THE REMEDIATION OF CLUMSINESS.
I: AN EVALUATION OF LASZLO’S 
KINAESTHETIC APPROACH

K Sims
S E Henderson
C Hulme
J Morton

It has been estimated that up to 10% of school-age children have a developmental co-ordination disorder (World Health Organization 1992, American Psychiatric Association 1994): they exhibit clumsiness which cannot be accounted for in terms of an intellectual deficit or an identifiable physical disorder (e.g. Brenner and Gillman 1966, Gubbay 1975, Henderson and Hall 1982). Such clumsiness may manifest itself in difficulty with fine motor tasks such as fastening buttons or writing, or with gross motor tasks such as hopping, jumping or catching a ball. Recent attempts to document the long-term prognosis for these children have shown that in the absence of intervention most continue to have difficulty well into the teenage years (Knuckey and Gubbay 1983, Losse et al. 1991, Cantell et al. 1994). Moreover, other difficulties may accrue which lead to underachievement in school, emotional and social difficulties and poor self-esteem (Losse et al. 1991, Schoemaker et al. 1994).

Various approaches to the treatment of clumsiness have been proposed, some requiring input over a long period (e.g. Ayres 1972, Gordon and McKinlay 1980). Although numerous studies have been published which claim success for particular methods, reviewers (Kavale and Mattson 1983, Densen et al. 1989, Polatajko et al. 1992) have pointed out that most such studies are invalid, since they fail to meet even the most basic design criteria required for a properly controlled intervention study. Densen et al. (1989) commented further that ‘the majority of studies that can be considered well designed... show no significant differences between treatment and control groups’ (p 222). In addition, they noted that very few of the methods of intervention currently popular are grounded in well-developed theories of clumsiness.

A few years ago, Laszlo et al. (1988) published an intervention study which grew out of a programme of research designed to investigate the relation between kinaesthetic sensitivity and motor control. In the early 1970s, Laszlo and Bairstow had developed a theory of motor control in which kinaesthetic acuity and the representation of kinaesthetic information in memory were key concepts (e.g. Laszlo and Bairstow 1980). Later, this theory was extended to include the notion of kinaesthetic readiness as a prerequisite for the normal development of movement competence (Laszlo and Bairstow 1983) and thence to the idea that many children who lacked motor competence did so because they were deficient in kinaesthesia. This led to the design of a standardised test, the Kinaesthetic Sensitivity Test (KST), to identify children whose kinaesthetic...
acuity and memory are poor for their age (Laszlo and Bairstow 1985a).

After a few small-scale attempts to show that such deficiencies are remediable, a comprehensive study was designed in which the provision of kinaesthetic training was contrasted with two other regimes described as the training of ‘spatial and temporal programming’ and ‘traditional remedial training’ (Laszlo et al. 1988). The study showed that children who received kinaesthetic training not only improved their kinaesthetic acuity and memory, but also surpassed the other groups in general motor competence, as assessed by the Test of Motor Impairment (TOMI) (Stott et al. 1984). In addition, teachers noted substantial improvements in performance which were still evident in many children 3 months later.

For a number of reasons, this study seemed to require replication. First, in contrast to earlier remedial studies, the method of intervention was remarkable in that it appeared to take effect very rapidly, with most children needing only 2 hours of training spread over a two-week period. Further support for an approach as economical as this would therefore be of considerable practical value. Second, the study by Laszlo and co-workers had offered training to only twenty children, rather a small number on which to base such an important claim. Third, the children in the experimental and control groups were not well matched in kinaesthetic ability. Fourth, the post-treatment assessment of the children was not carried out blind to the type of treatment. Finally, there was controversy over the method used by Laszlo and co-workers to evaluate kinaesthetic acuity.

