A Novel Video Game–Based Device for Measuring Stepping Performance and Fall Risk in Older People

Daniel Schoene, MSc, Stephen R. Lord, DSc, Paulien Verhoef, Stuart T. Smith, PhD


Objective: To determine whether a dance mat test of choice stepping reaction time (CSRT) is reliable and can detect differences in fall risk in older adults.

Design: Randomized order, crossover comparison.

Setting: Balance laboratory, medical research institute, and retirement village.

Participants: Older (mean age, 78.87±5.90y; range, 65–90y) independent-living people (N=47) able to walk in place without assistance.

Interventions: Not applicable.

Main Outcome Measures: Reaction (RT), movement, and response times of dance pad–based stepping tests, Physiological Profile Assessment (PPA) score, Digit Symbol Substitution Test (DSST) score, time to complete the Trail Making Test (TMT) A+B, Fall Efficacy Scale International (FES-I) score, Activities-specific Balance Confidence (ABC) Scale score, and Incidental and Planned Exercise Questionnaire (IPEQ) incidental IPEQ activity subscore.

Results: Test-retest reliability of the dance mat CSRT response time was high (intraclass correlation coefficient model 3,k=.90; 95% confidence interval [CI], .82–.94; P<.001) and correlated highly with the existing laboratory-based measure (r=.86; 95% CI, .75–.92; P<.001). Concurrent validity was shown by significant correlations between response time and measures of fall risk (PPA: r=.42; 95% CI, .15–.63; P<.01; TMT A: r=.61; 95% CI, .39–.77; TMT B: r=.55; 95% CI, .31–.72; DSST: r=.53; 95% CI, .71 to .28; P=.001; FES-I: Spearman ρ=.50; 95% CI, .25–.69; ABC Scale: Spearman ρ=.58; 95% CI, −.74 to −.35; P<.01). Participants with moderate/high fall-risk scores (PPA score >1) had significantly slower response times than people with low/mild fall-risk scores (PPA score <1) at 1146±182 and 1010±132ms, respectively (P=.005), and multiple fallers and single/nonfallers showed significant differences in RT (883±137 vs 770±100ms; P=.009) and response time (1180±195 vs 1031±145ms; P=.017).

Conclusions: The new dance mat device is a valid and reliable tool for assessing stepping ability and fall risk in older community-dwelling people. Because it is highly portable, it can be used in clinic settings and the homes of older people as both an assessment and training device.

Key Words: Accidental falls; Aged; Reaction time; Rehabilitation.

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THE ABILITY TO MAKE well-timed and appropriately directed responses to events surrounding us underpins our ability to successfully interact with our environment.1 Stepping, changing the base of support relative to our center of mass, provides the means by which we are able to avoid obstacles and counter such potentially destabilizing events as slips, trips, and missteps and therefore helps avoid falls. Protective stepping may be initiated volitionally when a threat to balance is perceived or induced reflexively when a disturbance moves the center of mass relative to the base of support at a speed that prevents engagement of volitional strategies.2 A number of studies suggest that both volitional and induced stepping abilities are significantly impaired in older individuals and significantly associated with fall risk.3 Older adults, particularly those with a history of falling, tend to be slower in initiating volitional step responses,4 make inappropriately directed or multiple short steps in response to an external perturbation of balance,5 and have an increased chance of collision between the swing and stance legs during compensatory stepping.6 Several stepping tests exist that discriminate between fallers and nonfallers,4,7,11 with limited evidence that cognitive load is needed.8 The choice stepping reaction time (CSRT) task has been better to discriminate between fallers and nonfallers than other sensorimotor and balance measures4 and to predict falls in older people, mediated through physiologic and cognitive pathways.12 Reaction time (RT) can be affected significantly

List of Abbreviations

| ABC | Activities-specific Balance Confidence |
| CI | confidence interval |
| CSRT | choice stepping reaction time |
| DSST | Digit Symbol Substitution Test |
| FES-I | Falls Efficacy Scale International |
| FOF | fear of falling |
| ICC | intraclass correlation coefficient |
| ICC3,k | intraclass correlation coefficient model 3,k |
| IPEQ | Incidental and Planned Exercise Questionnaire |
| LAB | laboratory-based measure of CSRT |
| MAT | dance mat measure of CSRT |
| MT | movement time |
| PPA | Physiological Profile Assessment |
| RT | reaction time |
| TMT | Trail Making Test |

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by cognitively demanding tasks and age-related deterioration in
information processing. Choice RT tasks, in which 2 or
more alternatives are presented to participants, have
been used to investigate age-related changes in responses that require
complex fast information processing, such as the generation of fast volitional stepping to avoid a fall.

