Effect of Focus of Attention and Age on Motor Acquisition, Retention, and Transfer: A Randomized Trial

Michal Emanuel, Tal Jarus, Orit Bart

Background and Purpose

Adult participants benefit more from external focus than internal focus when learning a new motor skill. Because learners from different age groups use different learning strategies, the purpose of this study was to investigate whether the effect of attention focus varies among children and adults.

Subjects and Methods

Thirty-four children and 32 adults were randomly assigned to internal or external focus-of-attention practice groups. Throwing darts toward a static target, participants performed 50 acquisition trials, 20 retention trials, and 20 transfer trials.

Results

The results indicate that focus of attention varies between children and adults in accuracy and variability in the acquisition phase and in accuracy in the transfer phase. No interactions were found in the retention phase.

Discussion and Conclusion

The findings suggest that external focus is more effective than internal focus in adults; therefore, physical therapists should instruct adult clients to focus their attention externally to facilitate motor learning. Physical therapists working with children should perhaps direct the client's attention internally; however, further study is needed.

M Emanuel, OT, MSc, was a graduate student in the Department of Occupational Therapy, School of Allied Health, Tel Aviv University, Tel Aviv, Israel, at the time of the study.

T Jarus, OT, PhD, is Associate Professor, Department of Occupational Science and Occupational Therapy, Can-Do Research Unit, University of British Columbia, Vancouver, British Columbia, Canada. Dr Jarus was Associate Professor, Department of Occupational Therapy, School of Allied Health, Tel Aviv University, at the time of the study. Address all correspondence to Dr Jarus at: tal.jarus@ubc.ca.

O Bart, OT, PhD, is Lecturer, Department of Occupational Therapy, School of Allied Health, Medical Faculty, Tel Aviv University.

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Teaching motor skills is a complicated multidimensional process. Adaptation of the environment or adaptation of task presentation may facilitate production of the desired responses by clients.[1,2] Jarus and Ratzon[1] proposed that principles of motor learning can assist the therapist in structuring rehabilitation in order to facilitate the client's learning of motor skills. *Motor learning* refers to a set of internal processes associated with practice or experience leading to relatively permanent changes in motor behavior.[3] The motor learning process involves 3 main phases: acquisition, retention, and transfer. For example, a client learning to lift a box correctly (acquisition phase) should be able to perform this task a week later (retention phase) and transfer this learning by correctly lifting different items at the workplace (transfer phase). The contemporary opinion on motor learning is that the motor changes seen during practice are possibly only temporary and, therefore, do not reflect learning.[3,4] The retention and transfer phases, however, may indicate learning.[2,3,5,6]

As therapists, we meet with our clients for a limited period of time. Our main focus is not necessarily on how a person performs a task during treatment, but rather on how the person will perform in the future in his or her natural environment—at home or at work.[1] Therefore, the therapist must ascertain the optimal learning (acquisition) conditions that will enable recall and transfer of the learned task.[1] Thus, in this article, the results of each study phase (acquisition, retention, and transfer) will be analyzed separately, where the acquisition results will reflect immediate performance and the retention and transfer results will be indicative of learning.

Research in the area of motor learning focuses on the understanding of acquisition and practice of motor skills by investigating how different factors influence the process of movement acquisition. Those factors include, among others, the instructions given to the learner. This study focused on the influence of instructions on acquiring motor skills and transfer in children and adults.

Instructions are important when teaching motor skills.[7] Physical therapists and occupational therapists use different forms of verbal instructions to direct clients of varied ages and diagnoses. One method of verbal instruction is to direct the clients' focus of attention to critical aspects of the movement. Wulf and Prinz[8] elaborated on the effect of different focuses of attention (ie, internal versus external) on learner performance. *Attentional focus* is the act of directing attention to information sources or to objects of an individual's attention.[5] Focusing attention externally (ie, on the object or the effect of the action) versus internally (ie, on the movement or the action itself) provides increased enhancement of motor learning and performance.[8–12]

