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Sound isolation provided by shading screens applied in façades

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In most European countries, legislation exists about airborne sound insulation in dwellings, including facades. Mainly in southern Europeans countries, the glazed windows of building facades normally have shading systems to minimize the excessive heating of interior rooms due to the solar rays' incidence and to provide for darkening of the room. The effect regarding sound isolation of those shading systems is usually not analyzed in the buildings' acoustic project. This study presents values of weighted sound reduction index (Rw) provided by several shading system types (outside screens and interior screens) and presents a simple model to predict their sound reduction index.

1 INTRODUCTION

This paper presents some sound insulation measurement results made in a masonry double wall (which is the solution the most used in Portugal as a façade wall) and, in the same wall, with two different glazed windows. Also presented are the results of laboratory tests for the same windows protected with shadow screens placed at both sides of the window. Based in the results, a simple model is presented to predict the weighted sound reduction index provided by these shading systems.

2 DESCRIPTION OF THE EXPERIMENTAL CONDITIONS

2.1 Measurements Procedures

The measurements were carried out in the reverberant chambers of the Laboratory of Acoustics of the College of Engineering, University of Porto (FEUP) which has a 10.25 m^2 test opening between the two rooms. The chambers characteristics are as set out in EN ISO 140-1[1] and the measurements procedures for determination of the sound reduction index (R) of each test were carried out using the measurement methods set out in EN ISO 140-2[2], EN ISO 140-3[3] and EN ISO 717-1[4].

The equipment used was a Brüel & Kjaer PULSE system with BK4190 microphones and BK4295 and 4292 sound sources. This equipment was used according the manufacturer instructions[5].

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The wall built between the two reverberant chambers was drying during three days before the first measurements were carried out.

2.1 Opaque Façade Wall

First, a double brick wall was built, made of hollow ceramic bricks with 11 and 20 cm width, and a 4 cm cavity filled with rockwool (average density of 70 kg/m^3). On the emission side of the wall a 15 mm thickness cement mortar covering was applied, and finish scoured, only for exterior façades. On the receiver side of the wall it was also applied a cement mortar covering, but with a plaster finish, in a way to be similar to an interior stucco surface (figures 1 and 2 show the two sides of the opaque wall). After drying, this wall was tested for verification of its sound reduction.

2.2 Description of window openings 1 and 2

After the acoustical test of the opaque wall, two window openings were created, where glazed windows were installed (figures 6 and 7). One had the dimensions 1.00 x 1.00 m which represented 5% of the total area of the wall. The second with 2.00 x 1.00 m what corresponded to 13% of the area of the separating wall. In both openings a triple chamber PVC frame 70 mm width was used, with metallic internal structure (brand DECEUNINCK) (figures 3 to 5). In the two openings, a double glass with 4(16)6 mm was used. Both window frames were perfectly sealed. Figures 6 and 7 show pictures of the two openings applied in the reverberant chambers separating wall.

2.4 Application of translucent exterior screens

After the tests made for each one of the window openings described above, solar protection screens (weight 330 g/m^2) were applied by the outside, made of fabric and specially protected for weather exposition. These screens were rolled around a horizontal axis positioned between the two side walls of the opening, immediately under the top of it. Tests were made with only a model of exterior screen and two positions were chosen for test; with the screen closed, that is, completely covering the glass, and half-closed.

Due to the absence of air dislocations in the interior of the laboratory chambers it was not necessary the assembly of ends' guides for the exterior screens fixation. The screen stayed barely intended due to the weight of the fixation bar in its extremity (figures 8 and 9).

2.5 Application of the opaque interior screens

The solar protection screens applied by the interior were completely opaque and were installed in a way to stop the entrance of light by the gaps between the screen and the wall. For such, the horizontal axis, where the screen was rolled, was located inside a metallic box that was positioned in the top of window opening (figures 10 and 11).

On both sides of the screen two guides in aluminum were installed, to stop brightness of entering when the screen is completely down. In the lower bar that serves also of weight for help in the descent of the screen, a strip of rubber was installed to stop light of entering under the lower bar (figure 12).

Three different kinds of screens were tested changing the weight of each one. Screen #1 of 400 g/m^2, #2 of 350g/m^2, and #3 of 300 g/m^2. Each screen was tested completely closed and half closed.

