



Goldsmiths
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Sanitary Ambiance

the noise effects of high speed hand dryers

- a preliminary study

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Acoustic Atmospheres / Ambiances

“The profound advantage offered by an Aesthetics of Atmospheres is that it can draw on a large reservoir of daily life experiences. One talks of a pleasant valley, of the depressive mood before a storm, of the tense atmosphere in a meeting, and it is easy to agree on what these phrases mean. If atmospheres are moods, which one feels in the air, then we are describing a phenomenon which is familiar to everyone; moreover, the potential source material for discussing and characterizing atmospheres is nearly inexhaustible. One speaks of a sombre atmosphere, a foreboding atmosphere, an exalted atmosphere, but one speaks also of an atmosphere of violence or holiness, and one even speaks of the boudoir atmosphere, or a petit-bourgeois atmosphere, of the atmosphere of the twenties.”

Gernot Böhme: Acoustic Atmospheres: A Contribution to the Study of Ecological , *Soundscape: The Journal of Acoustic Ecology*, Volume 1, Number 1, Spring, 2000

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WC Sound Source Inventory

- Plumbing (removal of wastes, distribution of clean water)
- Hand Dryers
- Paper Towel Dispenser
- Doors, locks
- Flush
- Mechanical Services: e.g. duct born fan noise
- Buzzing Lights
- Dripping and Flowing of Water from Taps and inside cistern
- PA (train station), Musak
- Speech, Whistling, Singing, Humming, Tapping, Coughing, Spitting, etc.
- Involuntary Human Sounds, flatulence, sneezing, foot steps, etc.

WC Building Acoustics

- Rectangular spaces with parallel walls (room modes).
- A single WC can be very small (broom cupboard) e.g. 20m^3
- Reverberant-field - multiple reflections, minimal absorption
- Reverberation time (T60) high, e.g. 1.5 seconds
- All surfaces highly reflective (very low absorption coefficients)
- 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 and windows, etc.

British Standards

– **BS 8233: 1999** (Residential, Industrial, Offices)

Sound insulation and noise reduction for buildings.

Provides internal noise criteria. Lower value is considered as a good standard and upper figure is considered as a reasonable standard.

Wash-room, toilet: 45 – 55 dB L_{Aeq}

Range is used to aid with privacy between spaces or between rooms.

Desirable reverberation times.

BB93 Education

Activity noise and noise tolerance for room type

Toilets:

Activity Noise (source room): Average

Noise Tolerance (receiving room): High

Ambient noise levels (dB $L_{Aeq(30mins)}$): 50

Impact Sound Pressure level limit (dB $L'_{nT}(tmf,max),w$): 65

Reverberation time ($T_{mf(s)}$): 1.5

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Absorption Coefficients at 1 kHz of common WC surfaces

- Full absorption is 1 whilst full reflection is 0
- Water 0.015
- Glass 0.03
- Painted concrete 0.06
- Marble or glazed tile 0.01

- http://www.sae.edu/reference_material/pages/Coefficient%20Chart.htm

Epidemiological Need for Hand Drying

- 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.
- http://www.bog-standard.org/adults_hand_hygiene.aspx

Hand Drying Options

– **Towels:**

- 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

High-Speed Hand Dryers

- *Airblade*
- *Airforce*
- *Air Fury C1*
- *Jet Towel*
- *Tornado Lite*
- *Typhoon T2000*
- *Xlerator*



Research Assistants



Case Study: Dyson Airblade™

Green Business Awards 2010.

