

Sanitary Soundscapes: the noise effects from ultra-rapid “ecological” hand dryers on vulnerable subgroups in publicly accessible toilets

John Drever

Goldsmiths, University of London, UK, Email: j.drever@gold.ac.uk

Introduction

Good hand hygiene greatly helps reduce the transmission of respiratory and gastrointestinal viral infections and pathogenic bacteria. The Hygiene Council recommends that hands should always be washed after using the toilet or before handling food [1]. The epidemiological importance of hand drying within hand hygiene should not be underestimated, and is regarded as an important component of the hand washing process, as this advice to parents from Bog Standard, a campaign to promote better toilets for pupils, warns:

“Warm, moist hands are a haven for bacteria. No sooner have we washed away the germs, wet hands begin to collect them again, beginning with the tap we turn off and the handle on the door out of the toilets. Wet hands can pick up and transfer much more bacteria than dry hands or even hands not washed at all.”[2]

In accordance with the importance of hand hygiene, hand drying provision is included in current British Standards that covers sanitary installation, BS6465. Part 1 prescribes the regulation for hand drying facilities:

“A hand-drying facility of any of the types described in BS 6465-3 [2006] should be provided. Hot-air dryers should be provided one to every three basins, other hand dryer facilities one for every four washbasins.” [3]

Hand Drying Options

There are a number of hand drying options that the toilet provider can consider split between two categories, towels and electric dryers [1]:

Towels:

- individual Cloth towels
- roller towels (one loop of towel)
- linen roller towels (clean section kept separate from used section)
- disposable paper towels

Electric Dryers:

- traditional warm electric hand dryers
- the more modern warm air jet-air dryers
- ultra-rapid, cold air, hand dryers

All these methods can be found, and often providers offer a choice of paper towel and electric dryer, or warm air dryer and cold air dryer.

There are ongoing disputes between the relative merits of paper towels, the classic warm air hand dryer and the new generation of ultra-rapid, cold air dryer. The dispute relates to three themes: hygiene, carbon footprint and economics and the weightings of each of these themes [4] [5] [6]. This paper, however, highlights another equally pressing and yet hitherto discussed theme with regards to the cold air dryer: noise. It will present the methods and findings of a preliminary study of the noise effects of ultra-rapid cold air hand dryers in publicly accessible toilets, including schools and restaurants, in particular looking at the Dyson airblade.

Cold Air Dryers

Lauded for their effectiveness and efficiency, the new generation of hand dryers harness the force of air at extraordinarily high speeds, stripping the hand and fingers of moisture, a radically different method to the traditional warm air dryer that evaporates the moisture. This generation of hand dryer first appeared on the market in 1993 with the Mitsubishi’s Jet Towel, and in the past 6 years with the launch and rapid uptake of Excel Dryer’s Xlerator, World Dryer’s Airforce and of greatest accreditation the Dyson airblade.

The Dyson airblade hand dryer and more recently the airblade tap (launched February, 2013) are the only commercial hand dryers that comply with the NSF International’s Protocol P335 on Hygienic Commercial Hand Dryers.[7]

An endorsement from a hospital that is equipped with the airblade clearly demonstrates why it has become a preferable hand drying method for many organizations that offer toilet provision:

“We chose the Dyson Airblade™ hand dryer because it provides an environmentally-friendly, cost-efficient and hygienic means of drying hands. It has proved to be just that, especially when compared with traditional hand drying methods.”[8]

On a personal note, I was initially drawn to the noise effects of cold air dryers, from my perspective as a father. I was shocked by a nappy changing facility in an amusement park in Hong Kong, which was on the same height on a wall in between a line of four Panasonic Denko’s Quick Power Dry FJ-T13V1-W hand dryers. There were in constant use, and my perception of the loudness was that it was akin to being close up to a jet aircraft taking off. My infant, naturally, was highly distressed, and as a result the facility was evidently

not fit for purpose. As my children developed from infant to school child, I have been continuously exasperated by the distress that the noise of cold air dryers have provoked in a wide range of context. Often the hand dryer has been triggered by mistake by my children due to the cramped placement of the dryer, which can be a particular shock for the child in room with relatively low background noise. On talking with the many parents, I became aware that this is a general noise hazard for a whole generation of children.



Figure 1: This photo of a Typhoon T2000 is emblematic of this theme. The hand made sign attached to the dryer by the proprietor of a small café, warns: “CAUTION LOUD WHEN IN USE! KNOWN TO STARTLE CHILDREN”. In contrast to this sign which represents the *in situ* user’s experience, the product details from the manufacturer state, “low noise 70dB” [9].