The psychophysical method adopted by Laszlo and co-workers for evaluating the kinaesthetic acuity component of the KST is the method of constant stimuli (described below, under Method, Kinaesthetic acuity). Between 1986 and 1988, Developmental Medicine and Child Neurology published a series of studies and letters in which Laszlo and Bairstow, and a Sheffield group led by Connolly, debated the relative merits of the method of constant stimuli and the method (also described below) of parameter estimation by sequential testing (PEST) (Bairstow and Laszlo 1986, Doyle et al. 1986, Bairstow and Laszlo 1986, Elliott et al. 1988). Connolly and colleagues argued that the method of constant stimuli proposed by Laszlo and co-workers yielded unreliable results. Bairstow and Laszlo (1986) countered that methodological compromises were necessary for measuring the capabilities of young children and clinical subjects, and that this method was the best for testing children’s kinaesthetic ability before training. They might have added that their primary concern was to identify children with problems rather than to measure the exact level of ability (see Sims and Morton, in preparation). In addition to the debate about the reliability of the test, Lord and Hulme (1987) questioned the suitability of the norms for children in the UK and reported an investigation in which a group of age-matched controls were not found to be significantly better on the KST than a clinically defined group of clumsy children.

The primary objective of the present investigation was to evaluate objectively the effectiveness of kinaesthetic training for so-called ‘clumsy’ children. We decided to begin with a simple study in which we addressed the question of whether, as uncommitted observers, we could find any effects of kinaesthetic training on motor performance. To do this, we compared a group of children who were given Laszlo’s training programme with a carefully matched untreated control group. ‘Before’ and ‘after’ assessments were administered by different testers, each one blind to the group identity of the children.

Having considered the controversy over the most appropriate psychophysical method of measuring kinaesthetic acuity, we elected to use PEST as our primary measure in this study, only using the method of constant stimuli to select our subjects (this allowed us to compare the children’s performance on both of these measures). As in the study by Laszlo and co-workers, the Test of Motor Impairment (Stott et al. 1984) was used as the primary measure of general motor competence. However, to broaden the validity of our findings we included two additional measures of the generalisability of the training which we felt were particularly
relevant to a child's progress in school. Both of these focused on the ability to control a writing implement, the first being a simple shape-copying task and the second, a more complex writing task. Since the time taken to complete our assessments was a major factor in this study, we decided not to use a lengthy standardised test of shape copying such as the Developmental Test of Visual-Motor Integration (Beery 1982), but simply to ask the child to copy three familiar shapes: a square, a diamond and a triangle. In the absence of a standardised test of handwriting, we asked the children to copy a simple sentence which included all the letters of the alphabet. For both tasks, highly experienced teachers rated the children's efforts.

While our studies were being conducted, a quite different attempt to replicate the findings of Laszlo and co-workers was reported in this journal (Polatajko et al. 1995). That study (discussed in detail below) failed to demonstrate any effects of kinaesthetic training on general motor performance in spite of improved kinaesthetic acuity.

Method
In the first and most important phase of our study, two groups of clumsy children were compared, one receiving kinaesthetic training (which we sometimes call 'Laszlo training' for the sake of brevity), the other acting as an untreated control group. In phase 2, the effectiveness of intervention for the group of children who had previously acted as controls was evaluated. This phase was included because the schools requested it and because the data might add to what we had already learned about the effectiveness of the treatment. Phase 3 was a follow-up investigation about 3 months after the end of phase 2.

Selection of Subjects
Children were selected sequentially in a series of assessments (henceforth called 'pretest scores'). First, classroom and/or head teachers from four primary schools in central London nominated subjects who they thought might have 'poor co-ordination for their age that was affecting their school-work'. The teachers nominated 33 such children (mean age 8 years 4 months; range 7 years 10 months to 10 years 1 month). Since their school medical records contained no evidence of illnesses or other conditions that might preclude their participation, all were entered into the next stage of the selection process.

At this point, our aims were (a) to confirm by objective testing that each participating child could be classified as clumsy and (b) to eliminate any child whose clumsiness was accompanied by a degree of intellectual retardation that might interfere with their ability to understand what was required during the intervention sessions. In the first instance, the objective assessment used was the TOMI, and the inclusion criterion adopted was a score at or below the 15th centile point (i.e. >3.5). In the second case, a verbal IQ of at least 70 on the short form of the WISC–R was the criterion for inclusion. On the basis of these two criteria, nine children were excluded (seven because of their TOMI scores and two because of their verbal IQ scores).

