

Running head: *MSRS-C validity confirmation*

RESEARCH ARTICLE

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

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1 **Abstract**

2 **Purpose:** To validate the Movement-Specific Reinvestment Scale for Children
3 (MSRS-C) in English-speaking children that assesses a child's propensity to
4 consciously monitor and control body movement (termed 'movement reinvestment').

5 **Method:** Three-hundred and forty children aged 7-13 years completed the MSRS-C
6 alongside a measure of sustained attention. **Results:** Results from the confirmatory
7 factor analysis revealed that the MSRS-C possessed sound internal validity, fair
8 convergent validity, acceptable internal consistency and test-retest reliability.

9 Negligible gender differences and no association with age were found. **Conclusions:**
10 Future research can further ascertain the predictive validity of the MSRS-C.
11 Understanding movement reinvestment in the child population has practical
12 implications for practitioners responsible for teaching children motor skills and in
13 children's sustained engagement in sport and exercise.

14

15

16 **Keywords :** attention; movement reinvestment; children; confirmatory factor

17 analysis; structural equation modelling

18 **Introduction**

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

31 The tendency to direct attention internally to monitor and control movements
32 has been termed *movement reinvestment* [7,10]. The inclination to reinvest differs
33 across individuals and in adults, this can be measured with the Movement Specific
34 Reinvestment Scale (MSRS) [12]. Research examining the MSRS has identified that
35 movement reinvestment can be triggered by factors such as anxiety, fatigue, and
36 movement difficulties stemmed from physical disorders [13,14]. For instance, when
37 temporal pressure increased, which raised anxiety, individuals who scored higher on
38 the MSRS displayed significantly poorer improvements in a surgical task [15]. Within
39 the clinical populations, those who had fallen, or who had suffered from Parkinson’s
40 disease or stroke, also scored higher on the MSRS than their age-matched controls
41 [13,16,17]. Additionally, professional experience seems to play a role in MSRS

42 tendencies in that novice physiotherapists seem to be pay greater attention to the style
43 of movement compared to their more experienced counterparts [18].

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

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

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

68 To further understand movement reinvestment in children, more motor
69 learning studies should examine movement reinvestment using validated versions of
70 the MSRS for children. However, to date, such a psychometric instrument is not
71 available in English. There is increasing evidence to suggest the association between
72 poor motor competence and low habitual physical activity level in children as early as
73 preschool in English-speaking populations, and without taking consideration of the
74 possible self-regulatory factors that might hinder motor skill development, motor skill
75 training or intervention is less likely to be fruitful, and the consequences of poor motor
76 competence can potentially result in a downward spiral and physical inactivity might
77 carry develop into adulthood [26]. We therefore aimed to validate an English version
78 of the MSRS-CC (known as the Movement Specific Reinvestment Scale for Children;
79 MSRS-C) in 7-13-year-old Australian children. The MSRS-C is comprised of two
80 factors – the propensity to consciously monitor and control body movement
81 (‘conscious motor processing’, CMP) and the propensity to scrutinise one’s own style
82 of movement (‘movement self-consciousness’, MSC). In addition to examining the
83 internal validity and reliability, we also investigated its convergent validity against
84 attention ability. Given that the process of *reinvesting* often requires the performer to
85 control and monitor their movements, it was conceivable that younger children would
86 report higher scores on the MSRS-C as they might still be in movement acquisition
87 phase in motor development. Moreover, since *reinvesting* requires sustaining attention
88 on a task (i.e., monitoring or controlling movements), we expected scores on the
89 MSRS-C to be positively associated with sustained attention ability [27]. Gender

90 differences were also investigated, however, we expect to find no gender effect given
91 that gender had minimal effect on scores in Chinese children [19].