However, these tests require the use of relatively fixed and
specialized laboratory equipment. This article reports the develop-
ment of a portable computer-based version of the CSRT
test using a dance mat input device for video games. The dance mat
approach has several advantages over current laboratory-based
instruments for measuring step reaction time. It is low
cost, can be administered at any location, and test duration is
less than 5 minutes. Moreover, it enables individuals to assess
their own performance and therefore is an example of tele-
health technology that opens the opportunity to deliver health
care to regional, rural, or remote areas and track performance
changes over time. Furthermore, as a computer game device, it
also offers a potentially effective approach for preventing falls
in independent-living older adults by engaging them in repet-
tive stepping exercise.

The primary aims of this study were to (1) determine the
test-retest reliability of the new dance mat measure of CSRT
(MAT), (2) assess the convergent validity against the estab-
lished laboratory-based measure of CSRT (LAB) device, and
(3) establish the concurrent validity of the CSRT test by its
associations with and discriminative ability on a range of
physiologic, cognitive, psychological, and health-related mea-
sures of fall risk, as well as retrospective falls.

METHODS

Participants

A convenience sample of 47 independent-living older people
(mean age, 78.87 ± 5.90y) participated in this study. Participants consisted of attendees of community talks and residents
of a retirement village. Eligibility criteria were 65 years and
older, able to walk in place without assistance (even if walking aids normally were used for ambulation), living in the com-

Table 1: Study Population Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (y) ± SD</td>
<td>78.87 ± 5.90</td>
</tr>
<tr>
<td>Age range</td>
<td>65–90</td>
</tr>
<tr>
<td>Women (%)</td>
<td>55</td>
</tr>
<tr>
<td>Fallen past year (%)</td>
<td>35</td>
</tr>
<tr>
<td>Multiple fallers (%)</td>
<td>50</td>
</tr>
<tr>
<td>Walking aids (%)</td>
<td>13</td>
</tr>
<tr>
<td>No. of chronic diseases (minimum–maximum)</td>
<td>2.78 (0–6)</td>
</tr>
<tr>
<td>People with pain (%)</td>
<td>28</td>
</tr>
<tr>
<td>PPA score</td>
<td>0.62 ± 0.89</td>
</tr>
<tr>
<td>FES-I score</td>
<td>24.28 ± 19.98</td>
</tr>
<tr>
<td>ABC Scale score</td>
<td>77.04 ± 23.10</td>
</tr>
<tr>
<td>Incidental activity score</td>
<td>26.52 ± 14.88</td>
</tr>
<tr>
<td>DSST score*</td>
<td>52.43 ± 12.76</td>
</tr>
<tr>
<td>TMT A score*</td>
<td>44.79 ± 14.81</td>
</tr>
<tr>
<td>TMT B score*</td>
<td>118.69 ± 54.62</td>
</tr>
</tbody>
</table>

NOTE. N = 47. Values expressed as mean ± SD (range) or % unless noted otherwise.

Outcome Measures

CSRT outcome measures. For both MAT and LAB, the respective software programs recorded (in milliseconds) step
RT, time between stimulus presentation and liftoff of either the left or right foot from the central stance panels; movement time
(MT), time between foot liftoff and touchdown on a panel; response time, the sum of RT and MT. In addition, the exper-
imenter categorized (yes/no) stepping strategies of participants as “weight shifters” and “eye movers.” Weight shifters visibly
transferred their center of mass over the stepping foot in most
trials, whereas non–weight shifters executed mostly tapping
step responses. Eye movers made multiple eye movements
between the screen and mat during most trials. Non–eye mov-
ers made few, if any, such eye movements and instead looked
mainly at the display screen.