Sound Power Test of Dyson Airblade

Dyson Airblade has a rated operating “noise power” of 85 dB(A) by its product makers [8]. It is assumed that “noise power” refers to sound power, i.e. $L_w = 10 \log (W/W_0)$ where $W_0 = 1 \times 10^{-12} W$. As the operational sound of a hand dryer is very loud and has a lot of high frequency content, it can be argued that A-weighting does not correlate well with what a person may actually hear. C-weighting, which is used in Control of Noise at Work Regulations with regards to industry and aircraft, may be a more appropriate measure here.

In ISO 3744:2010 [10] the standard frequency range studied is 1/3 octave bands with mid-band frequencies from 100 Hz to 10,000Hz, which gives the upper band limit of 11,300Hz. There is a note in the guidance that states that, “for special purposes, the frequency range can be extended” [10], however it is assumed that in the above “noise power” calculation, the upper band limit is 11,300Hz. As children had been a particular concern for this study, a sound power test that takes in the full spectrum would provide a more representative measurement. It could be taken to the 1/3 octave band of 20,000Hz, with an upper limit of 22,500Hz.

Product makers are providing various data on product noise, for example it is becoming more and more common to see a reading stating “dB(A) at 1 meter”. Product makers are not making explicit the actual testing method that the number they offer is derived from, i.e. ISO 3744. Moreover the use of use of ambiguous terms such as “noise power” is contributing to the confusion. Notwithstanding the public’s conflation of sound power and sound pressure and the interchangeable use of dB and dB(A).

The sound pressure of the Dyson airblade at 1 meter, if we assume that it was tested on a reflecting plane is 77dB(A).

For this study a sound power test following ISO 3744 was carried out of a Dyson airblade (AB01) that has had 2 years of continuous use. The tes was carried out in anechoic chamber at BRE, Watford (8th August 2011). The time weighting for each test was 10 seconds, the stipulated hand drying duration by Dyson [8]. To reflect the potentially wide variation of sound in the hand drying cycle due to turbulence, two tests were carried out:

Dy1.1 The measurement started once the hands were fully inserted, and are stationary for the whole duration.

Dy1.2 The measurement started the moment the airblade started to work as the hands went in and stopped once the hands were fully out. This is more representative of a hand drying cycle, with more spectral variation.

The same average male sized hands were used for both tests.

The results are:

Dy1.1 L_w dB: 93.2 L_{wA} dB: 92.9 (L_p at 1 meter 84.9dB(A))

Dy1.2 L_w dB: 92.4 L_{wA} dB: 92 (L_p at 1 meter 84dB(A))

There is a 7.9 dB(A) difference between the BRE measurement of the sound power of this particular device in Dy1.1 and Dyson’s rating. This difference may be due to the wide variation in turbulence noise depending on the movement and position of the hands or due to the device’s age and wear.

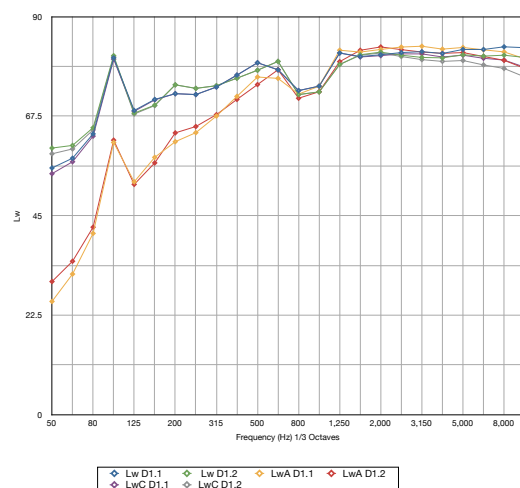


Figure 2: The sound power measurements of a Dyson Airblade from the two tests, including un-weighted, A-weighted and C-weighted measurements.

What is most evident is that there is a lot of high frequency content, staying about 80dB from 2,000Hz. It is unfortunate that the test does not give us readings from above 10,000Hz 1/3 octave band.