92

93 **Method**

94 *Participants*

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

101

102 *Study design*

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

112

113 *Measures and procedure*

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

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

143

144 *Analysis strategy*

145 To check the univariate normality of the data, absolute values of skewness and
146 kurtosis not exceeding 2 and 7 respectively was followed [28] and for multivariate
147 normality, the critical ratio is recommended to be ≤ 8.0 [29]. Once normality was
148 ascertained, the entire sample was randomly divided into half for confirmatory and
149 cross-validation purpose [30]. Factor structure of the MSC and the CMP was assessed
150 separately first before testing the entire scale by confirmatory factor analyses (CFAs),
151 based on maximum likelihood estimation and covariance matrix, using AMOS 5.0
152 software for structural equation modelling [31]. Lambda was set as 1 for the first
153 observed indicator of each latent variable (i.e., MSC and CMP) and error weights, and
154 all other parameters were allowed to be freely estimated. To determine the model fit,
155 the chi-square statistics, the standardized root mean square residual (SRMR; $\leq .08$ for
156 a good fit), the root mean square error of approximation (RMSEA; close to or $< .06$
157 for a good fit and $\geq .06 < .08$ for fair fit) [32], the Tucker-Lewis Index (TLI), the
158 goodness-of-fit index (GFI) and the comparative fit index (CFI; $\geq .95$ and $.90$ to
159 reflect a good fit and an adequate fit respectively) were evaluated [33]. Model
160 modification was carried out based on the chi-square statistics, cross-correlation of
161 error terms, modification indices (MIs) and factor loadings (greater than or equal to $.34$
162 was considered as acceptable) [34]. The modified model was tested again using the

163 cross-validation sample. Additionally, the internal consistency of each factor and that
164 of the entire scale were also calculated. For the former, Cronbach's alpha of
165 approximately .60 would be considered acceptable considering the small number of
166 items³³ whereas for the latter, Cronbach's alpha $\geq .70$ would be regarded as sound³⁴.
167 Test-retest reliability of sub-sample 1 was evaluated by intraclass correlation with
168 95% CI using a two-way random model (intraclass correlation coefficient (ICC) $\geq .81$
169 = excellent, .61–.80 = good, .41–.60 = moderate and $\leq .40$ = poor) [37]. Pearson
170 correlations were conducted to assess the convergent validity of the MSRS-C against
171 the attention test results and to evaluate the association between MSRS-C and age.
172 Lastly, gender differences in MSC, CMP and MSRS-C scores were evaluated using
173 one-way ANOVA after factorial invariance between genders was ascertained.

174

175 **Results**

176 *MSRS-C internal validity*

177 Tests for univariate normality suggest that the distribution of our data was
178 normal (skewness and kurtosis ranged from .31-.72 and .41-1.36 respectively), with a
179 multivariate critical ratio of 2.81. We therefore proceeded with CFAs of the scale.
180 Based on the confirmatory sample, both CMP ($\chi^2[5] = 8.12, p > .05$; SRMR = .05;
181 RMSEA = .06; CFI = .95; TLI = .90; GFI = .98) and MSC ($\chi^2[5] = 4.49, p > .05$;
182 SRMR = .03; RMSEA = .00; CFI = 1.00; TLI = 1.01; GFI = .99) presented a good
183 model fit. Conglomerating the models of MSC and CMP for the CFA of the MSRS-
184 C, results indicated that the model fit could be further improved ($\chi^2[34] = 53.00, p$
185 $< .05$; SRMR = .06; RMSEA = .06; CFI = .90; TLI = .87; GFI = .94). Perusing the
186 MIs of the error terms, although item 9 and 10 presented slightly higher MI than item
187 5 and 7, the latter pair seemed to convey similar concept which concerns attention to

188 one's own movement (item 5 – 'I am aware of the way I look when I am moving';
189 item 7 – 'I am aware of the way my body works when I am moving'). This provided
190 theoretical support for correlating the error terms of the two items and resulted in an
191 improved model fit ($\chi^2[33] = 46.60, p > .05$; SRMR = .06; RMSEA = .05; CFI = .93;
192 TLI = .90; GFI = .95).