The results of studies investigating the effects of attentional focus on motor learning and performance have been consistent for a variety of laboratory tasks, such as a ski-simulator task,[10] learning to balance on a stabilometer platform,[10,13] and sport skills, such as golf,[7] tennis,[14] volleyball,[11] and soccer.[14] In these studies, participants were divided into 2 groups: one group was instructed to focus internally (eg, on the pressure they exert with their legs), and the other group was instructed to focus externally (eg, on their skis). Participants practiced the skill using the attentional focus instructions that they were given and then were tested for retention and transfer. Wulf and colleagues[12,13,15] used the constrained action hypothesis to explain the benefits of adopting an external rather than an internal focus of attention; that is, when individuals are asked to adopt an internal focus, they try to consciously control their movements, which constrains the motor system and inadvertently disrupts automatic control processes. In contrast, focusing on the movement effect, or adopting an external focus, allows unconscious or automatic processes to control the movement, resulting in more effective performance and learning.[13,16]

Perkins-Ceccato and colleagues[17] investigated the effect of focus of attention on the performer's skill level. In their study, 2 groups of golfers—highly skilled and less skilled—were further divided into 2 instruction groups: internal and external focus of attention. Results indicated a significant interaction between skill level and instruction type during acquisition, retention, and transfer, where highly skilled golfers performed better with instructions for external focus of attention, whereas less-skilled golfers performed better with instructions for internal focus of attention.

It might be assumed that children are similar to novice players in their lack of experience, unfamiliarity with tasks, and limited motor repertoire.[18] In contrast, most adults have had some exposure to a greater diversity of motor tasks. In addition, young learners have difficulties focusing their attention during motor performance.[19] However, only one study has investigated (indirectly) focus of attention in children. In testing 4 different learning strategies, including external focus of attention, Cohen-Nachman and Madkar[20] reported that external focus of attention interfered with the learning process, as exhibited by the children's inferior performance during the retention phase. They did not examine internal focus of attention, however. There-

fore, the purpose of our study was to examine the influence of focus of attention on the motor performance of children and adults. The results of this study could help clinicians to improve methods of training patients according to client age and experience. We hypothesized that adults would benefit more from external focus of attention and that children would benefit more from internal focus of attention.

Method

Participants

Thirty-four children and 32 adults participated in this study. Twenty girls and 14 boys, 8.4 to 9.8 years of age ($\overline{X}$=9.04, SD=0.35), with no known delays or developmental concerns, were randomly selected from a mainstream elementary school and then randomly assigned to 2 groups: 17 in an internal focus group (average age=8.99 years, SD=0.32) and 17 in an external focus group (average age=9.09 years, SD=0.39).

A convenience sample of 32 adults (16 men and 16 women), 22.7 to 36.8 years of age ($\overline{X}$=28.73, SD=4.23), were randomly divided into 2 groups: 16 in an internal focus group (average age=30.19 years, SD=4.57) and 16 in an external focus group (average age=27.27 years, SD=3.39).

All of the participants were unfamiliar with the experimental task. All of the adult participants and the children's parents provided informed consent.

Apparatus and Task

The task was to throw darts into the center of a circular target, 1 m in diameter (Fig. 1). As shown in Figure 1, the target's height and distance were altered according to the age group and the experimental condition, as recommended in the Keogh