Physical, psychological, and cognitive measures of fall
risk. Physical fall risk was assessed by using the Physiologic-
al Profile Assessment (PPA), a test battery that predicts the
risk for multiple falls in community-dwelling older people with
75% accuracy. The PPA consists of 5 tests of sensorimotor

The laboratory CSRT device consisted of a wooden platform (84 × 74 cm) that contained
6 rectangular panels (30 × 15 cm), 2 stance panels, 1 stepping panel in front of each foot, and 1 stepping panel to the side of
each foot (fig 1B). One stepping panel for each trial was illuminated and participants were instructed to step onto this
panel as quickly as possible. The previously reported intraclass correlation coefficient (ICC) for test-retest reliability of this
device in a similar sample of community-dwelling older people was .84 (95% confidence interval [CI], .69–.93).

The University of New South Wales Human Research Ethics
Committee.

Test Description and Administration

Dance mat measure of CSRT. A custom-made dance mat
choice reaction time device, measuring 150 × 90 cm, contained
12 step panels, of which 6 were used for this test: 2 central
stance panels, 2 front panels, 1 left panel, and 1 right panel (fig
1A). An image was printed on each panel; left and right cartoon
feet on the central panels and directional arrows on the other
panels. The mat and a liquid crystal display monitor (reso-

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functions, including contrast sensitivity, simple hand RT, sway on a foam as measure of balance, joint position sense as a measure of peripheral sensation, and knee extension strength. A weighted $z$-transformed overall score is computed from these 5 tests, with higher scores indicating higher fall risk. 19

Psychological measures were fear of falling (FOF) and falls-related self-efficacy. FOF was assessed by using the Falls Efficacy Scale International (FES-I),20 and falls-related self-efficacy, by using the Activities-specific Balance Confidence (ABC) Scale.21 Both questionnaires consist of 16 items and have excellent psychometric properties.20,21 To assess the amount of physical activity, we used the Incidental and Planned Exercise Questionnaire (IPEQ), which measures activity levels relating to both basic and more demanding activities and has excellent psychometric properties.22

To evaluate cognitive performance, the Digit Symbol Substitution Test (DSST) and Trail Making Test (TMT) were chosen. Both tests are very sensitive to changes in cognitive function during aging and have good to excellent measurement properties.23 The DSST assesses attention, response speed, visuomotor coordination, and incidental memory. The number of correct marks after 120 seconds was counted. The TMT as a test of cognitive processing and executive functioning evaluates scanning, visuomotor tracking, divided attention, and cognitive flexibility. The TMT consists of 2 parts; A and B. Time in seconds to complete the test was measured. Participants who could not complete the TMT B in 5 minutes were assigned a time of 300 seconds.24 We also computed the difference in execution time between TMT B and TMT A because it is much less dependent on individual differences in visuomotor speed and gives a good estimate of executive function.23

Finally, people were asked whether they experienced falls in the 12 months before the assessment. Participants were classified as either multiple fallers or single/nonfallers. Because 1 fall during a 12-month period may be due to chance rather than reflecting a true increased fall risk, we put single and nonfallers in 1 group for analysis.

Procedure
Testing was performed on 2 occasions in a laboratory at Neuroscience Research Australia or in the gymnasium of a retirement village. To minimize some of the potential threats to repeated measurements of CSRT, all tests were performed on each participant at the same location and time for each test occasion. On the first occasion, participants were given questionnaires relating to demographic, health, activity, and fall-related information and underwent cognitive ability tests. Thereafter, stepping performance was measured using MAT and LAB in randomized order. After completion of the stepping tests, the PPA was conducted. On the second occasion (7.03±0.97d after the first), participants returned all questionnaires and completed the dance mat stepping tests for computation of test-retest reliability.