3 RESULTS

3.1 Opaque wall without and with glazed vain

The double wall described in the point 2.1 presented a weighted sound reduction index (Rw) of 52 dB. After the application of the glazed panel the results achieved for the Rw of the wall with the window installed were 45 dB with the smaller opening and 42 dB with the larger opening.

3.2 Translucent exterior screens

The exterior screens applied in the conditions described in point 1 presented a curve of sound reduction shown in figure 14. The weighted sound reduction index Rw obtained was 46 dB for the screen completely run down, and for the half screen closed (figure 8). These results show an increase of the Rw of 1 dB.

For opening #2, the value of weighted sound reduction index Rw obtained was of 42 dB, that is, the same value found for the glazed opening only.

3.3 Interior opaque screens

With the opaque interior screens more measurements were performed due to the availability of three models with different weights. On opening #1 the application of the three kinds of opaque screens revealed the same value of Rw, that is, 46 dB, 1 dB more than the same opening without screen.

For opening #2 the application of opaque interior screens revealed different values of Rw. With the 400 g/m^2 screen completely closed there was an increase of the Rw in 2 dB, passing from 42 to 44 dB. With the 350 g/m^2 and 300 g/m^2 screens, the increase of Rw was 1 dB, passing from 42 to 43 dB. Curiously, the value of the weighted sound reduction index for these screen models (lighter) are the same with the screens completely closed or half-closed.

The figures 16 and 17 show the sound reduction spectra of the two openings together with the different screens tested.

3.4 Translucent exterior screens plus interior opaque screens

Measurements were carried out to verify the acoustic behavior of this kind of screens acting in assembly; the exterior translucent screens at the same time with the interior opaque screens. These measurements were made with both the screens completely closed.

For opening #1, it is clear that the two kinds of screens, acting together, provide an increase of the weighted sound reduction index in 2 dB, changing Rw values from 45 to 47 dB.

In the case of a bigger opening like #2, the improvement of the sound reduction with the two kinds of screens applied is also 2 dB in case of the heaviest interior screen, and 1 dB in the two others.

Figures 18 and 19 show the sound reduction spectra of the two openings when applied the translucent exterior screens at the same time with the opaque interior screens.

4 PREVISION MODEL OF THE WEIGHTED SOUND REDUCTION INDEX

Based in the results of the measurements made, and with the help of data processing software for statistic analysis[6], the results achieved were analyzed and studied in order to predict the sound reduction provided by this kind of systems. In the figures 20 to 22 it may be seen the tendency curves of each one of the used systems. On the basis of those curves and its equations, the following basic expression is proposed to predict the weighted sound reduction index of a facade in which it will be applied these shadow systems.

$$Rw = 10.\log\left[\frac{S_{tot}}{\left(10^{\frac{-R1}{10}}.S1\right)+\left(10^{\frac{-R2}{10}}.S2\right)+\left(10^{\frac{-R3}{10}}.S3\right)}\right]+\Delta Rw_{SS} \qquad (1)$$

In which:
- *R1* is the value of wall Rw (dB);
- *R2* is the value of glass Rw (dB);
- *R3* is the value of window frame Rw (dB);
- *S1* is the surface of opaque façade wall (m^2);
- *S2* is the surface of glass (m^2);
- *S3* is the surface of window frame (m^2);
- S_{tot} is the total surface of façade wall (m^2);
- ΔRw_{ss} is the isolation difference due to shadow screens (dB).

Then, the value of ΔRw_{ss} will depend on the kind of screens used and will be a function of the opening area in the façade. The following equations are proposed to find this variable:

Translucent exterior screens	$\Delta Rwss = -0.02 + (2.54 / Psv)$	(dB)	(2)
Opaque interior screens	$\Delta Rwss = 0.07 + (5.56 / Psv)$	(dB)	(3)
Joint utilization…………	$\Delta Rwss = -0.03 + (10.39 / Psv)$	(dB)	(4)

In which; *Psv* **–** Percentage of opening surface.


Fig. 1 and 2 – Façade wall still closed; 1) "interior" side with stucco plaster;
2) “exterior” side with plaster of cement and sand.