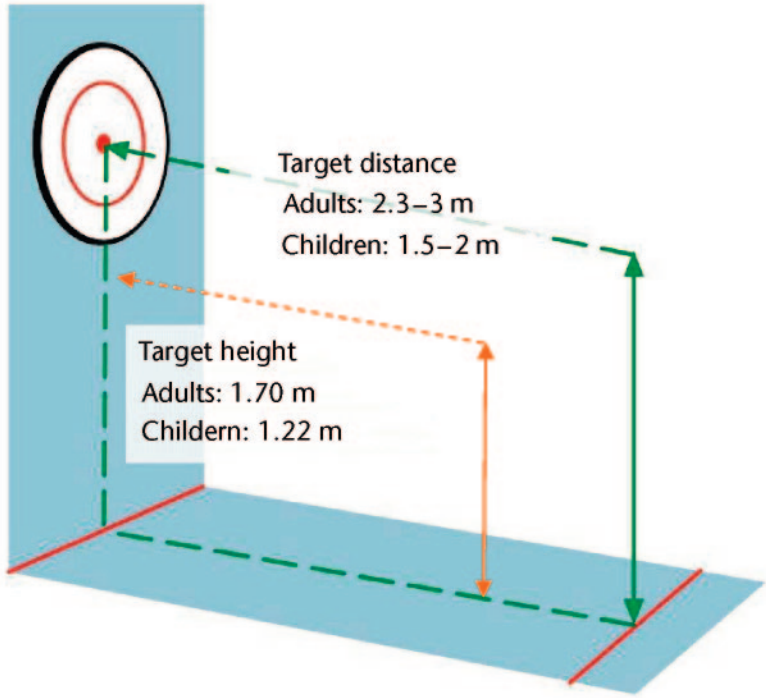

Figure 1.
The task setting.

test.[21] In the acquisition and retention phases, the target's distance was the same; whereas in the transfer phase, the target's distance was extended by the same amount relative to the original distance for children and adults. Ten standard soft-tip plastic-head darts were used for each trial block. After each trial block, the darts were collected from the target board by the experimenter (EM) and were used again for the next trial block.

Procedure

The experiment was conducted in a quiet room. Prior to the first (acquisition) phase, the experimenter spent 10 minutes with each participant to explain and demonstrate the basic technique of throwing darts. All participants were given the same general instructions regarding the task goal and the throwing position. Instructions for the internal focus group were directed at movements of the shoulder, arm, and fingers (eg, "attach your thumb, index finger, and third finger and then bend your elbow") (see Appendix for detailed instructions). Instructions for the external focus group were directed at the target, the darts, and the dart's course (eg, "hold the dart"). Each participant came for 2 consecutive days (the entire study). On the first day, during the acquisition phase, participants threw 50 times in 5 trial blocks (10 throws per block). At the end of each trial block, the experimenter marked where the dart hit the target, refreshed the focused instructions, and removed the darts from the target. At the end of the acquisition phase, each participant was asked what he or she focused on while practicing the task.

One day after the acquisition phase, both retention and transfer phases were conducted. In the retention phase, participants threw 20 darts (2 blocks of 10 throws each) from the same distance as in the acquisition phase. Several minutes later, the transfer phase was conducted, in

Table 1.
Analysis of Variance for Age and Practice Group: Error (in Centimeters) From Center (MRE[a]) and Variance (BVE[b])

Source	*df*	MRE		BVE	
		F	*P*	F	*P*
First trial block					
Practice group	1,62	0.392	.54	0.013	.91
Age	1,62	0.396	.53	0.06	.81
Practice group × age	1,62	3.45	.07	1.99	.16
Acquisition phase					
Practice group	1,62	0.46	.49	0.42	.66
Age	1,62	3.25	.07	1.96	.17
Practice group × age	1,62	0.65	.21	0.62	.26
Trial block	4,248	2.61[c]	0.036	2.2	.07
Trial block × practice group	4,248	1.95	0.10	1.28	.28
Trial block × age	4,248	0.76	0.55	0.68	.61
Trial block × practice group × age	4,248	3.66[d]	0.006	3.21[c]	.014
Retention phase					
Practice group	1,62	0.059	.81	0.45	.51
Age	1,62	5.25[c]	.025	9.95[d]	.002
Practice group × age	1,62	1.95	.17	0.12	.74
Transfer phase					
Practice group	1,62	0.06	.81	0.39	.54
Age	1,62	0.15	.70	0.15	.70
Practice group × age	1,62	3.92[c]	.05	1.73	.19