To determine whether the remaining 24 children with a motor impairment had poor kinaesthetic sensitivity, we first used the KST (Laszlo et al. 1988). Using the method of constant stimuli and criteria derived from the KST manual, 18 children failed on both components of the test and two failed on the kinaesthetic perception and memory component only; these 20 children were included in the final sample. The kinaesthetic acuity of these children was then re-assessed by PEST, since that was the method used for the remainder of this experiment. At this stage, all children also took two paper-and-pencil tests.

The 20 children in the final sample – 14 boys and six girls (mean age 8:10 years; range 8:0 to 9:11) – were then allocated on a pair-wise basis to two groups (A and B), with chronological age, sex, and PEST and TOMI scores used as criteria for matching. Assignment to groups within pairs was random. The two children who were within normal limits on the acuity component of the KST were treated as equivalent, with one assigned to group A and the other to group B (Table I).
### TABLE 1
Characteristics of children in groups A and B at pretest

<table>
<thead>
<tr>
<th></th>
<th>Group A (N=10)</th>
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<th>Group B (N=10)</th>
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<tr>
<td></td>
<td>Mean (SD)</td>
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<td>Mean (SD)</td>
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<tr>
<td>Age (yrs:mths)</td>
<td>8:11 (0:8)</td>
<td></td>
<td>8:9 (0:6)</td>
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<tr>
<td>Pretest scores</td>
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<tr>
<td>Verbal IQ (WISC-R)</td>
<td>88.2 (13.1)</td>
<td></td>
<td>86.6 (9.5)</td>
</tr>
<tr>
<td>Test of Motor Impairment</td>
<td>8.4 (3.6)</td>
<td></td>
<td>7.1 (2.6)</td>
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<td>Kinaesthetic Sensitivity Test</td>
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<tr>
<td>Kinaesthetic acuity</td>
<td></td>
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<tr>
<td>CS</td>
<td>18.5 (5.4)</td>
<td></td>
<td>18.5 (4.9)</td>
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<tr>
<td>PEST</td>
<td>12.2 (5.9)</td>
<td></td>
<td>11.5 (5.4)</td>
</tr>
<tr>
<td>Kinaesthetic perception and memory</td>
<td>77.9 (15.6)</td>
<td></td>
<td>78.6 (21.3)</td>
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</table>

CS = method of constant stimuli; PEST = method of parameter estimation by sequential testing. Age ranges; Group A 8:0–9:11, Group B 8:0–9:9.

### ASSESSMENT PROCEDURES AND PERFORMANCE MEASURES
All children were assessed individually in one of the four participating primary schools. The assessments were administered in a fixed order, and with only a few exceptions the total time taken for each child to complete all of the tests was 1 1/2 hours.

The verbal component of the short form of the WISC-R was used to select subjects at pretest. This consisted of the similarity and vocabulary subtests, which correlate with the full verbal form at \( r = 0.93 \) (Sattler 1974).

**Test of Motor Impairment**
The TOMI was used both to select subjects and to evaluate any change due to the intervention. The test evaluates manual dexterity, ball skills and balance, with difficulty levels increasing with age. Each item is scored on a three-point scale (0 to 2). The maximum total score is 16, with the higher scores indicating less motor competence. Extensive information on the validity and reliability of this test, now known as the Movement Assessment Battery for Children (Henderson and Sugden 1992), is presented in the manual for this test.

**Kinaesthetic Sensitivity Test**
The KST, also, was used for both selection and evaluation of subjects. The test's two components are designed one to evaluate kinaesthetic acuity and the other to evaluate kinaesthetic perception and memory. For the reasons given above, the kinaesthetic-acuity component of the test was administered in two different ways. So that we could compare our results with those of Laszlo et al. (1988), we first administered the test using the method of constant stimuli. This was done only once during the subject selection procedure. All subsequent tests adopted the psychophysical procedure, PEST, recommended by Elliott et al. (1988). The two components of the test and the ways of collecting data are outlined below.