World Architecture News (WAN) Product Awards

Best Interior Product Award

Building Better Healthcare Awards 2009

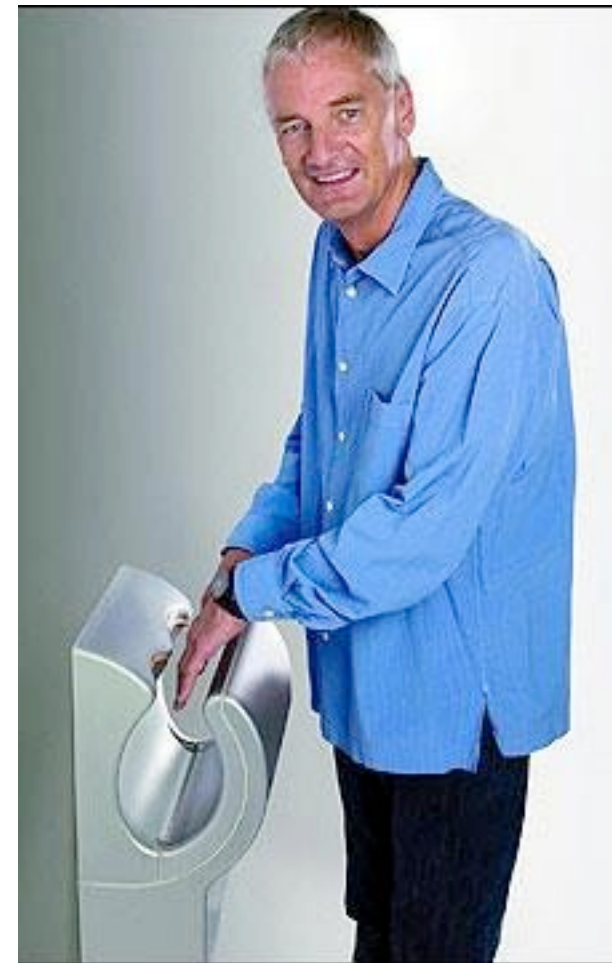
iF Product Design Award 2009 -Product Design
Award

Red Dot Design Award 2009 - Product Design
Award

GOOD DESIGN™ Award 2008

Carbon Positive Cutting Edge Award

South West C+ Carbon Positive Awards 2008



- The airblade uses two high-pressure “knives” of filtered room-temperature air to blow water off the hands at 400 mph, which are held apart and drawn through the airstream, whereas conventional dryers use warm air to evaporate moisture whilst hands are rubbed together. It take 10 seconds to dry compared to the recommend 30 – 35 seconds of the warm air dryer.

“Comparative evaluation of the hygienic efficacy of an ultra-rapid hand dryer vs conventional warm air hand dryers”

AM Snelling, T Saville, D Stevens, & CB Beggs
J Appl Microbiol. 2011 January; 110(1): 19–26.

Dyson on Product Noise

- **We bought one of your cleaners, which works well, but makes a hell of a noise. Isn't there a possibility to reduce the noise of your product?** *Rolf Hablutzel, Switzerland*

“At Dyson we have an acoustics team that spend all day, every day analysing noise and vibration levels. We have a semi-anechoic chamber which measures noise. Its walls and ceiling are covered in thick grey foam wedges. The wedges are designed to make sound travel away from the noise source – in Dyson’s case a vacuum cleaner or washing machine – without echoes.

You’ll find that noise does emanate from all different areas of the machine, but we do put a huge amount of work into getting this as balanced to ensure it is as quiet as possible. Remember that the fan rotates at 35,000rpm (**Schumacher’s Ferrari does 19,000**) – so it creates a loud noise to silence. But you are quite right and it is a major area for improvement. People care more about the machine's cleaning performance than they do about the noise though.”

http://www.ehow.co.uk/info_12011624_dyson-vacuum-noise.html

Noise = Power

“cultural association of loud industrial noise with admired societal traits,”

(Dembe 1996:203)

Sacred Noise

“The association of Noise and power has never really been broken in the human imagination. It descends from God to the priest to the industrialist and more recently to the broadcaster and the aviator. The important thing to realize is this: to have the Sacred Noise is not merely to make the biggest noise rather it is a matter of having the authority to make it without censure.

Wherever Noise is granted immunity from human intervention there will be found a seat of power.”

(Schafer 1994: 76)

Dyson on Mumsnet

Camilladyson, if you are still reading, what is Dyson's policy on seeking to install its Airblade dryer in disabled toilets, given the high proportion of disabled children who have sensory issues and thus are scared to visit the disabled toilet if it has a dryer in it?

Hi lingle

When developing new technology we always adhere to the official guidelines set out by the important bodies (I will come back with the official names) in all countries that it'll be sold in. And I know that the Airblade has cleared all standards set out - some are noisier than it.

Where the Airblades are installed comes down to the person that buys it, not us. We do sell some machines direct, **but which loos a venue chooses to put them in isn't our call**. And often they're sold via a distributor. I hope that doesn't sound dismissive, but that's generally how it works and it is out of our hands.

I am going to pass the link of this thread on to the sound team, because I know it will be of interest.

http://www.mumsnet.com/Talk/special_needs/946642-Please-sign-in-if-your-child-with-SN-might-benefit/AllOnOnePage

Sound Power

- the total amount of sound inherent in a particular sound source independent of the acoustic environment that it is in.

- $L_w = 10 \log (W/W_0)$ where $W_0 = 1 \times 10^{-12}$.