Data Analysis
The mean value of the 5 repeats for each mat panel was computed for each of the 3 time variables (RT, MT, and response time). Shapiro-Wilk test was used to assess the dis-
tributions of timing variables. A 2-way mixed-effects average-measure ICC model (intraclass correlation coefficient model 3,k [ICC3,k]) was used to assess test-retest reliability,25 which was rated poor (<.40), fair to good (.40–.75), and excellent (>0.75).26 Convergent validity was determined by using Bland-Altman plots and assessing correlation coefficients between MAT and LAB.27 Concurrent validity was assessed by investigating the ability of the CSRT test to distinguish between subgroups with different risk profiles. Pearson/Spearman rank correlation coefficients and Student t tests/Mann-Whitney U tests were used for normally/non–normally distributed data. Type I error rate was set to 5%, and 95% CIs were computed for all parameters. Processing and analysis of data were conducted using Matlab Version 7.10d and PASW Version 18 for Windows.9

RESULTS

Log-transformed time-based measures of CSRT and other outcome measures with the exception of psychological self-reports were normally distributed (Wilk-Shapiro normal test <.05). Test-retest results are listed in table 2. ICCs for the MAT were excellent, with parameters ranging from .86 to .91 (P<.001).

Figure 2 shows Bland-Altman plots for RT and MT for LAB versus MAT. Although almost all values were between the limits of agreement, there was a systematic shift to slower RT and faster MT for MAT. On average, participants needed 175 milliseconds longer for the MAT test compared with the LAB test. Pearson correlation coefficients comparing times between LAB and MAT were excellent (table 3).

With the exception of physical activity (Pearson r = −.28; 95% CI, −.04 to 0.53; P=.054), all fall-risk measures showed significant associations with the MAT test of moderate size (table 4). Age was a discriminator of step performance, with people 80 years and older having slower RTs (824±119ms) and response times (1103±167ms) than people younger than 80 years (753±97ms; P=.030; 1008±145ms; P=.046, respectively). Furthermore, the MAT was able to discriminate between people with different levels of fall risk. Comparisons between multiple fallers and single/nonfallers showed significant differences in RTs (883±137 vs 770±100ms; P=.009) and response times (1180±195 vs 1031±145ms; P=.017), but not MTs. People with moderate/high (PPA score >1) and low/mild fall-risk scores (PPA score <1) also were significantly different in response times (1146±182 vs 1010±132ms; P=.005).

Weight transfer and eye movements toward the mat significantly influenced performance (table 5). Participants who transferred their body weight while stepping had longer MTs (281±61ms) than those who did not transfer their gaze (243±67ms; P=.048). People who looked from the screen to the mat before or while they were stepping also had longer RTs and MTs (865±138ms; P=.042; 320±71ms; P=.046) compared with participants who did not transfer their gaze (774±104ms; P=.040; 257±67ms; P=.046). The group of participants who transferred their gaze also showed trends to poorer scores on cognitive tests (DSST, P=.068; TMT A, P=.057; TMT B, P=.026; TMT A−TMT B, P=.079).

DISCUSSION

This study shows that the dance mat step timing device provides a satisfactorily reliable measurement of CSRT in community-dwelling older people. Correlations between the old and new measure were high, but did not agree completely,

Table 2: Reliability - ICCs for Stepping Test Within 1 Week

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Outcome</th>
<th>ICC (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT</td>
<td>RT</td>
<td>.86 (.75–.92)</td>
</tr>
<tr>
<td></td>
<td>MT</td>
<td>.91 (.84–.95)</td>
</tr>
<tr>
<td></td>
<td>Response time</td>
<td>.90 (.82–.94)</td>
</tr>
</tbody>
</table>

*All P<.001.

Table 3: Validity - Correlation Coefficients for Stepping Tests

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Outcome</th>
<th>Correlation (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAB−MAT</td>
<td>RT</td>
<td>.81 (.69–.89)</td>
</tr>
<tr>
<td></td>
<td>MT</td>
<td>.82 (.70–.90)</td>
</tr>
<tr>
<td></td>
<td>Response time</td>
<td>.86 (.75–.92)</td>
</tr>
</tbody>
</table>

*All P<.001.

NOTE. N=47.