**Kinaesthetic acuity.** The apparatus for measuring the accuracy of children's kinaesthetic perception of their own limb movement and position consists of two runways which can be independently set at angles between 0° and 20° from the horizontal. A masking box covers the child's arms to exclude vision. The child starts with the hands holding two pegs at the base of the runways. The experimenter then draws the child's hands up the slopes (in what Laszlo et al. [1985a] call 'passive movement'). The child's hands are then released and the child is required to indicate (usually by wiggling a finger on the chosen side) which of the two is the higher. Before the test, a check is made to ensure that the child understands the task and can perform the necessary discriminations visually. The variable manipulated is the difference between the heights of the two runways.

To measure kinaesthetic acuity by the method of constant stimuli, which is the method recommended in the KST manual, one of the two runways is always set at the standard angle of 12°. Systematic
variation of the other in steps of either 3° or 5° yields four pairs of angles, which are each presented eight times in random order. The 32 trials are administered with a break after the first 16. The child’s score is the total number of correct responses out of 32.

The other method used to measure kinaesthetic acuity was PEST. This procedure was first described by Taylor and Creelman (1967) and was refined by Penland (1980). The essential feature of the method is its closed-loop, adaptive nature. Unlike other psychophysical methods, in which the parameters are preset, in PEST a threshold is established on-line by progressively setting parameters on the basis of the subject’s success or failure. Thus on the present task a series of successful judgments at any one ramp separation would automatically lead to a reduction in the difference in height between the two ramps. Conversely, failure would lead to an increase. Success would then lead to a decrease, and so on. The first setting was always at 11° of difference. For example, if the child passed at 11°, then failed at 5°, passed at 8° and then at 6.5°, the final score would be \((5+6.5)/2 = 5.75\), rounded to 6. The number of trials at each setting is calculated from a formula given by Taylor and Creelman (1967).

Kinaesthetic perception and memory. In this component of the KST, the child’s task is to remember the orientation of a complex pattern. The apparatus consists of a series of perspex discs which can be mounted on a base and rotated. Cut into each disc is a curved, closed pattern forming a ‘nonsense’ shape. Around the stationary base is a scale against which the orientation of the patterns is measured in degrees. On each trial, the child’s hand is moved passively around the pattern for two circuits under the masking box. The child’s hand is then removed, and the experimenter alters the orientation of the pattern and removes the box. The subject then attempts to restore the pattern to its former position, with the aid of visual input. The child’s score on a trial is taken as the difference between the initial pattern orientation and the child’s estimate of it in degrees. The overall score is the mean of the error scores for all shapes.

**Graphic-production tasks — shape copying and handwriting**

For the shape-copying task, the children were required to copy a square, a diamond and a triangle, without the use of a ruler. In the handwriting task, they were asked to copy the sentence ‘The quick brown fox jumps over the lazy dog’ in their best handwriting. Independent adults, blind to the original classification of the children, were given the samples in pairs (e.g. the one produced before intervention with the one produced after intervention) and asked to decide whether they preferred either one, or saw ‘no difference’. In addition, a more detailed evaluation of the children’s handwriting was obtained in which overall tidiness, letter formation and word spacing were rated separately on a four-point scale.

**INTERVENTION SESSIONS**

**Phase 1**

Approximately a week after the pretesting and assignment to groups, the 10 children in group A began their kinaesthetic training, which took place over 10 school days in one of the schools. Children were seen individually every day, with each session lasting 20 to 25 minutes. Before the first training session, the children were told that the movement difficulties they experienced were due to the fact that they were having trouble ‘feeling’ their movements and that the training they were about to receive might help them with this problem. Following Laszlo’s suggestion, training on the kinaesthetic acuity and kinaesthetic perception and memory tasks alternated on successive days. During this phase, group-B children received no intervention and simply attended school in the normal way.

In Laszlo’s training method, the first session of acuity training begins with the angle of separation of the runways set at 20°. The child’s hands are guided up and down several times until a correct response is made. If the child finds the task too difficult even at this separation, the masking box is removed so that the child can see the difference in the heights of the two runways. Then the box is replaced and more trials are given until the criterion for success is achieved, i.e. four out of five correct choices without
visual cueing. The angle of separation is then reduced progressively in two-degree steps, the number of steps within a session depending on the progress made. Throughout the sessions, every effort was made to maintain the child’s interest and motivation to succeed. Therefore, each session began with easy trials and gradually progressed in small steps to more difficult trials to ensure that failure was minimised. Also, frequent positive feedback was provided. These were key features proposed by Laszlo and Bairstow (1985a).