- **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 plan.

This is carried out in an anechoic chamber.

Rated Operating Noise Power: **85dB(a)**

<http://www.dysonairblade.co.uk/specification/>

Results of Sound Power Test done by Drever at BRE on the 8th August 2011

50Hz - 10kHz:

L_w dB: 93.2dB

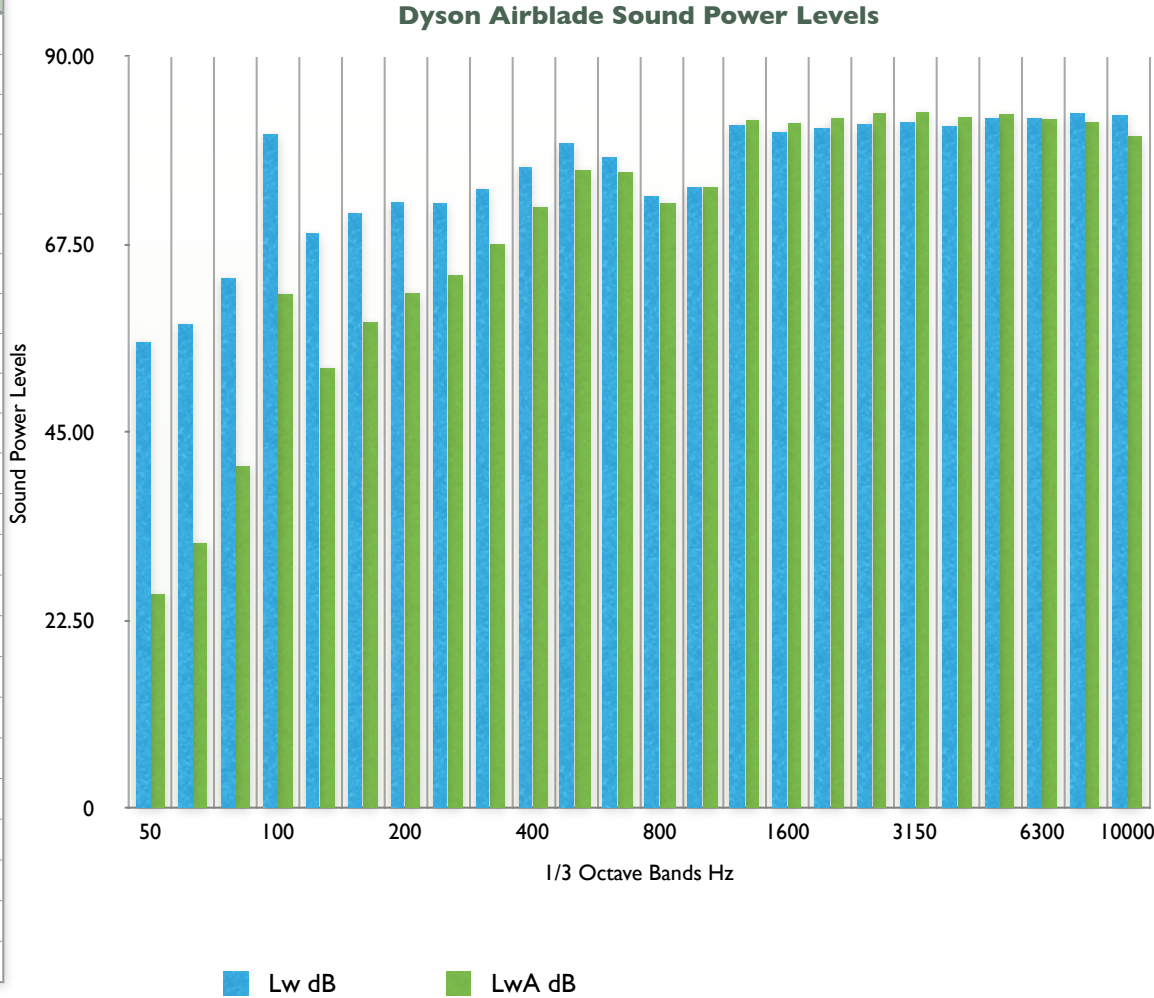
L_{wA} dB: 92.9dB(a)



