a different number of trials were necessary for the volunteers to reach performance criteria as a result of the different amount of information provided prior to the practice, which led to the analysis of this measure.

As regards the number of trials necessary to reach performance criteria, the one way ANOVA did not identify significant differences in this variable ($F_{1, 38}$=0.058, p = .8). The result of the analysis shows that both groups needed a similar number of trials to reach performance criteria (Table 1), which determined the moment acquisition phase was over and characterized the learning of dart throwing with a postero-anterior movement.

Total number of subjects per group

Another measure that can provide information on the effect of number of demonstrations is the number of subjects required to obtain a sample of 20 subjects who reached performance criteria and produced the standard movement according to what was demonstrated by the model. Not all the subjects met the performance criteria established, hence they did not perform the transfer test and, consequently, their results were not included in the analysis of performance measures.

As regards this measure, the Mann-Whitney's test identified a significant intergroup difference (U=634.5, p< .01). The test showed that group D2 needed a larger number of subjects to comprise 20 subjects per group (Table 1) that presented the correct spatial characteristics of the movement pattern, according to those of the model, and who had reached performance criteria across the 120 trials allowed in the acquisition phase.

Total number of subjects who did not perform the pattern of movement correctly

Another secondary measure used was the number of subjects who did not perform the pattern of movement correctly, according to what was demonstrated by the model. This difference was characterized by spatial alterations, such as the positioning without opposition of the limbs in the dart throwing, or even throwing above shoulder line. In this analysis, the Mann-Whitney's test identified that group D2 had a larger number of subjects with errors in the pattern of performance (Table 1) when compared with group D10 (U=45, $p< .01$).

Total number of subjects who did not reach performance criteria

As we mentioned before, not all the subjects reached the performance criteria used in this study. Therefore, this was the last secondary measure analyzed so that we could acquire a better understanding on the effect of number of demonstrations on the acquisition of motor skills. According to the Mann-Whitney's test, group D2 had a larger number of subjects who did not reach performance criteria (U=4.5, $p< .01$)when compared with group D10 (Table 1). In other words, the use of two demonstrations was less effective as regards the performance of the subjects who learned the dart throwing motor skill with postero-anterior movement.

Table 1. Comparisons between D2 and D10 in four secondary measures

Measures	D2	D10
Number of trials to reach the criterion of performance	*M*= 40.5 *SD*= 32.9	*M*= 42.8 *SD*= 28.1
Number of participants	*Total* = 47*	*Total* = 27
Participants that did not perform the required movement pattern	*Total* = 18*	*Total* = 5
Participants that dis not reach the criterion goal	*To*tal = 9*	*Total* = 2

Note: *Statistical difference
Source: Authors

Discussion

The objective of this study was to investigate the effect of number of demonstrations on discretemotor skill learning, that is, saloon dart throwing with postero-anterior movement. For that purpose, there were two experimental groups: one with two and the other with 10 demonstrations. The analysis of the measures related to score, obtained in the acquisition phase, showed that both groups had a similar performance. In other words, they increased precision and reduced variability across the process. These results allow us to ascertain that demonstration, along with practice and feedback, allowed both groups to learn the task. More specifically, the accuracy of both groups increased significantly.

The analysis of the quantitative measures between the end of the acquisition phase and the transfer test showed that both groups behaved in a similar way, with decreased precision and increased score variability. These results indicate that the representation generated from different numbers of demonstrations did not have the capacity to preserve performance in the transfer test in relation to the structure previously acquired. The results of this analysis corroborate the explanatory hypothesis of Newell, Morris and Scully[15], and the results of Horn, Williams and Scott[11], and Bruzi et al.[19], according to which demonstrations convey to the learner general information about the movement, such as the angular pattern and the relative timing. However, for the learner to reach the goal of the task, in this case the transfer test, physical practice itself is necessary, once it allows, along with feedback, the acquisition of information for the necessary adjustments specific to that situation.

On the other hand, the results of this analysis are in disagreement with those of Sidaway and Hand[25], and of Shea et al.[4]. The difference between this experiment and that of Sidaway and Hand[25] might be attributed to the number of trials in the transfer test. Unlike in our experiment, where 10 trials were used in the transfer test, Sidaway and Hand[25] used 30 trials, which enhanced a moment of learning the new task, as demonstrated by the significant increase in precision and consistency of golf throws from the initial to the final trials in the test.

The difference from the experiment of Shea et al.[4] might be accounted for by differences regarding type of task, considered simple since it required the control of few articulations in the use of a computer keyboard to keep a cursor in a straight trajectory. Therefore, the alteration in the task to the transfer test might have created motor demands compatible with the structure formed during the acquisition phase, which made for a good performance of the groups during the transfer test.

Consequently, it is possible to assume that, in this experiment, the situation created by the transfer test allowed only the internal changes regarding the pattern of movement to be used to the benefit of the new task. The new distance might have required too big an adjustment, and the increase in precision and consistency might happen in function of a higher amount of practice.