For the kinaesthetic-perception-and memory-component of the training, the procedure suggested by Laszlo and Bairstow was followed exactly. This involves a progression from a simple straight line to more complex patterns. For the child who failed only the perception-and-memory task, the entire session was devoted to training in that task (as recommended by Laszlo and Bairstow 1985a).

After the children in group A had completed their 10 intervention sessions, all 20 children from groups A and B were given the first post-test. For 18 children, this comprised the KST (PEST version), the kinaesthetic-perception-and-memory test, the TOMI and the two graphic-production tasks. For the two children who had passed the kinaesthetic-acuity test initially, this component was omitted from the post-test.

Phase 2
Immediately after the end of phase 1, group B began their kinaesthetic training. Two children were unable to complete these sessions and had to be omitted from this phase. Once the remaining eight children in this group had completed their training, they were given the second post-test, and thus were tested again on the KST, the TOMI and the two graphic-production tasks.

Phase 3
Approximately 3 months after the end of training, children in both groups were retested on the TOMI and the two graphic-production tasks (follow-up data). Only seventeen children were available for these assessments: one had left school and two were absent. One further child refused to be tested on the TOMI, but completed the graphic tasks.

Results
Children’s performance on the acuity component of the KST was measured using two quite different psychophysical procedures, PEST and constant stimuli. Doyle et al. (1986) reported no correlation between the two in their ‘normal’ sample. In the present study, the correlation was 0.67 (N=20, p<0.001). All subsequent references to acuity concern PEST unless otherwise specified.

Pre-test scores - Adequacy of matching
Table 1 shows the means and standard deviations of the variables on which the two groups of children were matched. When subjected to appropriate statistical analyses, no differences between the groups were revealed on any of the tests (kinaesthetic acuity, F=0.08; perception and memory, F=0.01; TOMI, F=0.81; verbal IQ, F=0.11: all df(1,19) ns).

TREATMENT VS NO TREATMENT - ANALYSIS OF PHASE 1
Figure 1 shows the scores obtained by the two groups of children before (pretest) and after (post-test 1) group A had received training but group B had not. Both groups improved on all three measures – the two components of the KST and the TOMI.

For the two components (kinaesthetic-acuity and kinaesthetic-perception and memory) of the KST, two-way analyses of variance were applied, with 'group' as a between-subject variable and 'pre- and post-intervention' as a within-subject variable. For both components, these analyses revealed a main effect for pretest versus PT-1: acuity, F(1,16)=26.7, p<0.0001; perception and memory, F(1,18)=16.03, p<0.001), but no main effect of group and no interaction (acuity, F=3.23; perception and memory, F=0.56). However, the improvement on the perception and memory test was small in both groups, with the mean error dropping only from 75° to 65°.

Since the distribution of the TOMI difference scores (pre-test minus PT-1) was reasonably normal, we were able to use
Fig. 1. Phase 1, experiment 1: scores of clumsy children on tests of kinaesthetic sensitivity and motor performance at pretest and 2 weeks later (post-test), after kinaesthetic training (group A: 'Laszlo training'), and of untrained controls (group B). PEST = parameter estimation by sequential testing; TOMI = Test of Motor Impairment. Lowered scores denote improvement.

ANOVA on these scores too. The outcome of this analysis was very similar to that for the KST tests. A main effect was found $F(1,18)=24.47$, $p<0.001$ showing that TOMI improved significantly from pre-test to PT-1. There was no effect of group ($F=0.28$) and no interaction ($F=1.28$). Thus, while both groups improved their motor performance, there was no differential effect of the formal treatment programme. When the change in TOMI scores was analysed further, Wilcoxon's signed ranks tests revealed that the largest amount of improvement was in balance ($z=2.5$, $p<0.05$). The changes in ball skills and balance did not reach statistical significance.

