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RESEARCH ARTICLE

Confirmation of psychometric properties of the Movement Specific Reinvestment Scale for Children (MSRS-C).

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Abstract

Purpose: To validate the Movement-Specific Reinvestment Scale for Children (MSRS-C) in English-speaking children that assesses a child's propensity to consciously monitor and control body movement (termed 'movement reinvestment'). **Method**: Three-hundred and forty children aged 7-13 years completed the MSRS-C alongside a measure of sustained attention. **Results**: Results from the confirmatory factor analysis revealed that the MSRS-C possessed sound internal validity, fair convergent validity, acceptable internal consistency and test-retest reliability. Negligible gender differences and no association with age were found. **Conclusions**: Future research can further ascertain the predictive validity of the MSRS-C. Understanding movement reinvestment in the child population has practical implications for practitioners responsible for teaching children motor skills and in children's sustained engagement in sport and exercise.

Keywords : attention; movement reinvestment; children; confirmatory factor analysis; structural equation modelling

Introduction

Being able to move fluently and efficiently is imperative to effective functioning in everyday activities, and to physical activity engagement, for both children and adults [1,2]. Empirical evidence suggests that superior motor proficiency is characterised by a focus of attention on movement outcomes (external focus) rather than movement execution (internal focus) [3,4]. Indeed, focusing attention internally hinders movement fluency and disrupts automaticity [5,6]. Substantial research has focused on understanding the reasons underlying the effect of an internal focus of attention [7-9]. The general consensus is that an internal focus of attention leads to the development of explicit “rules” about how to move [10]. Not only is attention to explicit rules cognitively demanding, it also causes disruption to the ‘flow’ of movements as previous automatic execution is now de-automatized, which is likely to result in motor performance impairment [8,11].

The tendency to direct attention internally to monitor and control movements has been termed *movement reinvestment* [7,10]. The inclination to reinvest differs across individuals and in adults, this can be measured with the Movement Specific Reinvestment Scale (MSRS) [12]. Research examining the MSRS has identified that movement reinvestment can be triggered by factors such as anxiety, fatigue, and movement difficulties stemmed from physical disorders [13,14]. For instance, when temporal pressure increased, which raised anxiety, individuals who scored higher on the MSRS displayed significantly poorer improvements in a surgical task [15]. Within the clinical populations, those who had fallen, or who had suffered from Parkinson’s disease or stroke, also scored higher on the MSRS than their age-matched controls [13,16,17]. Additionally, professional experience seems to play a role in MSRS tendencies in that novice physiotherapists seem to be pay greater attention to the style of movement compared to their more experienced counterparts [18].

The practical significance of the MSRS is clear – the identification of individuals who are more likely to reinvest can facilitate the development of individualised training programs that focuses on implicit acquisition or execution of movements. MSRS research, however, has focused primarily on adults. Consequently, our understanding of how movement reinvestment affects children's motor proficiency is limited. In view of this, the MSRS was recently modified and translated to a child-friendly version in Chinese, (known as Movement Specific Reinvestment Scale for Chinese Children; MSRS-CC). The MSRS-CC was shown to possess acceptable internal validity, internal consistency, and test-retest reliability in children aged 7-12 years [19]. This newly developed scale therefore provides researchers with the opportunity to assess the relationship between movement reinvestment and motor performance in Chinese children.

By way of example, Chinese children who reported a greater inclination to focus on the mechanics of body movements (termed 'conscious motor processing', a factor within the MSRS-CC) also reported more positively about their perceived physical coordination [19]. Albeit a rather crude measurement of coordination, this pointed to the possibility that the tendency to focus internally on body movements might benefit motor performance in children. Additionally, athletes who scored higher on conscious motor processing exhibited greater self-regulatory ability [20]. However, we should be cautious with these conclusions, as numerous studies have shown that learning was impaired for children with poor motor ability when the practice environment encouraged *reinvesting* via the correction of movement errors [21-23].

Similar result was also found when children were presented with multiple internal explicit instructions [24,25].