Building Acoustics

The sound power test gives us a robust method of comparing the levels of different makes of hand dryer, but what

happens to these levels when you install a hand dryer with a sound power of 85dB(A) / 92.9dB(A) into room which has the following building acoustics issues?:

- small rectangular room (e.g. 20m³) with parallel walls (tendency for high frequency room modes/ standing waves).
- most surfaces in toilets (porcelain, marble, tiling, glazed bricks, glass, painted concrete, water) have very low absorption coefficients across the spectrum.
- reverberation time (T₆₀) high, e.g.>1.5 seconds.
- need for sound insulation between rooms.
- need for high levels of background noise for privacy.
- egress of hand dryer noise through wall that it is attached to, and *via* doors, windows and ceiling.

There is surprisingly little guidance on the acoustic design of toilets. In the UK the most detailed guidance is in the design of toilets for schools, BB93 [11]. It recommends levels of source room and receiving room, and impact sound pressure level limit. It specifies an upper limit to ambient noise levels of 50dB L_{Aeq(30min)}. It also specifies the mid-frequency reverberation time, T_{mf1} (seconds), <1.5 [11]. The focus is on noise egress.

In situ testing

In situ testing was done to ascertain the sound pressure levels of the Dyson airblade once it is installed in the context that it is used, the public toilet (not the anechoic chamber as in ISO 3744). As well as the airblade, *in situ* measurements were taken of the Mitsubishi's Jet Towel, which has been marketed for its quietness. Within their four bullet points, the current version of Mitsubishi's Jet Towel, quote a "quiet operation" of 59dB or 52dB in the low power mode, "making it one of the quietest high-speed hand dryers on the market", and ensuring that, "that no one outside of the restroom is disturbed when in use [12]."

As well as sound pressure levels, FFT and T₆₀ (when possible) were taken. The room dimensions were also measured.

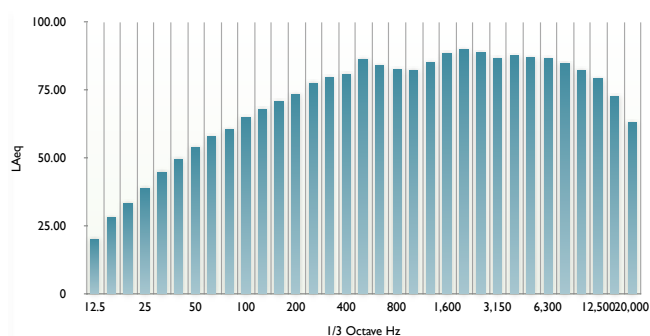


Figure 3: The L_{Aeq(10sec)} taken at 1 meter of a Dyson Airblade in a typical single, small rectangular WC (H: 3.50, L: 2.16, W: 2.67, volume: 20.19m³) in a restaurant. The background noise was <42dB(A).

These measurements showed a L_{Aeq} of 98.3dB, a L_{Ceq} of 99.4dB, and L_{AFmax} of 105.4dB, and a L_{CFmax} of 106dB. Unlike the sound power test a fuller spectrum has been included in 1/3 octave bands from 12.5 Hz to 20,000Hz.

These levels are akin to the sound level of a road drill and are exceptionally loud considering the sensitivity of the context.

Other *in situ* tests of airblades had similar results. The results of a test of Mitsubishi Jet Towel in a similar sized toilet (H: 2.48m, L: 2.38m, W: 3.66m, Volume: 21.60m³) were significantly quieter, but still loud: L_{Aeq} 86.5dB and L_{Ceq}, 89.9dB.

There is no published research on product makers testing their hand dryers in the context of the toilet acoustic, and the often quoted sound power measurements do not give a good indication of the actual levels that may be encountered in the ultra reflective and resonant toilet.

Vulnerable Subgroups

For the final part of the project an initial survey was made on the vulnerable subgroups that are particularly affected by hand dryer noise. The WHO's Community Noise (1999) refers to vulnerable subgroups as, "people with decreased personal abilities (old, ill, or depressed people); people with particular diseases or medical problems; people dealing with complex cognitive tasks, such as reading acquisition; people who are blind or who have hearing impairment; fetuses, babies and young children; and the elderly in general" [13].