On the shape-copying task, all judges favoured more post-test than pre-test samples, the ratios of pretest to post-test samples preferred being 2 to 6 for group A (with 2 samples judged the same) and 4 to 6 for group B. However, this effect was not significant. For handwriting, the overall preference judgements slightly favoured the pre-test samples (6 to 3 for group A and 6 to 4 for group B) but again this effect was not statistically significant. Similarly, the more specific handwriting ratings gave an unclear picture. After summing the children's specific scores across all judges to give a composite score, there was a 1 to 7 advantage for the post-test 1 sample for group A ($p=0.04$ on a binomial test) but no difference for group B.

**INTERVENTION FOR GROUP B — ANALYSIS OF PHASE 2**

The scores on post-test 2 for group B, achieved after kinaesthetic training for this group, show that intervention further improved this group's scores on both kinaesthetic tasks (Fig. 2, top and middle); only the improvement in acuity reached statistical significance ($F(1,6)=7.54$, $p<0.05$). However, there was no further improvement in this phase on the TOMI (Fig. 2, bottom).

On the shape-copying and handwriting tasks, none of the analyses performed showed significant effects, and groups A and B did not differ from each other at this point.

When the present study began, we had no normative data for PEST against which to compare the children in this study. Recently, such data have been collected (Sims and Morton, unpublished), and we have been able to compare the performance of our clumsy children on PEST with a randomly selected sample of children. At the outset of this study, 50% of the clumsy sample had scores which placed them below the 25th centile. After completing the programme of
testing/training, only two children remained in that category.

DO THE EFFECTS PERSIST? — ANALYSIS OF PHASE 3

At follow-up about three months after the end of phase 2, the mean total TOMI score for group A was 3.5 and for group B, 4.4. Taking both subject groups together, this further decrease was statistically significant (Wilcoxon N=16, z=-2.24, p<0.05). Immediately after intervention, improvement was largely confined to balance. In contrast, the phase-3 assessment revealed significant progress in all three sections of the test: (manual dexterity, z=-3.52, p<0.0005; ball skills, z=-2.09, p<0.05; balance, z=-2.93, p<0.005). Nevertheless, while half our subjects had now progressed above the 20th centile on the test, for some children, improvements were still not large enough to place them at the same motor level as their well co-ordinated peers.

For the graphic-production tasks, we had a total of 17 samples. At this stage the picture was much clearer. Overall, the raters judged the follow-up samples to be better than the originals for both tasks, with a ratio of 3 to 11 (binomial, p=0.06) for shape copying and 1 to 13 (p=0.001) for handwriting, with the remaining samples being judged as ‘no different’. On the more specific ratings, it was the ‘tidiness’ judgements that differentiated the samples most clearly (p=0.019), there being no significant effects for spacing or form.

Discussion

As this study unfolded, it became clear that some aspect of the children’s experience was undoubtedly causing improvements in performance. Our primary finding was that for both the kinaesthetic subtests, as well as for the TOMI, the largest and most robust improvement was found between pretest and post-test 1, whether or not formal training had been received. The only differences observed between the groups was the magnitude of the improvement on kinaesthetic acuity, in which group A had been specifically trained. On the test of kinaesthetic perception and memory, and on TOMI, there were no differences between the two groups in the amount of improvement.

These results are unusual in a number of ways, the most striking being that the improvements on the TOMI made by our trained subjects could not be distinguished from the improvements made by our untrained controls. Although this failure to find a difference between the groups could have been due to a lack of statistical power resulting from our rather small sample size, what is more important is that both groups improved significantly as opposed to staying the same. Given that attempts to treat clumsiness in the past have been somewhat
unsuccessful, we are now in the perplexing position of having to explain how a group of children withheld from a formal training programme might make motor advances. Before addressing this question directly, however, we will compare our study with the recent Canadian study by Polatajko et al. (1995), which not only shares our focus on the Laszlo training but is also one of the few studies in this field with sufficient detail on subject selection and measures of outcome.

Polatajko and co-workers did not find any effects of Laszlo training on motor performance. Curiously, however, they did not administer the TOMI immediately after training, thus reducing the possibility of detecting an immediate effect. All that can be safely concluded from their study, therefore, is that any effectiveness of the Laszlo training had dissipated by the time the children were reassessed on TOMI (other measures peculiar to the Canadian study indicated some immediate improvement confined to children trained by the Laszlo method).