[a] MRE=mean radial error, calculated as:

$$MRE = \overline{RE} = \frac{1}{m}\sum_{i=1}^{m} RE_i$$

$$RE = \sqrt{X^2 + Y^2},$$

where *RE*=radial error (distance between the throw and the center), *m*=number of trials, and *i*=a particular trial.
[b] BVE=bivariate variable error, calculated as:

$$BVE = \sqrt{\frac{1}{k}\sum_{i=1}^{k} (X_i - X_c)^2 + (Y_i - Y_c)^2},$$

where *k*=number of trials, *i*=a particular trial, and X_c and Y_c=the average distance from the X and Y axes, respectively.
[c] $P<.05$.
[d] $P<.01$.

which participants threw 20 darts (2 blocks of 10 throws each) from a further distance. No further instructions were given in both retention and transfer phases.

Data Analysis

The dependent measures included: accuracy (mean radial error [MRE]) and variability or inconsistency (bivariate variable error [BVE]) of throws. The MRE, analogous to absolute error (AE) in one-dimensional tasks, provides an indication of the average deviation of the darts from the center of the target (in centimeters). Lower scores indicate a more accurate performance. The BVE, analogous to variable error (VE) in one-dimensional tasks, provides an indication of the standard deviation of each of the participant's throws from a typically positioned trial.[22] In order to calculate those measurements, the distance of the arrows on the X and Y axes (while the center of the target is the zero point) were measured (in centimeters) (see formula in Tab. 1).

In order to ensure that baseline differences between the 2 groups were not significant, thus avoiding confounding comparison of absolute retention and transfer test results, a 2-way analysis of variance (ANOVA) (practice group × age group) was performed on the first trial block for each of the dependent variables.

For the acquisition phase, these data were combined to form 5 blocks of trials (10 trials per block) for each of the 2 dependent measures to allow analysis of the change as practice progressed. For the retention and transfer phases, an average of all 20 trials was calculated for each of the 2 dependent measures.

For analysis of the acquisition phase, a 3-way ANOVA—2 (practice group) × 2 (age group) × 5 (trial block)—with repeated measures on the last factor was performed on each of the dependent measures. For analysis of the retention and transfer phases, a 2-way ANOVA—2 (practice group) × 2 (age group)—was performed on each of the dependent measures for each of the phases. For all analyses, participants were divided into practice groups based on initial instructions and not based on self-reported focus of attention. *Post hoc* Scheffé

Table 2.
Means (Standard Deviations) of Analysis of Variance for Interaction of Age Group × Practice Group During the Acquisition Phase[a]

	Focus of Attention	Trial Block				
		1	2	3	4	5
MRE						
Adults	Internal	10.64 (2.83)	10.80 (3.27)	10.94 (3.81)	11.68 (3.68)	11.00 (2.71)
	External	12.50 (3.44)	10.04 (3.11)	9.90 (3.54)	9.62 (2.70)	9.66 (2.85)
	Total	11.56 (3.24)	10.42 (3.16)	10.41 (3.67)	10.65 (3.34)	10.33 (2.82)
Children	Internal	12.49 (3.00)	10.99 (2.26)	11.60 (3.23)	12.52 (2.83)	11.42 (2.61)
	External	11.57 (2.83)	12.00 (3.01)	10.88 (2.86)	12.05 (2.54)	11.83 (2.78)
	Total	12.03 (2.91)	11.48 (2.68)	11.24 (3.02)	12.28 (2.66)	11.63 (2.67)
Total	Internal	11.59 (3.02)	10.88 (2.75)	11.28 (3.48)	12.11 (3.24)	11.21 (2.63)
	External	12.02 (3.13)	11.05 (3.17)	10.40 (3.20)	10.87 (2.86)	10.78 (2.98)
	Total	11.81 (3.06)	10.97 (2.95)	10.84 (3.35)	11.49 (3.10)	11.00 (2.80)
BVE						
Adults	Internal	11.23 (2.67)	10.93 (3.37)	10.92 (3.32)	11.82 (3.64)	11.48 (3.02)
	External	12.24 (2.61)	9.96 (2.61)	10.20 (3.37)	10.06 (2.52)	10.09 (3.32)
	Total	11.73 (2.65)	10.45 (3.00)	10.56 (3.31)	10.94 (3.21)	10.78 (3.20)
Children	Internal	12.33 (3.18)	10.99 (2.36)	11.96 (3.34)	12.09 (2.89)	11.60 (2.83)
	External	11.47 (2.26)	12.21 (2.61)	10.80 (3.00)	11.94 (2.58)	11.67 (2.43)
	Total	11.90 (2.75)	11.60 (2.52)	11.38 (3.18)	12.02 (2.70)	11.64 (2.60)
Total	Internal	11.80 (2.95)	10.96 (2.84)	11.46 (3.32)	12.00 (3.23)	11.54 (2.88)
	External	11.84 (2.43)	11.12 (2.81)	10.51 (3.15)	11.03 (2.67)	10.91 (2.96)
	Total	11.82 (2.68)	11.05 (2.81)	10.98 (3.25)	11.49 (2.98)	11.22 (2.91)