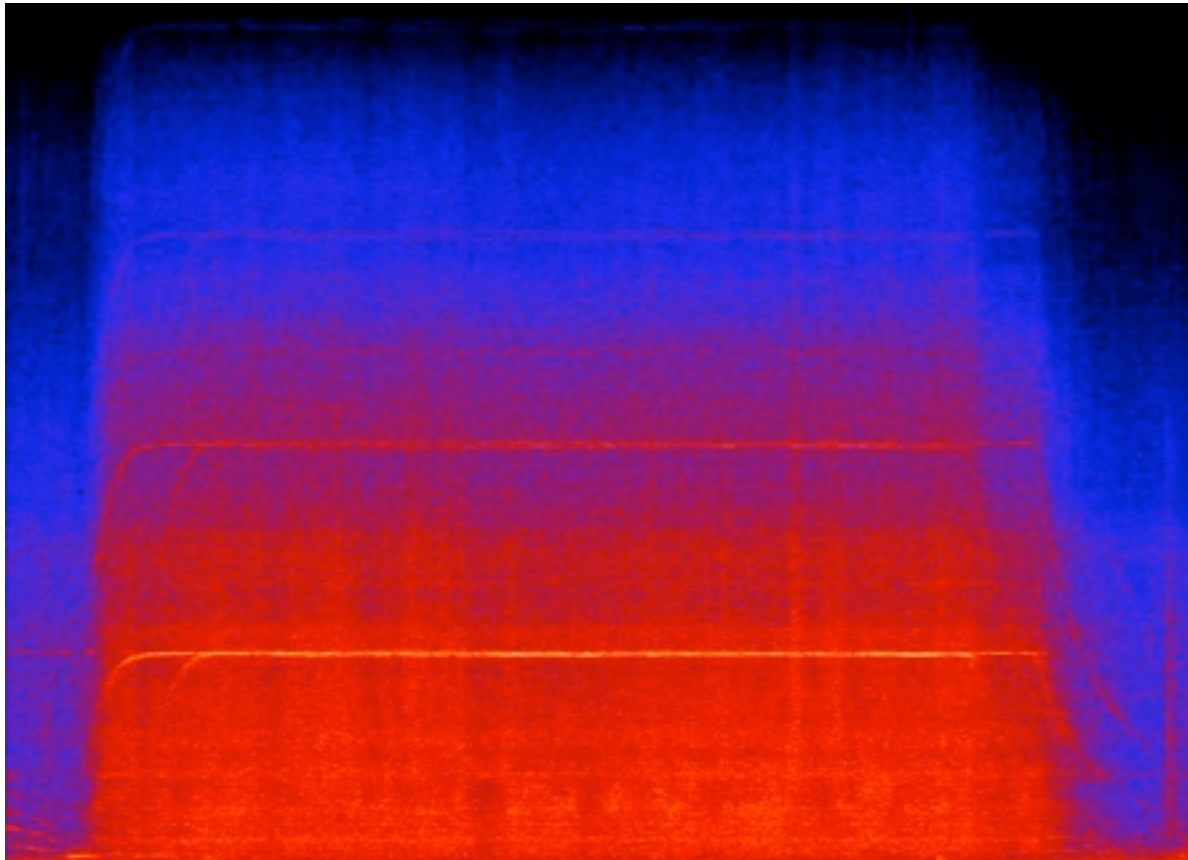


Dyson Airblade

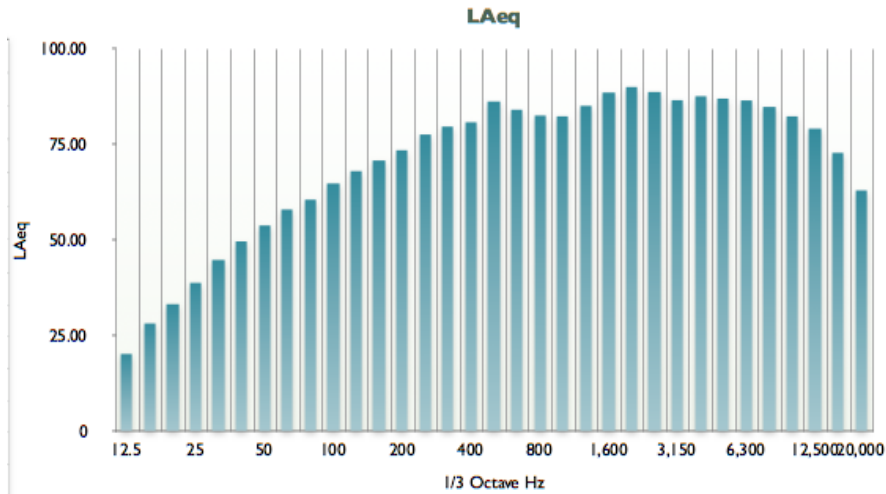
Hz	LW DB	LWA DB
50	55.80	25.60
63	58.00	31.80
80	63.50	41.00
100	80.70	61.60
125	68.80	52.70
160	71.30	58.20
200	72.60	61.70
250	72.40	63.80
315	74.10	67.50
400	76.80	72.00
500	79.60	76.40
630	78.00	76.10
800	73.30	72.50
1000	74.30	74.30
1250	81.80	82.40
1600	81.00	82.00
2000	81.40	82.60
2500	81.90	83.20
3150	82.10	83.30
4000	81.70	82.70
5000	82.60	83.10
6300	82.60	82.50
8000	83.20	82.10
10000	83.00	80.50