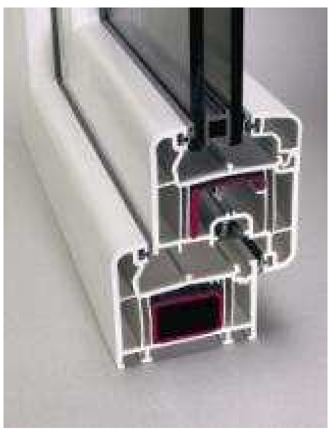
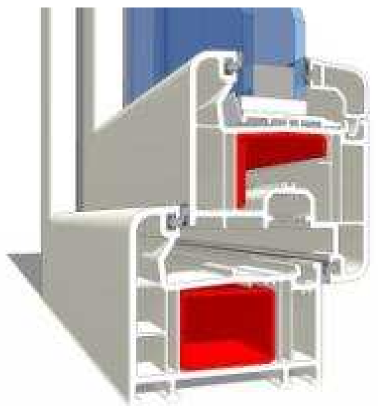
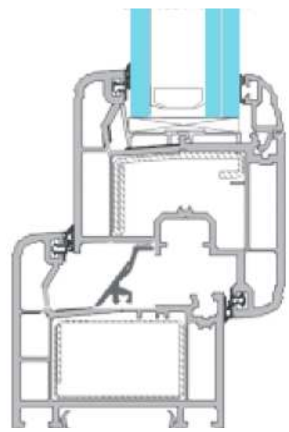




Fig. 3, 4 and 5 - 3) Window frame used; 4) same, seen in perspective 3D; 5) and in cut [7].


Fig. 6 and 7 – Façade wall with opening; 6) opening 1, with 1.00x1.00 m; 7) opening 2, with 2.00x1.00 m.


Fig. 8 and 9 – Application of the screens by the outside of the opening 8) exterior screen, half closed, on opening #1; 9) exterior screen on opening # 2, entirely closed.

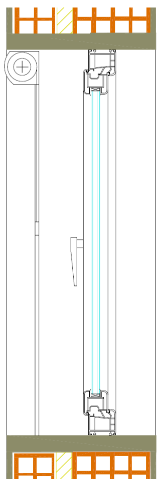
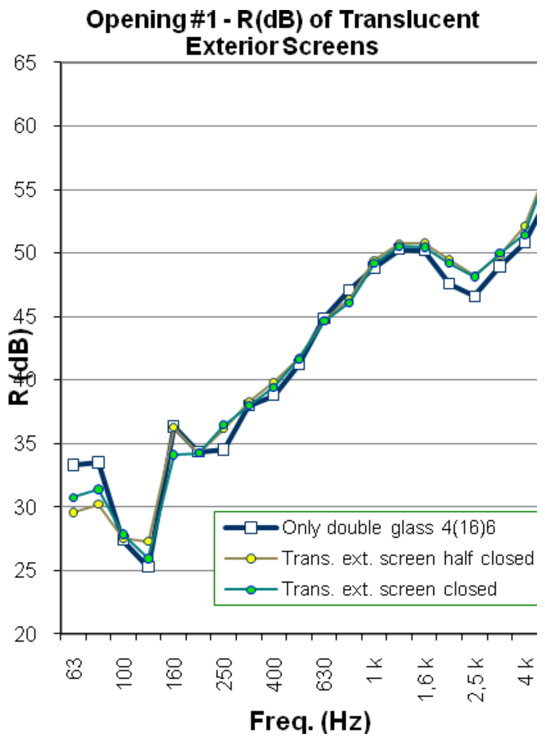



Fig. 10 and 11 - 10) Schematic cut of the window and interior screen; 11) Opening #1 with the opaque interior screen, half closed.


Fig. 12 and 13 – 12) Upper side of opening with the interior screen open; 13) Opening #2 with the interior screen closed.