[a] MRE=mean radial error, BVE=bivariate variable error.

tests were performed if the ANOVAs were significant to test for significant differences between the means.

To check whether participants followed the instructions regarding focus of attention, the gap between the ascribed practice group and the participant's report on what he or she was focused on while practicing the task was analyzed using a chi-square test. The level of significance was set at .05 for all statistical tests. All statistical analyses were performed using SPSS-14.*

* SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606

Results

The results of the 2-way ANOVA indicated that there were no significant differences between groups at baseline (Tab. 1). Therefore, performance of participants was analyzed for each study phase separately. Preliminary tests of the assumptions of the statistical tests, including normality, homogeneity of variance, and multisample sphericity, for the repeated-measures ANOVA were met.

Acquisition Phase

The results of the ANOVA for the acquisition phase indicated there was no significant interaction between age and focus of attention. In addition, neither of the main effects for focus of attention or age group was significant (Tab. 1). A significant main effect for trial blocks was found only for the MRE measure. Collapsed over all other variables, based on *post hoc* analysis, participants improved significantly from trial block 1 to trial blocks 2, 3, and 5. A significant 3-way interaction was found among age, focus of attention, and trial block for both measures (MRE and BVE). Performance of the adults who practiced in the internal focus group was less accurate and consistent as practice progressed, whereas the adults from the external focus group improved significantly throughout subsequent trial blocks

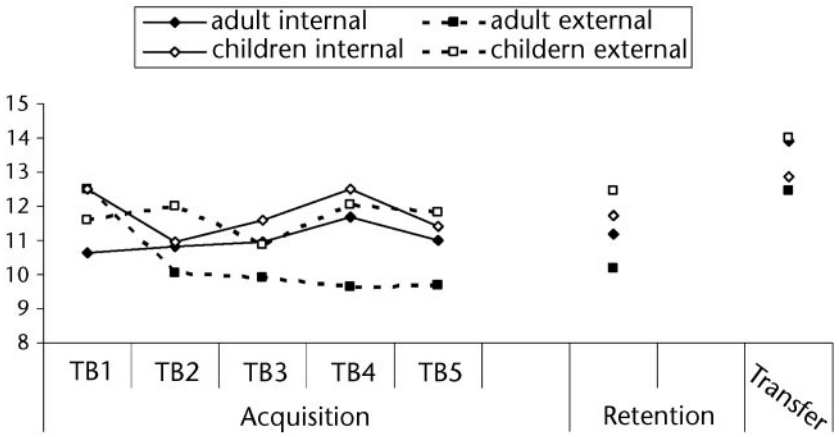

Figure 2.
The interaction effect among age (adult versus children), focus of attention (internal versus external), and trial block (TB) during the acquisition, retention, and transfer phases for the mean radial error measure.

(Tab. 2, Figs. 2 and 3). In the children's practice groups, no statistically consistent pattern of improvement was found along the trial blocks for either internal or external focus of attention.