Another possibility is that the children participating in the three studies (Laszlo and co-workers', Polatajko and co-workers', and our own) were different in some way. The authors of the Canadian study themselves suggested this, pointing out that they selected their sample from hospital clinics, whereas Laszlo and co-workers, like us, recruited their sample through mainstream schools in London. However, when we consider (a) that the mean TOMI score of the group given Laszlo training in the study by Polatajko and co-workers was very close to the mean score for our own group (9.0 and 7.8, respectively) and (b) that the range of age and IQ for the groups was also comparable, then it seems unlikely that differences in sample characteristics produced the discrepancies in outcome.

Another factor that seems to deserve more serious consideration than the foregoing, however, is the apparent failure of Polatajko and co-workers to establish that all of their subjects actually had impaired kinaesthetic sensitivity. Given that Laszlo and co-workers suggest that 25% of children with movement difficulties do not have this problem, it is possible that the Canadians' failure to obtain more generalised motor improvements was due to a ceiling effect in kinaesthetic sensitivity in their sample. In the design of our study, we followed Laszlo's recommended selection procedure of pursuing only those subjects who scored at chance or below on the KST.

Other differences between the various studies might be worth noting. First, during training, Polatajko and co-workers asked subjects to close their eyes, while we followed Laszlo's recommended procedure of using a masking box to shield the child's view of the ramps. Whether this apparently minor variation in procedure could affect the difficulty of the task in some way requires investigation. Finally, there were differences in the way the training was distributed over time. While the overall amount of training in both our own study and the original was meagre, it was highly concentrated. Polatajko and co-workers' deviation from Laszlo's day-by-day training programme, in order to follow the more usual clinical practice of seeing children 2 to 3 times a week, raises the possibility that concentration is important. However, since Schoemaker et al. (1994) did succeed in obtaining improvement using a conventional therapy with similar dilution, concentration alone seems unlikely to be crucial.

By comparing Laszlo's original study (Laszlo et al. 1988), the Canadian study and our own attempt to replicate the findings of Laszlo and co-workers, we had hoped to throw light upon the differences in outcome among the three studies. Instead, we seem to have identified a number of minor procedural differences, none of which appears to be sufficient to account for the Canadian study's failure to find any effect of KST training on motor competence.

We now turn to the question of how our own results can be reconciled with the finding of Laszlo and co-workers that performance improved only after training. The most obvious difference between their study and ours is our deviation from Laszlo and Bairstow's recommended test procedure for determining kinaesthetic acuity. Since their procedure had been the target of sustained criticism in the literature, we substituted a version
of PEST. Aware though we were of Bairstow and Laszlo's (1988) admonition that PEST might constitute a form of training, nothing had prepared us for the possibility that it might be so effective as to occlude any effect of the formal training programme.

If the critical difference between these studies is truly the fact that PEST functioned incidentally as a training procedure, then our data force the conclusion that simply using this technique to determine the limits of discriminability will improve general motor skill. It is not obvious what features of PEST might be responsible. A possible reason could lie in after-effects of the kinaesthetic feedback given by the procedure, particularly as this was the only feedback available to these subjects. This is consistent with Sims and Morton's (unpublished) finding from another study, which showed that a high proportion of normal children improve in kinaesthetic acuity during the PEST procedure itself.

We have seen that PEST and the Laszlo training programme had equivalent effects on TOMI in the first phase of the experiment. What of phase 2, when the children in group B were given the Laszlo training? There were further improvements in both of the kinaesthetic tests, as might have been expected, but no further improvement in TOMI. This could not be because these children had no further improvements to make, since many of our subjects achieved scores even at follow-up that fell far short of that attainable by age peers. We can only assume that the children had reached a local maximum.