List of Vulnerable Subgroups related to hand dryer noise:

- people who rely on effective speech intelligibility
- fetuses, infants and children
- pregnancy
- the elderly in general and Alzheimer's disease sufferers
- people with particular diseases or medical problems (e.g. high blood pressure)
- people dealing with complex cognitive tasks
- visual impairment: "anything which masks environmental sound "information" is a problem, how serious varies, but as hand dryers are often situated by the door, not being able to hear the movement of the door is likely to lead to head injuries. (Hugh Huddy, RNIB Campaign Officer)
- hearing impairment (conductive, sensorineural & mixed hearing loss)
- hearing aid users: "I have to remove my aids just to dry my hands." [14]
- hyperacusis, misophonia, phonophobia, recruitment sufferers and hyperacute hearing
- autistic spectrum disorders with hyperacute hearing: "I can't stand those hand dryers and it amazes me whenever I see people nonchalantly using them like the sound is nothing. It's very painful for me. I won't go in restrooms that have them unless it's absolutely necessary and if someone uses the dryer while I'm in there, I plug my ears. I don't care if I look like an idiot." (From an ASD chat room)

Interestingly the research also came across people being distressed by the new generation of high speed toilet flushes.

Vulnerable subgroups for Acoustics Privacy Issues

Silence in toilets is not an option however, as there are vulnerable subgroups that demand a high level of acoustic privacy:

- paruresis - shy bladder/ stage fright
- parcopresis - shy bowel

Role of Sound Art to Communicate Noise Issues

To help communicate the themes and issues in this research a number of innovative sound art works and installations have been devised and presented:

- *Litany of the Hand Dryers* by Drever
Comparative Sequence of near-field recordings of different brands of hand dryers
- *sanitary tones: air #1* by Drever
A sonic study exploring the full range of audible spectrum of sound energy of a Dyson Airblade

Conclusion

From this initial study it is evident that ultra rapid cold air hand dryers are loud, and this loudness is vastly augmented in the highly reverberant and reflective small toilet. A wide range of vulnerable subgroups are being seriously affected by hand dryer noise, resulting in unwelcome stress in this sensitive space, and in extreme cases people are being excluded from public spaces, the workplace and schools. The following recommendations have been made:

- Urgent need for large-scale project assessing the noise impact of high speed hand dryers, including survey from FULL range of users (the experts).
- Product testing in the field - not only free-field (i.e. anechoic chamber).
- Clear and standardized information given on loudness of products and frequency content, e.g. sound pressure at 1m / sound power.
- Review the adequacy of A weighting. D (aircraft noise) may be more appropriate due to high frequency content of hand dryers.
- Include full frequency band up to 20kHz in sound power test.
- Installations guidance required derived from acoustic know-how, which includes a limit on the number of dryers and location.
- WC building acoustics review, prioritizing needs for vulnerable subgroups.
- Psychoacoustic test should be used to garner a subjective impression: roughness, sharpness, fluctuation strength.
- Engineers MUST work hand in hand with Sound Designers.
- The above points need to be dealt with holistically including other accessibility and epidemiological issues related to WCs and in accordance with sustainability.

References

- [1] The Hygiene Council.
URL: http://hygienecouncil.co.uk/Best_Practice.pdf
- [2] The Bog Standard: Better Toilets for Pupils.
URL: <http://www.bog-standard.org/>
- [3] BS 6465-1:2006+Amendment 1:2009 Sanitary installations. Code of practice for the design of sanitary facilities and scales of provision of sanitary and associated appliance.
- [4] Redway, K. & Fawdar, S., A comparative study of different hand drying methods: paper towel, warm air dryer, jet air dryer. European Tissue Symposium, 2008.
- [5] Huang, C., Ma, W., Stack, S., The hygienic efficacy of different hand-drying methods: a review of the evidence. Mayo Clin Proc. 2012 Aug;87(8):791-8.
- [6] Hand Dryers Vs. Paper Towels.
URL: <http://www.handdryersvspapertowels.com/>
- [7] NSF Protocol P335: Hygienic Commercial Hand Dryers.
URL: <http://www.nsf.org/Certified/Protocols/Listings.asp?Company=3E300&Standard=P335&>
- [8] Dyson Airblade
URL: <http://www.dyson.co.uk/handdryers/>
- [9] C & W Berry Ltd.
URL: http://www.cwberry.com/Inquiry_ProductDetails.aspx?ItemNumber=07111300
- [10] BS EN ISO 3744:2010, Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane
- [11] DfES Building Bulletin 93 (BB 93): Acoustic Design of Schools, 2003.
- [12] Mitsubishi Jet Towel
URL: <http://www.mitsubishijettowel.com/benefits.html>
- [13] Berglund, B., Lindvall, T., Schwela, D.H., Guidelines for Community Noise, World Health Organization 1999.
- [14] Action on Hearing Loss & Deafness Research
URL: <http://www.actiononhearingloss.org.uk>