To further understand movement reinvestment in children, more motor learning studies should examine movement reinvestment using validated versions of the MSRS for children. However, to date, such a psychometric instrument is not available in English. There is increasing evidence to suggest the association between poor motor competence and low habitual physical activity level in children as early as preschool in English-speaking populations, and without taking consideration of the possible self-regulatory factors that might hinder motor skill development, motor skill training or intervention is less likely to be fruitful, and the consequences of poor motor competence can potentially result in a downward spiral and physical inactivity might carry develop into adulthood [26]. We therefore aimed to validate an English version of the MSRS-CC (known as the Movement Specific Reinvestment Scale for Children; MSRS-C) in 7-13-year-old Australian children. The MSRS-C is comprised of two factors – the propensity to consciously monitor and control body movement (‘conscious motor processing’, CMP) and the propensity to scrutinise one’s own style of movement (‘movement self-consciousness’, MSC). In addition to examining the internal validity and reliability, we also investigated its convergent validity against attention ability. Given that the process of *reinvesting* often requires the performer to control and monitor their movements, it was conceivable that younger children would report higher scores on the MSRS-C as they might still be in movement acquisition phase in motor development. Moreover, since *reinvesting* requires sustaining attention on a task (i.e., monitoring or controlling movements), we expected scores on the MSRS-C to be positively associated with sustained attention ability [27]. Gender differences were also investigated, however, we expect to find no gender effect given that gender had minimal effect on scores in Chinese children [19].

Method

Participants

Three hundred and forty children aged 7 to 13 years (Grades 1 to 6) were recruited from 7 local primary schools in Melbourne's metropolitan region (52.9% boys; mean age = 10.24 years ± 1.27). All participants provided written assent while their parents/guardians provided written consent. All measures and procedure were approved by the Institutional Ethics Committee for Human Research and Department of Education (Victoria).

Study design

At their respective schools, all participants completed the Movement-Specific Reinvestment Scale for Children (MSRS-C) at Time 1 with the assistance of a researcher and/or a teacher and a sub-sample (n=103, sub-sample 1, 48.5% boys; mean age = 10.61 years ± 1.05) completed the questionnaire at Time 2 for assessing test-retest reliability of the scale. Particularly for the younger age groups, each question and choice of answers was read out to the participants to aid comprehension of the items. A second sub-sample (n=108, 54.6% boys; mean age = 9.46 years ± .62) also completed an attention task in order to facilitate predictive validity evaluation of the MSRS-C.

Measures and procedure

Movement Specific Reinvestment Scale for Children (MSRS-C). The MSRS-C comprises two factors – movement self-consciousness (MSC) and conscious movement processing (CMP). There are 5 items for each factor. Each item is anchored by 1 = *strongly disagree* and 4 = *strongly agree*. The MSRS-C was translated and modified from the original Movement Specific Reinvestment Scale for Chinese Children (MSRS-CC) which has demonstrated sound internal validity, internal consistency, and test-retest reliability [19]. An example item for CMP - 'I try to think about my movements when I carry them out', and for MSC – 'I am aware of the way I look when I am moving'. In the modification process, two researchers experienced in translating research-related documents from English to Chinese and vice versa, and working with young children were consulted on the wordings for each item. Any discrepancies in the translation were discussed and resolved to mutual satisfaction. For example, the discrepancy between the translated expression of 'check out' my movement and 'look at' my movement was discussed and the former was agreed upon as it seem to be more in tune with the everyday language of the targeted age group. The questionnaire was then pilot tested on 7 children from 6 – 11 years of age. The children were encouraged to ask questions about the meaning of the items. They were also asked, at random, to give examples that reflected their choice of answers to check their understanding of the items. All children appeared to comprehend the items without difficulty, although reading out the items seemed to benefit the youngest children most in their comprehension. Hence, during the questionnaire administration a researcher read out each item to the participants and any explanations provided were ensured to be consistent across the administering researchers. The questionnaire was completed in class on a normal school day. The full MSRS-C is shown in Appendix I.

Attention task. The Score! test was adopted to evaluate participants' ability to sustain attention and was completed before the MSRS-C. Participants were required to count the number of auditory beeps (each lasted for 345 ms) over 10 trials. Each trial included 9-15 beeps, with a 500 to 5000 ms interval between each beep. Possible scores ranged from 0-10.