Sonogram: showing prominent high frequency



Field Study of an Airblade in a Small Single WC (including background noise)



Measurements

Start Time 21/09/2011 18:27:48

Stop Time 21/09/2011 18:28:10

Elapsed Time 00:00:22

Temp 21C

12.5Hz - 20kHz

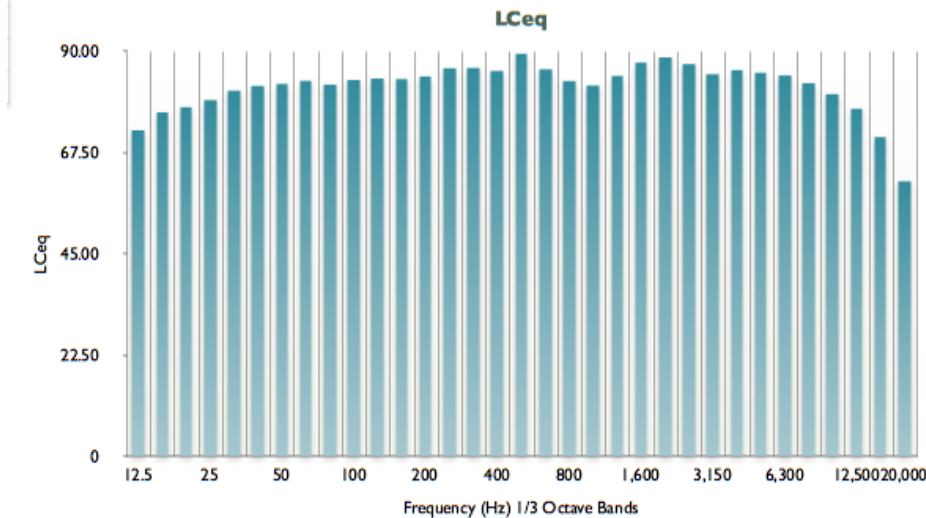
LAeq [dB] 98.3

LCpeak [dB] 123.0

LAFmax [dB] 105.4

LAFmin [dB] 90.5

Loudness Level [phon] 112.7



Room Dimensions

H: 3.50

L: 2.16

W: 2.67

Surface Area:

45.34m²

Volume: 20.29m³

Examples of A-weighted sound pressure levels (NB not sound power Lw)

(A-weighted sound levels dB(A) attempt to build in the human response to different frequencies at different loudness)

140 dB(A)	Threshold of Pain
120 dB(A)	Jet Aircraft at 100m
110 dB(A)	Inside a very noisy factory
100 dB(A)	Road Drill, Loud Disco
90 dB(A)	DIY Drill (close to ear), Lorry (roadside)
80 dB(A)	Traffic at a busy road-side
70 dB(A)	Hair Dryer
60 dB(A)	Washing Machine
50 dB(A)	TV in Lounge
40 dB(A)	Quiet Office
30 dB(A)	Bedroom at Night
10 – 20 dB(A)	Broadcasting Studio (background noise level)
0 dB(A)	Threshold of Hearing

Adverse Health Effects of Noise (WHO 1999)

- Hearing Impairment
- Speech Intelligibility
- Sleep Disturbance
- Physiological Functions
- Mental Illness
- Performance - Impairment of Reading Acquisition
- Social and Behavioural Effects of Noise; Annoyance
- Combined Effects on Health of Noise from Mixed Sources
- Vulnerable Subgroups
- <http://whqlibdoc.who.int/hq/1999/a68672.pdf>

Vulnerable Subgroups - from preliminary survey

- Babies & Children
- Hearing Aid Users
- Visual Impairment
- Hyperacusis
- Tinnitus
- Pregnancy
- Autistic Spectrum
- Dementia