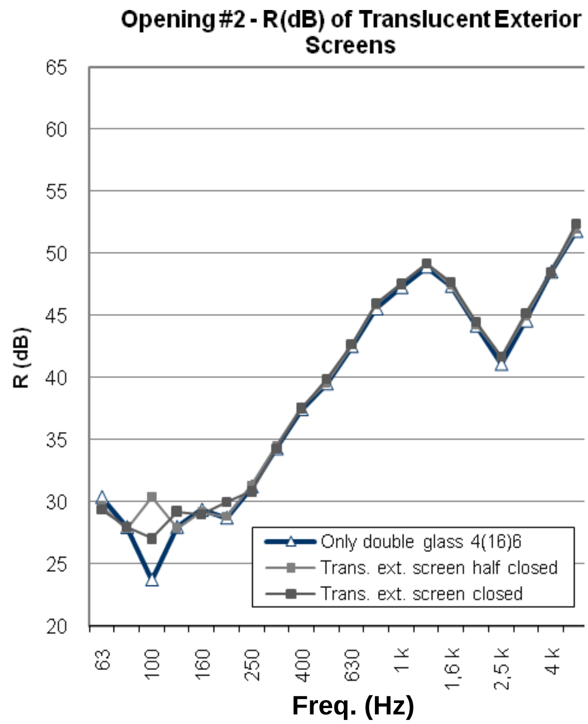
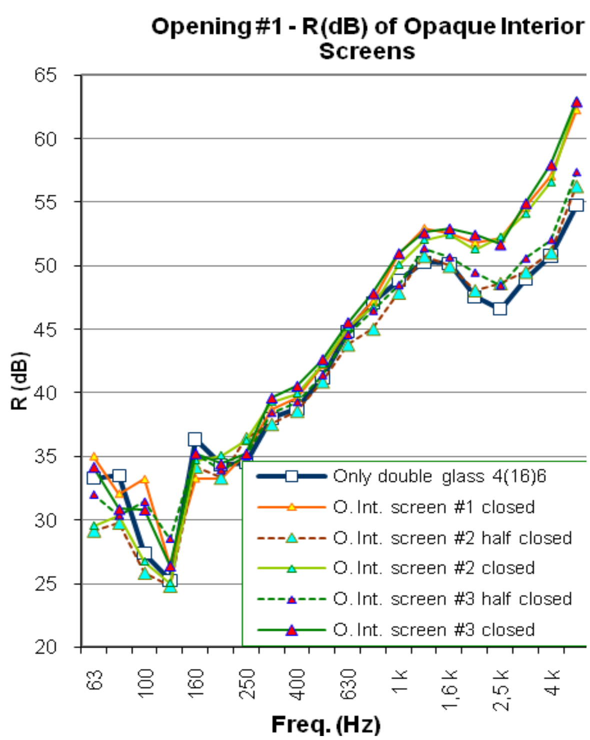


Fig. 14 and 15 – Isolation curves for the translucent exterior screens; 14) Opening #1; 15) opening #2.



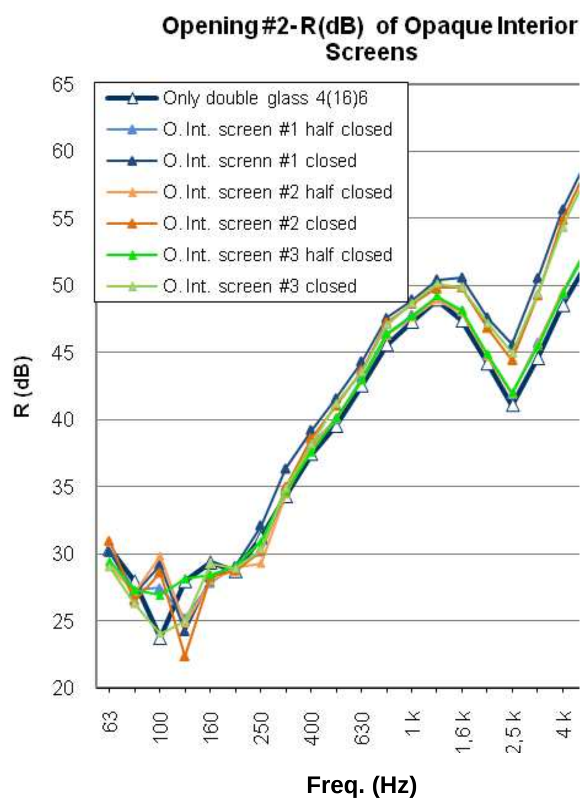


Fig. 16 and 17 – Isolation curves for the opaque interior screens; 16) for opening #1; 17) for opening #2.