Analysis strategy

To check the univariate normality of the data, absolute values of skewness and kurtosis not exceeding 2 and 7 respectively was followed [28] and for multivariate normality, the critical ratio is recommended to be ≤ 8.0 [29]. Once normality was ascertained, the entire sample was randomly divided into half for confirmatory and cross-validation purpose [30]. Factor structure of the MSC and the CMP was assessed separately first before testing the entire scale by confirmatory factor analyses (CFAs), based on maximum likelihood estimation and covariance matrix, using AMOS 5.0 software for structural equation modelling [31]. Lambda was set as 1 for the first observed indicator of each latent variable (i.e., MSC and CMP) and error weights, and all other parameters were allowed to be freely estimated. To determine the model fit, the chi-square statistics, the standardized root mean square residual (SRMR; ≤ .08 for a good fit), the root mean square error of approximation (RMSEA; close to or < .06 for a good fit and ≥ .06 < .08 for fair fit) [32], the Tucker-Lewis Index (TLI), the goodness-of-fit index (GFI) and the comparative fit index (CFI; ≥ to .95 and .90 to reflect a good fit and an adequate fit respectively) were evaluted [33]. Model modification was carried out based on the chi-square statistics, cross-correlation of error terms, modification indices (MIs) and factor loadings (greater than or equal to .34 was considered as acceptable) [34]. The modified model was tested again using the cross-validation sample. Additionally, the internal consistency of each factor and that of the entire scale were also calculated. For the former, Cronbach's alpha of approximately .60 would be considered acceptable considering the small number of items[33]whereas for the latter, Cronbach's alpha ≥ .70 would be regarded as sound[34]. Test–retest reliability of sub-sample 1 was evaluated by intraclass correlation with 95% CI using a two-way random model (intraclass correlation coefficient (ICC) ≥. 81 = excellent, .61–.80 = good, .41–.60 = moderate and ≤ .40 = poor) [37]. Pearson correlations were conducted to assess the convergent validity of the MSRS-C against the attention test results and to evaluate the association between MSRS-C and age. Lastly, gender differences in MSC, CMP and MSRS-C scores were evaluated using one-way ANOVA after factorial invariance between genders was ascertained.

Results

MSRS-C internal validity

Tests for univariate normality suggest that the distribution of our data was normal (skewness and kurtosis ranged from .31-.72 and .41-1.36 respectively), with a multivariate critical ratio of 2.81. We therefore proceeded with CFAs of the scale. Based on the confirmatory sample, both CMP ($\chi^2[5] = 8.12$, $p > .05$; SRMR = .05; RMSEA = .06; CFI = .95; TLI = .90; GFI = .98) and MSC ($\chi^2[5] = 4.49$, $p > .05$; SRMR = .03; RMSEA = .00; CFI = 1.00; TLI = 1.01; GFI = .99) presented a good model fit. Conglomerating the models of MSC and CMP for the CFA of the MSRS-C, results indicated that the model fit could be further improved ($\chi^2[34] = 53.00$, $p < .05$; SRMR = .06; RMSEA = .06; CFI = .90; TLI = .87; GFI = .94). Perusing the MIs of the error terms, although item 9 and 10 presented slightly higher MI than item 5 and 7, the latter pair seemed to convey similar concept which concerns attention to one's own movement (item 5 – 'I am aware of the way I look when I am moving'; item 7 – 'I am aware of the way my body works when I am moving'). This provided theoretical support for correlating the error terms of the two items and resulted in an improved model fit (χ^2[33] = 46.60, $p > .05$; SRMR = .06; RMSEA = .05; CFI = .93; TLI = .90; GFI = .95).

However, applying the factor structure of the confirmatory sample to the cross-validation sample saw a less than satisfactory model fit (χ^2[33] = 51.35, $p < .05$; SRMR = .06; RMSEA = .06; CFI = .85; TLI = .80; GFI = .95). From inspection of the MIs of the error terms, those of item 8 and 10 were notably higher and there appeared to be an overlap in the meaning of the items (item 8 – 'I am concerned about the way I move'; item 10 – 'I am concerned about what people think about me when I am moving'). For these reasons, the error terms of the pair were allowed to correlate and the resulting model fit appeared satisfactory (χ^2[32] = 37.05, $p > .05$; SRMR = .05; RMSEA = .03; CFI = .96; TLI = .94; GFI = .96). The confirmatory sample was tested using this revised model and a comparably satisfactory model fit was demonstrated (χ^2[32] = 44.18, $p > .05$; SRMR = .05; RMSEA = .05; CFI = .94; TLI = .91; GFI = .95). A summary of the model fit indices at each step of the model modification is presented in Table 1.

Table 1. Model fit indices and factor loading range of the original and the modified model for the MSRS-C and its factors.