The absence of intergroup difference in the quantitative analyses does not exempt demonstration from an important role in the learning process of motor skills, which is in the transmission of information on spatial and temporal patterns[4] and in the process of error detection and correction[7]. Finally, other authors suggest that physical practice and feedback are adamant for providing information that allows individuals to adjust the movement and reach the goal proposed by the demonstration[2,14].

The analysis of secondary measures was also important in the search for indications of the effects of the variable, not only on performance, but on the process through which the expected performance was reached as well. In the analysis of number of trials to reach performance criteria, it was expected that group D10 would reach this criteria faster, for having had more chances to identify relevant information for the performance of the task. This assumption, however, was disproved. The results showed that the groups needed similar amounts of practice to reach performance criteria. The results of this analysis do not corroborate those in the studies of Weiss[23], Weiss and Klint[24], and Meaney[21], which suggest that a greater amount of information supplied by demonstration would require less physical practice for individuals to formulate a consistent structure to reach learning criteria, since they already had a robust cognitive representation of the general and specific characteristics of the task.

These data strengthen the idea that demonstrations supply information on general aspects of spatial and temporal patterns of the movement, and corroborate the study of Shea et al.[4]. The results point to presuppositions that both numbers of demonstrations were effective so that the subjects in each group would acquire the idea of the movement, and hence need similar amounts of practice to promote adjustments in the movement in order to reach the score band set for performance criteria. This result indicates that the number of demonstrations used later would not make any difference in the learning speed.

Still analyzing the results of this experiment and those of Weiss[23], Weiss and Klint[24], and Meaney[21], we may infer that there is a relation between the number of demonstrations and the complexity of the task. Also regarding the movement pattern, this study carried out a "macroscopic" analysis. However, the use of a kinematic analysis together with performance measures is a strategy that should be considered in future studies.

Moreover, we aimed at assessing whether there were intergroup differences as regards other measures, such as the total number of subjects per group; the number of subjects who did not perform the right movement pattern, and the number of subjects who did not reach performance criteria.

The discussion regarding the secondary measure *total number of subjects* will dissolve into the discussion of number of subjects who did not reach the correct pattern of movement and those who did reach performance criteria, since the total number of subjects is the blend of those two measures.

The number of subjects who did not perform the correct pattern of movement according to the model shows that 10 demonstrations were better than two. An explanation might be the fact that group D10 had more opportunities to gather general information on the spatial and temporal pattern of the task, and therefore fewer subjects in that group were disqualified for errors in the pattern of movement.

These results corroborate the theoretical presuppositions of Bandura[2] and the studies of Feltz[16], Carroll and Bandura[8] and Laguna[17]. In fact, the higher number of demonstrations facilitated the formation of a cognitive representation with information that generated a pattern of movement closer to that performed by the model. The need apprentices have to observe the model repeatedly in order to gather information on the movement is compelling. They need information on the pattern of space and time[4] and on the process of error detection and correction[7] when they aim at learning a certain motor skill that will lead them to reach their goal more effectively. According to Horn et al.[11], as the apprentice is exposed to demonstrations, his/her visual search becomes more refined, and the rate of distribution of observation focuses more strongly on the most important components of the movement.

On the other hand, the result regarding number of subjects who did not perform the pattern of movement correctly does not corroborate the study of Bruzi et al.[19]. This might have happened because Bruzi et al.[19] used a less complex task than the ones used in our experiment and in that of Feltz[16], Carroll and Bandura[8], and Laguna[17]. Consequently, tasks considered simple may not require a large number of demonstrations that generate a wealth of information. This suggests a more specific relationship between the number of demonstrations and the complexity of the motor skill to be learned that deserves to be further investigated.

The result regarding the number of subjects who did not reach performance criteria shows that more subjects in group D2 were not able to make the adjustments inherent to the task within the 120 trials allowed in the acquisition phase. These data reflect that volunteers in group D10 managed to collect more information about the necessary adjustments to reach the goal of the task because they had ample opportunity to identify information on the spatial and temporal pattern of the movement[8,16,17], to the point of receiving a redundancy of information that allowed them to perform the necessary adjustments. This finding highlights the adequacy of performance criteria as a measure to detect actual performance stability[22]. This similarity between the treatments in the analysis of performance partially corroborates the results of Weeks and Choi[18] and the studies of Feltz[16] and Bruzi et al.[19].

This study gives one step forward about understanding the effects of the number of demonstrations during the learning of a discrete motor skill. More specifically, our secondary measures show the importance of using a higher number of demonstrations when one teaches a discrete motor skill that requires adjustments on the motor control. However, future studies should adopt kinematic measures to understand the changes in the motor control, especially with complex motor skills.

Conclusion

In general, to the learning of the dart throwing task, two demonstrations were as suficient as ten. Additionaly, the secondary measures support the hypothesis that a larger number of demonstrations do not influence learning, but rather the subject's capacity to detect relevant information to perform the task.

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