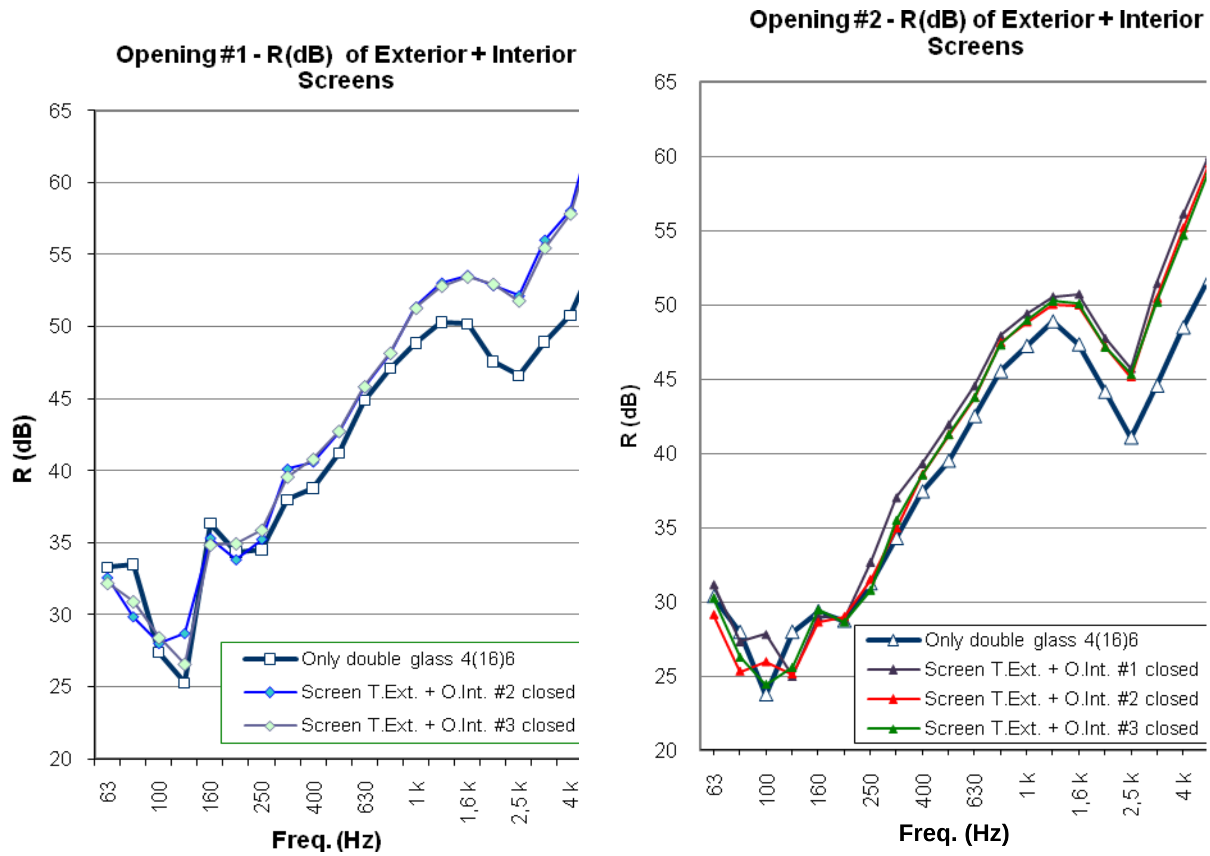


Fig. 18 and 19 – Graphics of isolation curves for the translucent exterior screens and opaque interior screens assembled together; 18) for opening #1; 19) for opening #2.