		Modification steps	**χ^2**	***df***	***p***	**SRMR**	**RMSEA**	**CFI**	**TLI**	**GFI**	**Factor loadings**
CMP	Original factor structure	---	8.12	5	.15	.05	.06	.95	.90	.98	.34 - .50
MSC	Original factor structure	---	4.49	5	.48	.03	.00	1.00	1.01	.99	.33 - .72
MSRS-C	Original factor structure (confirmatory sample)		53.00	34	*.02**	.06	.06	.90	.87	.94	.35 - .64
	Model modifications	Correlate error terms for items 5 and 7	46.60	33	.06	.06	.05	.93	.90	.95	.34 - .65
MSRS-C	Modified factor structure (cross-validation sample)	Correlate error terms for items 5 and 7	51.35	33	*.02**	.06	.06	.85	.80	.95	.22 - .64
		Correlate error terms for items 8 and 10	37.05	32	.25	.05	.03	.96	.94	.96	.35 - .76
	Modified factor structure (confirmatory sample)	Correlate error terms for items 5 and 7 and for items 8 and 10	44.18	32	.07	.05	.05	.94	.91	.95	.35 - .58

Note: MSRS-C- Movement-Specific Reinvestment Scale for Children; MSC – Movement self-consciousness; CMP – Conscious motor processing, χ^2 = chi-square; *df* = degree of freedom; SRMR = standardized root mean square; RMSEA = root mean square error of approximation; CFI = comparative fit index; *p < .5

Internal consistency, test-retest reliability, convergent validity and association with age

The internal consistency for the 5-item MSC and the 5-item CMP was acceptable (Cronbach's alpha = .58 and .56 respectively). A similar conclusion can be drawn for the internal consistency of the entire scale (Cronbach's alpha = .69) as it only falls slightly short of the criterion. Moderate test-retest reliability was noted (ICC = .53, 95% CI, .31- .68). Considering that the time lag in test-retest ranged from 7-115 days due to school schedule constraints, we considered this test-retest result acceptable. MSRS-C score was also found to be positively associated with attention score ($r = .23$, $p < .05$) but not with age ($r = -.10$, $p > .05$)

Gender comparisons

To allow for gender comparisons on the MSRS-C score, we first ascertained the invariance of the model's factor structure for both genders. A non-significant χ^2 change from the constrained to the unconstrained model ($\chi^2[8] = 8.45$, $p > .05$; SRMR = .06; RMSEA = .04; CFI = .90; TLI = .90; GFI = .95) suggested that both genders share the same factor structure. One-way ANOVAs revealed that girls scored significantly higher in MSC and overall MSRS-C compared to boys (*p's* < .05), however, the effect sizes were small (please refer to Table 2 for details).

Table 2. Internal consistency (Time 1) and test-retest reliability (Time 1 and Time 2) of MSRS-C, MSC and CMP and their respective mean ± SD scores for boys and girls as well as ANOVA results for gender comparison.

		Time 1 mean ± SD (n=340)	**Time 2 mean ± SD** (n=103)	**Internal consistency**	**Test-retest reliability (ICC)**	**Gender differences (ANOVA)**
MSRSC	**boys**	25.84 ± 4.93	26.97 ± 5.37	.69	.53 (95% CI, .31-.68)	$F(1,339) = 4.32$, $p = .04$, $\eta^2 = .01$
	girls	26.99 ± 5.26	26.36 ± 5.35			
MSC	**boys**	11.66 ± 3.25	11.71 ± 3.31	.58	---	$F(1,339) = 4.07$, $p = .04$, $\eta^2 = .01$
	girls	12.38 ± 3.26	11.96 ± 3.28			
CMP	**boys**	14.18 ± 2.75	15.26 ± 2.93	.56	---	$F(1,339) = 2.05$, $p = .15$, $\eta^2 = .01$
	girls	14.61 ± 2.84	14.40 ± 2.84			

Note: MSRS-C - Movement-Specific Reinvestment Scale for Children; MSC – Movement self-consciousness; CMP – Conscious motor processing, ANOVA – Analysis of variance; ICC – Intraclass correlation coefficient; CI – Confidence interval

Discussion

While movement reinvestment is recognised as an important contributing factor to motor proficiency and learning in adults, little is known on its effect in children. To facilitate a better understanding of movement reinvestment in children, this study aimed to validate a psychometric instrument that measures the propensity to monitor and control movements in English-speaking children. Results suggest that the MSRS-C possessed sound internal validity and acceptable internal consistency for each factor and for the scale on the whole. Test-retest reliability was also adequate, especially considering a relatively long time lag between its first and second administration for a proportion of participants. The convergent validity of the instrument was also ascertained against the score of a sustained attention task. Lastly, a negligible significance was found in gender differences in MSRS-C scores, which resonated with the findings in Chinese children [19].