At follow-up, we were still able to detect changes in the children's motor performance. Whereas the significant improvements on TOMI at post-test 1 were confined to balance, at post-test 2 the children had also improved their manual dexterity and ball skills. On the graphic production tasks, our findings were similar to those obtained by Laszlo and co-workers. Immediately after training, the children's shape copying did not improve significantly and our handwriting data were inconclusive. At follow-up, however, evidence of improvement in both tasks was much clearer. Features common to those tasks which exhibited this delayed effect are that they are formally taught and/or appear to require a number of complex strategies for their performance. Laszlo's explanation of these delayed effects is that the competencies engendered by the training programme require further elaboration for the acquisition of these more complex skills (Laszlo and Bairstow 1985b). However, before drawing any firm conclusions about our findings, we need to make sure that such delayed effects can be replicated.

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Authors' Appointments
*Dr Kerry M Sims, MRC Cognitive Development Unit, 4 Taviton Street, London WC1H OBT, UK: Prof. John Morton, Director, MRC Cognitive Development Unit: Visiting Professor, Department of Psychology, University College, London; Dr Sheila E Henderson, Reader, Institute of Education, London; Prof. Charles Hulme, Department of Psychology, University of York.

* Correspondence to first author.

SUMMARY
The effectiveness of a kinaesthetic training programme proposed by Laszlo for children with movement difficulties was evaluated by comparing two groups of 10 'clumsy' children matched pairwise on age, IQ and sex as well as degree of kinaesthetic and motor impairment. Tests of kinaesthetic ability, using the Parameter Estimation by Sequential Testing (PEST) procedure, and motor competence administered before and after treatment revealed an improvement in both groups on all measures but no differential effect of the training programme. Immediately after training, the changes we obtained in motor performance were confined to balance skills but, at follow up, 3 months later, changes in manual and ball skills were also evident. This unusual pattern of change
requires replication. Our findings forced us to consider the possibility that any effect of Laszlo's recommended training programme had been obscured by our use of the PEST procedure, which had in itself facilitated motor learning.

Résumé
La correction de la maladresse. 1. Une évaluation de l'approche kinesthésique de Laszlo
L'efficacité d'un programme d'apprentissage proposé par Laszlo pour les enfants ayant des troubles moteurs a été évaluée en comparant deux groupes d'enfants maladroits appariés par paire pour l'âge, le Q.I. et le sexe aussi bien que pour le degré de trouble moteur et de difficultés kinesthésiques. Des tests d'aptitude kinesthésique utilisant le procédé du Parameter Estimation by Sequential Testing (PEST), et ceux de compétence motrice administrés avant et après le traitement prouvèrent un progrès dans les deux groupes mais sans effet différent dans le groupe avec programme d'apprentissage. Immédiatement après l'apprentissage, le bénéfice obtenu en performance motrice était limité aux fonctions d'équilibre mais au suivi, 3 mois plus tard, un progrès évident s'étendait au geste et au maniement d'une balle. Cette distribution inhabituelle des modifications demande à être reproduite. Nos données nous oblige à envisager la possibilité que certains effets du programme d'entraînement recommandé par Laszlo aient été masqués par l'emploi du PEST qui, par lui-même aurait eu un effet de facilitation de l'apprentissage moteur.

Zusammenfassung
Behandlung bei Unbeholfenheit - I: Beurteilung des kinaesthetischen Konzeptes nach Laszlo

Resumen
La mejora de la torpeza: I Evaluación de la aproximación cinestésica de Laszlo
La eficacia de un programa de entrenamiento cinestésico propuesto por Laszlo para niños con dificultades del movimiento, fue evaluada comparando dos grupos de 10 niños 'torpes' de la misma edad, CI, sexo, grado de alteración cinestésica y motora. Los test de habilidad cinestésica utilizando el modelo de Estimación Paramétrica por Pruebas Secuenciales (PEST en inglés), y la competencia motora, administrados antes y después del tratamiento, revelaron una mejora en ambos grupos en todas las mediciones, pero ningún efecto diferencial en el programa de entrenamiento. Inmediatamente después del entrenamiento, los cambios obtenidos en la realización motora se reducían al equilibrio, pero 3 meses más tarde eran también evidentes en las habilidades manuales y con la pelota. Este patrón inusual de cambios requiere una replicación. Estos hallazgos nos obligaron a considerar la posibilidad de que cualquier efecto del programa Laszlo había quedado obscurecido por la utilización del EPPS, que por si mismo había facilitado el aprendizaje motor.

References