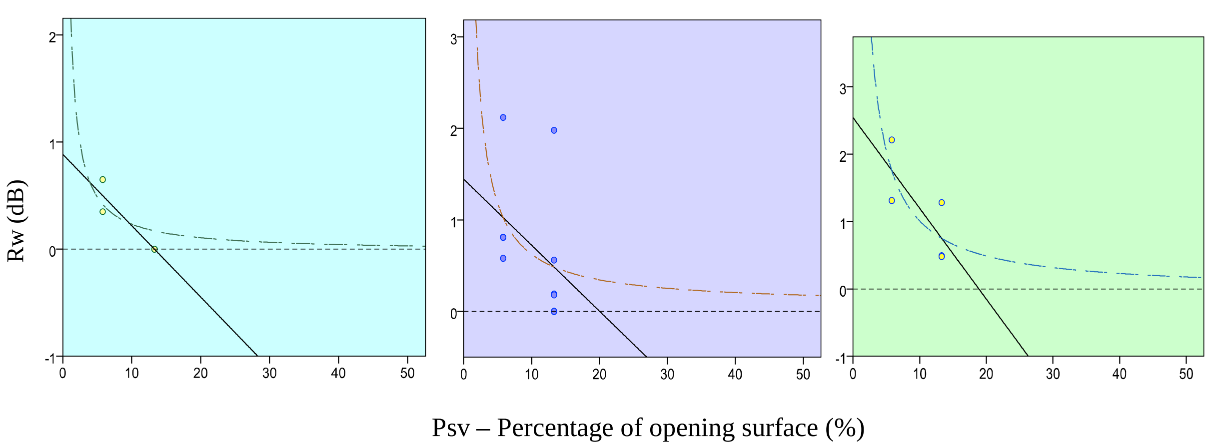


Fig. 20, 21 and 22 –Acoustic behavior of type of screens; 20) translucent exterior screens; 21) interior opaque screens; 22) interior and exterior screens applied together.

5 CONCLUSIONS

The utilization of exterior screens for sunlight protection, even though translucent and with rests between these and the exterior walls provides an increase in the acoustic isolation on smaller openings, about 1 dB. With the increase of the opening surface (in this case for the double) this benefit is not so evident.

It may be concluded that the use of an opaque interior screen, even partially closed, increases the sound reduction index of a facade between 1 to 2 dB, for an opening of 1 m^2 of surface. When the surface of the glazed opening is increased, in that case for 2 m^2, the insulating effect of the opaque interior screens is not accentuated, although in some cases can reach also the 2 dB of difference. The medium value of the weighted sound reduction index (Rw) is lower in this case, comparing with the smaller opening.

When they are assembled together, once again a discrepancy between the values obtained for opening with 1 m^2 and the one with 2 m^2 are verified. In the first case (opening #1) the weighted sound reduction index Rw increases 2 dB; in the second case (opening #2) such difference is reached only for one of the interior screen models, and for the others the difference is 1 dB.

In general it can be concluded that the application of opaque interior rolled screens, improve the sound isolation of the opening in facades, with Rw differences that may reach 2 dB, depending on the kind of material used in the screen construction.

The exterior screens, despite the fact that they are not built in a way to prevent the air passage, and therefore do not prevent the sound waves' infiltration, they present even so, an effect of sound reduction. In the case of opening #1, with 1 m^2 surface, the index Rw increased 1 dB. For the opening with 2 m^2 surface no change of Rw value was reported.

Those changes in Rw values are obtained by two main reasons: in the first place, the introduction of the screens, due to its weak strictness, alter the resonance frequency of the assembly, as it can be seen in the presented graphics; in second place, they increase partially the R values at high frequencies, mainly above the 1,250 Hz frequency band.

The use of shadow screens may help acoustical designers to reach the acoustical project goals, and they may look to this architectural accessory as a cost-effective solution that may be used to improve acoustical performance of old building facades.

6 ACKNOWLEDGEMENTS

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7 REFERENCES

1. International Organization for Standardization ISO 140-1: Acoustics – *Measurement of sound insulation in buildings and of building elements – Part 1: Requirements for laboratory test facilities with suppressed flanking transmission.* Geneva, (1997).

2. International Organization for Standardization ISO 140-2: *Acoustics – Measurement of sound insulation in buildings and of building elements – Part 2: Determination, verification and application of precision data.* Geneva, (1991).

3. International Organization for Standardization ISO 140-3: *Acoustics - Rating of sound insulation in buildings and elements of building elements – Part 3: Laboratory measurements of airborne sound insulation of building elements.* Geneva, (1995).

4. International Organization for Standardization ISO 717-1: *Acoustics - Rating of sound insulation in buildings and building elements – Part 1: Airborne sound insulation.* Geneva, (1996).

5. Brüel & Kjaer, *Aplication of B&K equipment to acoustic noise measurements*, Denmark, ed: Brüel & Kjaer, 3rd ed., (1978).

6. SPSS, *Statistical Package for the Social Sciences*, Statistics Software V.17, SPSS Inc., (2009).

7. http://www.deceunink.co.uk, accessed on October 2009.