Fig 2. Bland-Altman plots representing comparisons between LAB and our MAT. (A) RT for LAB-MAT, (B) MT for LAB-MAT. In each plot, the mean line represents the mean difference between any 2 measures, with upper and lower lines representing the limits of agreement (2SD).
as shown in the Bland-Altman plot, indicating a new measure of CSRT that is cognitively more demanding. Furthermore, the MAT test correlated moderately with a range of fall-risk measures. Adults older than 80 years recorded slower times than those 80 years and younger, and multiple fallers recorded slower times (~150ms slower in their response time, 110ms of which was in RT) than non–multiple fallers, differences that likely reflect perceptual and cognitive impairments.

The data presented show that RT for the MAT was significantly longer than for the LAB. It is likely that this difference may be accounted for by extra processing time required to translate from the spatial coordinates of the display screen, where the stimulus was presented to the spatial coordinates of the mat on which the response was executed. However, in the case of the LAB task, the spatial location of stimulus appearance and response execution was coincident; both were under the feet of the participant. It is well known that spatial coordinate frame transformations introduce significant processing latencies in object recognition tasks, and as such, a cost in step RT may result from sensorimotor transformations involved in dance mat CSRT tasks.

It was also observed that MT was faster for the MAT compared to the LAB device. The LAB consisted of a wooden frame in which the plastic switch plates were built. Each switch plate on the laboratory device was separated from the others by small raised edges, which may have caused participants to be more cautious in making their steps to avoid a possible trip on the edges of switch and frame. However, for the dance mat device, all step-sensitive panels were contained within a single smooth flat surface, and participants may have felt more confident to step faster on the even 1-piece structure of the mat.

Correlations between cognitive measures and the dance mat step timing measures were moderate. People who transferred their gaze needed more time to step onto the correct panel and had trends to poorer performance in cognitive tests. These results are consistent with other studies reporting that compared with single/nonfallers, multiple fallers performed worse on a number of cognitive measures, including choice RT, executive function, and visual attention, compared with single/nonfallers, indicating a general cognitive decline in recurrent fallers. Cognitive function also has been predictive for future falls in community-dwelling old people, and cognitive impairment and dementia are known risk factors for falls. Visuospatial processing introduces a greater challenge for posture tasks than nonspatial tasks. Translation of task-relevant perceptual information from screen-based to dance mat–based frames of reference therefore may provide a technique by which impairments in visuospatial processing can be measured.

The MAT presented here correlated significantly with measures of sensorimotor function assessed by using the PPA, an instrument shown to predict the risk for multiple falls in community-dwelling old people with 75% accuracy. The response time of the MAT test correlated moderately with knee extension strength, balance control measured by using postural sway, contrast sensitivity, and simple RT, all independent risk factors for falls. These measures also are likely to reflect underlying processes involved in the generation of protective stepping responses because they represent perceptual encoding of the environment, information processing, and response generation. This therefore suggests the possibility that CSRT performance measured by using the dance mat system may provide a proxy measure of fall-risk.

In addition, this study also investigated the relationship with psychological processes and self-reported levels of physical activity related to the incidence of falls in older people. It was found that the measures of FOF and falls efficacy are associated with previous and prospective falls. Falls efficacy is associated with objective measures of physical fall risk, such as balance and strength, and moreover, concerns about falling elicit greater gait adjustments under conditions of postural threat.