Retention Phase

The results of the ANOVA for retention indicated that age contributed a significant main effect in both outcome measures (Tabs. 1 and 2). As expected, the adults performed more consistently and accurately than the children. The interaction effect between age and focus of attention was not significant (Tab. 3).

Transfer Phase

The ANOVA during the transfer phase indicated a significant 2-way interaction between age and practice group for the MRE measure (Tab. 3). In adults, the external focus group was more accurate than the internal focus group, whereas in the children, the internal focus group was more accurate than the external focus group (Tab. 3, Fig. 2). No other significant effects were found. Neither age nor focus of attention affected the performance of the participants during the transfer phase, nor was there an interaction effect between practice group and age for the BVE measure (Fig. 3).

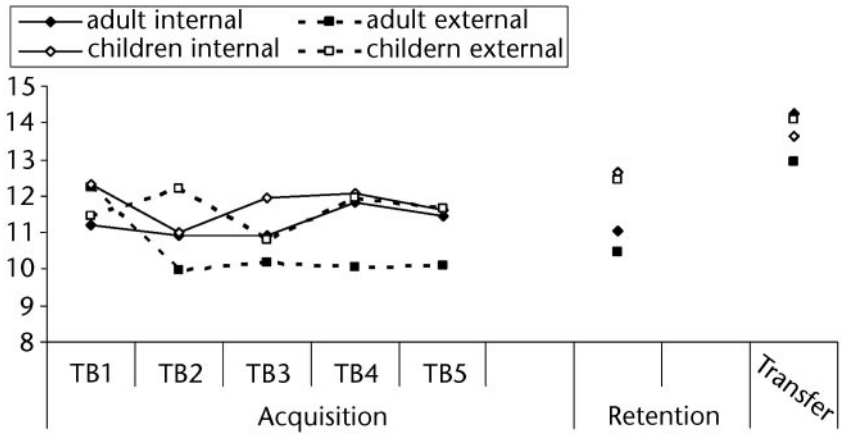

Figure 3.
The interaction effect among age (adult versus children), focus of attention (internal versus external), and trial block (TB) during the acquisition, retention, and transfer phases for the bivariate variable error measure.

Focus of Attention—Instructions Versus Reported

To check whether participants followed the instructions regarding focus of attention, the gap between the ascribed practice group and the participant's report on what he or she was focused on while practicing the task was analyzed. Most of the adults (91.6%) followed the instructions given. All participants who reported focusing differently than instructed (n=3) shifted from the instructed internal focus of attention to external focus of attention. A higher percentage of nonadherence (29.4%) was found among the children. Unlike the adults, most of these children (n=6) shifted from the instructed external focus of attention to internal focus of attention. Despite this nonadherence rate, an intention-to-treat analysis method was used, where all ANOVA results reported above were based on the initial ascribed practice groups, including all participants.

Discussion

We investigated the effect of focus of attention in 2 different age groups: elementary school children and young adults. In previous research,[7–17] it has been shown that external focus of attention is more beneficial than internal focus of attention for skill acquisition among adults. We investigated whether this also was true for children. Our results reinforced previous findings regarding the advantage of external focus of attention (focus on the action results) over internal focus of attention (paying attention to the body movements) in adults. However, no

Table 3.
Means (Standard Deviations) of Analysis of Variance for Interaction of Age Group × Practice Group During the Retention and Transfer Phases[a]

	Retention		Transfer	
Focus of Attention	**MRE**	**BVE**	**MRE**	**BVE**
Adults				
Internal	11.19 (2.86)	11.05 (2.50)	13.91 (2.72)	14.27 (2.65)
External	10.18 (2.47)	10.48 (2.42)	12.45 (2.83)	12.92 (2.87)
Total	10.69 (2.68)	10.76 (2.44)	13.18 (2.83)	13.60 (2.80)
Children				
Internal	11.75 (2.16)	12.64 (2.04)	12.86 (2.05)	13.62 (2.26)
External	12.46 (2.50)	12.46 (2.25)	14.00 (2.97)	14.11 (3.38)
Total	12.10 (2.58)	12.55 (2.12)	13.43 (2.58)	13.87 (2.84)
Total				
Internal	11.48 (2.50)	11.87 (2.38)	13.37 (2.42)	13.94 (2.44)
External	11.35 (2.71)	11.50 (2.51)	13.25 (2.97)	13.53 (3.16)
Total	11.42 (2.58)	11.68 (2.43)	13.31 (2.69)	13.74 (2.81)