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

206 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	<i>df</i>	<i>p</i>	SRMR	RMSEA	CFI	TLI	GFI	Factor loadings	207	
CMP	Original factor structure	---	8.12	5	.15	.05	.06	.95	.90	.98	.34 - .50	210
MSC	Original factor structure	---	4.49	5	.48	.03	.00	1.00	1.01	.99	.33 - .72	211
MSRS-C	Original factor structure (confirmatory sample)		53.00	34	.02*	.06	.06	.90	.87	.94	.35 - .64	212
	Model modifications	Correlate error terms for items 5 and 7	46.60	33	.06	.06	.05	.93	.90	.95	.34 - .65	213
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	215
		Correlate error terms for items 8 and 10	37.05	32	.25	.05	.03	.96	.94	.96	.35 - .76	217
	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	219

222

223 Note: MSRS-C- Movement-Specific Reinvestment Scale for Children; MSC – Movement self-consciousness; CMP – Conscious motor

224 processing, χ^2 = chi-square; *df* = degree of freedom; SRMR = standardized root mean square; RMSEA = root mean square error of225 approximation; CFI = comparative fit index; **p* < .5

226

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

229 The internal consistency for the 5-item MSC and the 5-item CMP was
230 acceptable (Cronbach's alpha = .58 and .56 respectively). A similar conclusion can
231 be drawn for the internal consistency of the entire scale (Cronbach's alpha = .69) as
232 it only falls slightly short of the criterion. Moderate test-retest reliability was noted
233 (ICC = .53, 95% CI, .31- .68). Considering that the time lag in test-retest ranged from
234 7-115 days due to school schedule constraints, we considered this test-retest result
235 acceptable. MSRS-C score was also found to be positively associated with attention
236 score ($r = .23, p < .05$) but not with age ($r = -.10, p > .05$)

237

238 *Gender comparisons*

239 To allow for gender comparisons on the MSRS-C score, we first ascertained
240 the invariance of the model's factor structure for both genders. A non-significant χ^2
241 change from the constrained to the unconstrained model ($\chi^2[8] = 8.45, p > .05$;
242 SRMR = .06; RMSEA = .04; CFI = .90; TLI = .90; GFI = .95) suggested that both
243 genders share the same factor structure. One-way ANOVAs revealed that girls
244 scored significantly higher in MSC and overall MSRS-C compared to boys (p 's
245 $< .05$), however, the effect sizes were small (please refer to Table 2 for details).

246 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 \pm
 247 SD scores for boys and girls as well as ANOVA results for gender comparison.

		Time 1 mean \pm SD (n=340)	Time 2 mean \pm SD (n=103)	Internal consistency	Test-retest reliability (ICC)	Gender differences (ANOVA) ²⁴⁸
MSRSC	boys	25.84 \pm 4.93	26.97 \pm 5.37	.69	.53 (95% CI, .31-.68)	$F(1,339) = 4.32, p = .04, \eta^2 = .01$ ²⁴⁹
	girls	26.99 \pm 5.26	26.36 \pm 5.35			
MSC	boys	11.66 \pm 3.25	11.71 \pm 3.31	.58	---	$F(1,339) = 4.07, p = .04, \eta^2 = .01$ ²⁵⁰
	girls	12.38 \pm 3.26	11.96 \pm 3.28			
CMP	boys	14.18 \pm 2.75	15.26 \pm 2.93	.56	---	$F(1,339) = 2.05, p = .15, \eta^2 = .01$ ²⁵¹
	girls	14.61 \pm 2.84	14.40 \pm 2.84			

252

253 Note: MSRS-C - Movement-Specific Reinvestment Scale for Children; MSC – Movement self-consciousness; CMP – Conscious motor

254 processing, ANOVA – Analysis of variance; ICC – Intraclass correlation coefficient; CI – Confidence interval