It is surprising that age is not associated with movement reinvestment considering that younger children might have stronger tendencies to attend to and control their movements when they might be in the motor developmental stage where they are acquiring new motor skills. Arguably, however, the process of *reinvesting* often requires the performer to possess ‘rules’ about a skill, and these rules are expected to accumulate with age, hence we might even expect older children to possess greater tendencies to attend to their body movements. It is thus worth considering the potential relationship between movement reinvestment and motor competence. Interestingly, children who perceived their physical coordination more positively also reported higher scores on the MSRS-CC [19]. This suggests that movement reinvestment might facilitate early motor learning in children. Likewise, adults with higher MSRS scores also displayed greater improvements during the early learning phase of a golf putting task [38]. These findings may allude to importance of encouraging an internal focus of movements by physical education professionals and coaches at the early motor acquisition phase [18]. However, we should not assume that movement reinvestment is important for early learning, as children with poor motor ability displayed inferior learning when the practice environment encouraged error-correction processes (akin to *reinvesting*) compared to when error-correction was required less [21-23]. Indeed, we suspect that an interaction exists between movement reinvestment and motor proficiency, or motor competence, when learning new motor skills. To investigate this issue, researchers can use the validated MSRS-C to assess children's propensity to *reinvest*, alongside measures of motor competence and assessments of motor learning in different motor development stages in order to ascertain the effects of movement reinvestment on skill acquisition and motor competence.

Similar to the results on age, the association between attention ability and movement reinvestment appeared fair only. This was possibly due to the non-movement related stimuli involved in the attention task despite that internal validity was evidenced and that it was relatively simple to administer with the target age group. We expected attention ability to be associated with MSRS-C as the process of monitoring movement demands sustained attention. However, perhaps a sustained attention task that is movement-relevant will be more closely associated with MSRS-C.

In addition to the aforementioned age-related factors that might affect movement reinvestment, other cognitive factors might also moderate the effect of movement reinvestment on children's motor performance. For example, children with lower working memory capacity were found to be disadvantaged on a basketball shooting task when asked to follow multiple explicit (internal) instructions [24]. Although the results did not confirm whether this was due to working memory capacity or working memory efficiency (i.e., the ability to use working memory resources), it would be of interest to investigate if movement reinvestment affects children with lower working memory capacity more than children with higher working memory capacity. Indeed, evidence suggests that there is a positive correlation between movement reinvestment and measures of verbal working memory capacity in English speaking children [27]. However, we should interpret this relationship with caution given the small sample size and that the psychometric instrument used in the study had not been validated in this population.

A few limitations of the current study are worth noting. First, the completion of the MSRS-C and the attention task was not counter-balanced as it could be logistically demanding for the school schedule. Given that the attention task was not movement related, performing this task first was expected to pose minimal to no influence on completing the MSRS-C. Hence, it was unlikely that scores on the MSRS-C were affected by the attention task. Moreover, a more challenging attention task that requires simultaneous attention to more than one stimulus can be used in future studies as the demand for working memory engagement might be able to better distinguish between those in the extreme spectrum of movement reinvestment tendencies. Future research can also examine the predictive validity of the MSRS-C against motor competence in children of different ages. Lastly, test-retest reliability can be further confirmed in future studies when a shorter test and retest period is logistically feasible.

To conclude, the current study demonstrates that the MSRS-C is a valid tool for assessing children’s tendency in monitoring and controlling their body movements in an English-speaking population. We encourage researchers to include measures of MSRS-C when assessing motor competence or administering motor learning interventions as it can potentially increase our understanding of the predictive validity of the MSRS-C. For example, could the MSRS-C predict performance change when children focus attention internally (thereby promoting reinvestment) as opposed to externally (thereby discouraging reinvestment) during the skills acquisition phase or during execution after the skills have been learned? Questions such as this one can only be addressed via the inclusion of a validated assessment of movement reinvestment in children. The significance of this line of research is evidenced by the consistent finding that poor motor competence negatively impacts habitual physical activity levels, mental and physical health (including self-esteem), risk of depression, physical fitness, obesity and cardiovascular diseases [39,40]. Hence, understanding the factors influencing motor comptence and motor learning in children has critical physical and psychological implications.

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Conflicts of interest

The authors declare no conflicts of interest.

Appendix 1. Items in the Movement-Specific Reinvestment Scale for Children (MSRS-C)

I remember the times when I could not do well in certain movements.[a]

If I see my reflection in a shop window, I will check out my movements.[b]

3. I think a lot about the movement I have done. [a]

I try to think about my movements when I carry them out. [a]

5. I am aware of the way I look when I am moving.[b]
6. I sometimes have the feeling that I am watching myself move. [b]
7. I am aware of the way my body works when I am moving. [a]

I am concerned about the way I move. [b]

9. I try to figure out why I cannot do well in certain movements. [a]
10. I am concerned about what people think about me when I am moving. [b]

Note. [a] Items representing conscious movement processing (CMP); [b] Items representing movement self-consciousness (MSC).