[a] MRE=mean radial error, BVE=bivariate variable error.

significant differences were found between the internal and external focus of attention among children, except for advantage for internal focus of attention in MRE during the transfer phase.

Perkins-Ceccato and colleagues[17] found that highly skilled golfers performed better with instructions on external focus of attention than with instructions on internal focus of attention. Low-skilled golfers, however, performed better with instructions on internal focus of attention than with instructions on external focus of attention. Bernstein[23] suggested that that external focus of attention might be more beneficial for skilled athletes than for less-skilled athletes due to the different level of movement automation they exhibit. Expert athletes have more highly developed automatic motor skills than recreational athletes.[23,24]

Our results concur with those of the studies by Perkins-Ceccato et al[17] and Beilock et al,[24] in which adults benefited from external focus of attention, but, in the children's groups, instructions aimed at internal focus of attention were more advantageous than those on external focus of attention in the transfer phase, and a similar trend seemed to show in the retention phase. We can argue that the adults had relatively more motor experience than the children and thus performed the task more automatically, even though they had no specific dart-throwing experience. Consequently, children may be more similar to low-skilled adult players who have no experience with such activities, exhibiting lower level of movement automation[20]; however, the results of the current study are inconclusive in this regard.

Automatic motor control is an implicit process in which movement becomes more efficient and regulation becomes more accurate.[5] Among adults, conscious control of body movements (as in the instructions on internal focus of attention) may interrupt the motor control process that automatically regulates movements.[9,10] Specifically, instructions on internal focus of attention seem to interfere with implicit learning. Perhaps children do not manifest this process, as their implicit learning is not yet mature.[25] Automatic motor control, which is linked to motor experience, may be less effective in children than in adults. Therefore, children may use body movement guidance (instructions on internal focus of attention) to improve their motor learning, unlike adults for whom these instructions seem to compromise automatic motor control, but the results of this study are inconclusive in this regard.

Other explanations for the differences in focus of attention between children and adults include information processing and sensory system (visual, kinesthetic) differences between the 2 age groups. Adults tend to be assisted spontaneously by visual information,[26] whereas children, who are more immature in information system processing, function differently.[27] Children are slower at information-processing tasks and often collect irrelevant cues from the visual field.[28]

Thus, directing children's attention to the visual cues (ie, the target and the arrow [external focus of attention]) decreases their performance. During our data collection, many children asked the investigator to remove the darts from previous throws that were still embedded in the target before the next throw. They pointed out that the remaining darts distracted them when throwing the next dart in the block. These concerns were not voiced by the adults.

The use of the kinesthetic system as a feedback source to improve motor behavior, motor awareness, and motor learning also is different in children and adults.[27] The kinesthetic system matures around 11 years of age,[27] whereas the children in our study were younger. In instructions on internal focus of attention, the emphasis is on the kinesthetic system. Research has shown that, by directing children to focus on their body movements, their kinesthetic feedback and motor performance can be improved.[28] Perhaps the results of these studies indicate that focusing on body movements (internal focus of attention) is more effective than focusing on the results of the movement itself (external focus of attention) in children because it contributes to information processing. The variable performance of the children among the trial blocks during the acquisition phase also may be explained by the fact that children at this age have difficulties in regulating active and passive force components, causing inconsistent patterns of movement.[29,30] Yet, further study is needed to explore these explanations.