255 Discussion

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

268 It is surprising that age is not associated with movement reinvestment
269 considering that younger children might have stronger tendencies to attend to and
270 control their movements when they might be in the motor developmental stage
271 where they are acquiring new motor skills. Arguably, however, the process of
272 *reinvesting* often requires the performer to possess ‘rules’ about a skill, and these
273 rules are expected to accumulate with age, hence we might even expect older
274 children to possess greater tendencies to attend to their body movements. It is thus
275 worth considering the potential relationship between movement reinvestment and
276 motor competence. Interestingly, children who perceived their physical coordination
277 more positively also reported higher scores on the MSRS-CC [19]. This suggests that
278 movement reinvestment might facilitate early motor learning in children. Likewise,
279 adults with higher MSRS scores also displayed greater improvements during the

280 early learning phase of a golf putting task [38]. These findings may allude to
281 importance of encouraging an internal focus of movements by physical education
282 professionals and coaches at the early motor acquisition phase [18]. However, we
283 should not assume that movement reinvestment is important for early learning, as
284 children with poor motor ability displayed inferior learning when the practice
285 environment encouraged error-correction processes (akin to *reinvesting*) compared to
286 when error-correction was required less [21-23]. Indeed, we suspect that an
287 interaction exists between movement reinvestment and motor proficiency, or motor
288 competence, when learning new motor skills. To investigate this issue, researchers
289 can use the validated MSRS-C to assess children's propensity to *reinvest*, alongside
290 measures of motor competence and assessments of motor learning in different motor
291 development stages in order to ascertain the effects of movement reinvestment on
292 skill acquisition and motor competence.

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

301 In addition to the aforementioned age-related factors that might affect
302 movement reinvestment, other cognitive factors might also moderate the effect of
303 movement reinvestment on children's motor performance. For example, children with
304 lower working memory capacity were found to be disadvantaged on a basketball

305 shooting task when asked to follow multiple explicit (internal) instructions [24].
306 Although the results did not confirm whether this was due to working memory
307 capacity or working memory efficiency (i.e., the ability to use working memory
308 resources), it would be of interest to investigate if movement reinvestment affects
309 children with lower working memory capacity more than children with higher working
310 memory capacity. Indeed, evidence suggests that there is a positive correlation
311 between movement reinvestment and measures of verbal working memory capacity in
312 English speaking children [27]. However, we should interpret this relationship with
313 caution given the small sample size and that the psychometric instrument used in the
314 study had not been validated in this population.

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

328 To conclude, the current study demonstrates that the MSRS-C is a valid tool
329 for assessing children's tendency in monitoring and controlling their body movements

330 in an English-speaking population. We encourage researchers to include measures of
331 MSRS-C when assessing motor competence or administering motor learning
332 interventions as it can potentially increase our understanding of the predictive validity
333 of the MSRS-C. For example, could the MSRS-C predict performance change when
334 children focus attention internally (thereby promoting reinvestment) as opposed to
335 externally (thereby discouraging reinvestment) during the skills acquisition phase or
336 during execution after the skills have been learned? Questions such as this one can
337 only be addressed via the inclusion of a validated assessment of movement
338 reinvestment in children. The significance of this line of research is evidenced by the
339 consistent finding that poor motor competence negatively impacts habitual physical
340 activity levels, mental and physical health (including self-esteem), risk of depression,
341 physical fitness, obesity and cardiovascular diseases [39,40]. Hence, understanding
342 the factors influencing motor competence and motor learning in children has critical
343 physical and psychological implications.

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449 **Conflicts of interest**

450 The authors declare no conflicts of interest.

451 **Appendix 1. Items in the Movement-Specific Reinvestment Scale for Children**452 **(MSRS-C)**

453

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

454 *Note.* ^a Items representing conscious movement processing (CMP); ^b Items

455 representing movement self-consciousness (MSC).