**Table 4: Validity - Correlation Coefficients (95% CI) for RT for MAT and Fall-Risk Measures**

<table>
<thead>
<tr>
<th>Physical Fall Risk (PPA)*</th>
<th>Cognition†</th>
<th>FOF‡</th>
<th>Physical Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall score</td>
<td>DSST</td>
<td>FES-I</td>
<td>IPEQ.</td>
</tr>
<tr>
<td>.42 (.15 to .63)</td>
<td>-.53 (-.71 to -.28)</td>
<td>.50 (.25 to .69)</td>
<td>-.28 (-.53 to .004)</td>
</tr>
<tr>
<td>R²=.17.4%</td>
<td>R²=.28.1%</td>
<td>R²=.24.9%</td>
<td>R²=.8%</td>
</tr>
<tr>
<td>Knee extension</td>
<td>TMT A</td>
<td>ABC Scale</td>
<td></td>
</tr>
<tr>
<td>-.48 (-.67 to -.22)</td>
<td>.61 (.39 to .77)</td>
<td>-.58 (-.74 to -.35)</td>
<td></td>
</tr>
<tr>
<td>R²=.23.0%</td>
<td>R²=.37.6%</td>
<td>R²=.33.2%</td>
<td></td>
</tr>
<tr>
<td>Sway</td>
<td>TMT B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-.38 (.10 to .60)</td>
<td>.55 (.31 to .72)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R²=.14.4%</td>
<td>R²=.30.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contrast sensitivity</td>
<td>TMT B−A*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-.39 (-.61 to -.12)</td>
<td>.46 (.20 to .66)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R²=.15.2%</td>
<td>R²=.21.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand RT†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.34 (.06 to .57)</td>
<td>R²=.11.6%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE.** R² is coefficient of determination. *P<.01; †P<.001; ‡N=46; †P<.05.

**Table 5: RTs for MAT and Subgroups**

<table>
<thead>
<tr>
<th>Group or Subgroup</th>
<th>Mean ± SD RTs (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall mean (n=47)</td>
<td>1056±162</td>
</tr>
<tr>
<td>Age ≥80y (n=24)</td>
<td>1102±167*</td>
</tr>
<tr>
<td>Multiple fallers (n=8)</td>
<td>1179±194*</td>
</tr>
<tr>
<td>PPA score ≥1 (n=16)</td>
<td>1145±181*</td>
</tr>
<tr>
<td>Watch mat (n=8)</td>
<td>1184±186*</td>
</tr>
<tr>
<td>Transfer mat (n=21)</td>
<td>1083±158*</td>
</tr>
</tbody>
</table>

*Significantly different from overall mean value (P<.05).
activity, measured by using the incidental activity subscore of the IPEQ, and step timing. The relationship between activity level and fall risk generally is held to be U shaped, with very active and very inactive people at a higher risk than those who participate in moderate levels of activity. More active and therefore fitter people are likely to show better performances in tests of physical and cognitive ability. Although correlation between IPEQ scores and MAT was low, the data suggest that people who self-report higher levels of physical activity performed better on the MAT.

Study Limitations
This study has several limitations. First, although sample size was sufficiently powered to show the validity and stability of measurement of the dance mat system, some comparisons showed only trends toward statistical significance with wide CIs (eg, physical activity and overall step response time, \( r = -0.28; 95\% CI, -0.04 \) to 0.53; \( P = 0.054 \)). In an extension to the present study, these issues will be investigated in a larger random (rather than convenience) sample. Second, the study was performed in 2 different testing locations; a laboratory-based environment and a general-purpose hall in a retirement facility. Any factors that change error variance across testing occasions or testing location have implications for reporting of the stability of measurements over time. Third, it is acknowledged that this study was conducted in a nonrandom sample of independently living adults 65 years and older without serious cognitive impairment. As a consequence, conclusions drawn from the results are limited to this population. Finally, a computer is required for this test and it has yet to be shown that older people can perform it by themselves.

CONCLUSIONS
This study reports on a new MAT as a proxy of fall risk that is satisfactorily valid and reliable in a population of independently living older adults without severe cognitive and physical impairment. The system offers a safe, low-cost, portable, easy-to-use measure of CSRT in clinical settings and homes of older people to determine fall risk and monitor long-term changes. To improve the measure, future research should address how well the validity and reliability of this device generalizes to a wider range of older adults and outcome measures (eg, tests of mobility and daily function).

Acknowledgments: We thank Jamie Lennox and Thomas Davies for software programming and Ulrike Bruns for assisting with the figures.

References

Suppliers
a. Falls and Balance Research Group, Neuroscience Research Australia, Hospital Rd, Randwick NSW 2031, Australia.
b. Microsoft Corp, One Microsoft Way, Redmond, WA 98052-6399.
c. Python Software Foundation, PO Box 37, Wolfeboro Falls, NH 03896-0037.
d. The Mathworks Inc, 3 Apple Hill Dr, Natick, MA 01760-2098.
e. SPSS Inc, 233 Wacker Dr, 11th Fl, Chicago, IL 60606.