Although a significant interaction between age and focus of attention was found in the transfer phase for one measure (MRE), the means suggest that the participants did not achieve an overall learning effect during the transfer phase, compared with the acquisition and retention phases. We propose that the increase in target distance during the transfer phase required participants to invest more force, which served to decrease the accuracy of the throw. Previous studies showed that a change in the force factor usually worsened the throw accuracy among novice players.[31,32] In addition, the change in throw distance caused participants to alter their pattern of movement and to make more mistakes.[33] Thus, it is our interpretation that these results were not due to lack of learning, but rather to changes in the physical demand of the task. Further studies are needed to clarify this.

At the end of the acquisition phase, we asked the participants about what they were focusing on during the dart throws. Almost 30% of the children reported focusing on something other than the instructions that they had been given, especially children from the external focus group, who reported focusing on the hand itself. We suggest this finding reflects the children's spontaneous preference for internal focus of attention. Conversely, the adult group showed less than 10% unsuitability between instructed and actual focus of attention, and all of them were part of the internal focus group that reported on focusing on the target or the arrow (external focus).

Limitations of the Study

Although the one-way ANOVA performed on block 1 of the data showed no statistically significant baseline effects, there was a trend for between-group differences ($P=.07$, Tab. 1) for the MRE data. Yet, because these groups were randomized, we already know that there were no true population differences among the groups and that any differences at baseline were necessarily due to random sampling variation. The repeated-measures analysis used in this study appropriately adjusted for between-subject variation in the dependent variables.

We decided not to "throw out" people who changed their attention focus because the integrity of a randomized design depends on people being analyzed as randomized, corresponding to what would be called an "intention-to-treat analysis" in applied work. In particular, we wanted to test whether instructions about focus matter in any practical way; therefore, we had to contend with the reality that people do not always follow instructions exactly, regardless of adherence. This is particularly true when we consider the implications of the results of this study to clinical work, as clients do not always follow instructions exactly.

In addition, only short-term retention was tested one day away from the acquisition phase. Further study is needed to learn more about the effect of focus of attention on long-term retention and transfer.

Conclusion and Clinical Recommendation

The results of our study for the adult groups concur with those of previous studies[7–17] (ie, motor learning and performance can be enhanced by directing the performers' attention to the effect of their movement [external focus of attention]). With adult clients who are learning or relearning a movement in the clinic, the therapist should use instructions on external focus of attention to improve movement execution. For example, when the client is practicing walking, the therapist should direct the client's attention to the chair at the end of the hall, rather than on the client's heel movement or the leg. This needs to be investigated with adult clients with movement disorders to verify generalizability of the results. Among children, our results were unclear. Only in the transfer phase was an advantage of using

an internal focus of attention found. More research is needed to further examine the influence of focus of attention in children of various ages, with different tasks and different methods of conveying the instructions that might be developmentally appropriate for children.

Ms Emanuel and Dr Jarus provided concept/idea/research design and data analysis. All authors provided writing. Ms Emanuel provided data collection, project management, and subjects. Dr Bart provided consultation (including review of manuscript before submission).

Ethical approval for this study was granted by the ethical committee of Tel Aviv University.

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Appendix.

Instructions for the Two Focus Groups (Internal and External)

Internal Focus Group instructions:

On your right hand, place your thumb next to your middle finger and index finger.

Flex your elbow until your hand reaches your eye height.

Before throwing, concentrate on your finger motion and the correct position. Pay attention to your grasp and to the flexing and extending of your elbow.

Bring your hand backward, approximately to your ear, and while throwing extend all of your fingers together so that, at the end of the throw, your hand is directed forward and your elbow is fully straightened.

After every 10 trials: Focus on how your arm and hand (elbow, wrist, and fingers) feel before and during the throw.

External Focus Group instructions:

Hold the dart with your right hand. Roll the dart and concentrate on its weight and position.

Pay attention that the dart is parallel to the ground.

Bring the dart to eye level and feel the dart directly in front of you on your right.

Look at the target center carefully for few seconds.

Bring the dart toward your right ear and throw the dart.

While throwing the dart, concentrate on its flight directly toward the target.

After every 10 trials: Focus on the dart (how it feels, its weight and position) and look at the target.