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Speech Disturbance

- Importance of speech intelligibility, e.g between parent and child.
- Speech Transmission Index (STI)
 - reverberation
 - masking (background noise)

Hyperacusis

- Children with hyperacusis often cover their ears when the noise is too painful for them.
- Very common for people on the autistic spectrum

- “It's not totally just volume per se that I'm hypersensitive to, but certain frequencies, types of sound and some other issues I can't quite explain.”
- “It's very painful for me. I won't go in restrooms that have them [high speed hand dryers] unless it's absolutely necessary and if someone uses the dryer while I'm in there, I plug my ears.”
- People speaking about high speed hand dryers and hypersensitive hearing from an autism and hyperacusis forum

Effects of Loud High Frequency Sound

- In sensitive individuals, higher noise levels had been found to cause annoyance, tinnitus, headaches, fatigue and even nausea. These sensations/feelings subsided after cessation of the high-frequency sounds.
- ISVR Report 2006.
- <http://www.compoundsecurity.co.uk/about-us/downloads/isvr-report>

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Hearing Aid Users

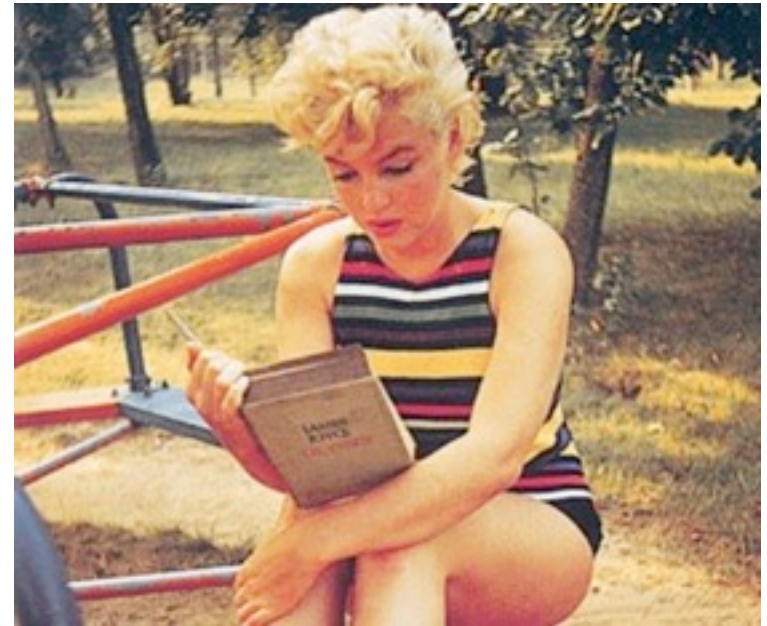
- An important consideration with regard to aural pain is the effect of noise on hearing-aid users. Discomfort associated with exposure to sudden loud noises, loud music, and even raised voices is a common complaint of people who wear hearing aids. Hearing aids that automatically limit output to 100-120 dB SPL or less, provide protection for sensitive ears, provided they are properly selected and fitted
- (Gabrielsson et al., 1974).

Visual Impairment

- “Regarding the visual impairment related ramifications, 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. It is not a straightforward case to mount against high speed jets though, as the lower speed jets also mask door movement and other sounds.”
- Hugh Huddy

Acoustic Privacy

" There's a very good joke about Marilyn Monroe when she married Henry Miller.. They were engaged then. He said," I would like you to meet my mother, she would like to see you. So i thought we'd go to her little apartment in the Bronx, we'll have a little dinner, and she'll get to know you." And Marilyn said," Wonderful, wonderful." So they go there to that tiny little apartment, with a kind of very flimsy door between the living room and the toilet. They're having a very good time , they get , along great, and then Marilyn Monroe says she's got to go to the WC, the toilet. And she goes , and because the walls are thin , she turns on all the faucets so they would not hear it in the next room. Now she comes out, and everything's beautiful, kiss, kiss, kiss. Next day Arthur calls the mother and says, " How did you like her ? " And the mother says, " She's sweet, a wonderful, wonderful, wonderful girl, but she pisses like a horse ! "



'Conversations with Billy Wilder' - Cameron Crowe p86

Health Issues Related to Lack of Acoustic Privacy

- Paruresis - Shy bladder/ stage fright
- Parcopresis - shy bowel

Masking: Acoustics Camouflage

Otohime - Sound Princess

- Many women find the "toilet sounds" distasteful and few would deny that they'd rather be listening to soft music or some other background noise. In Japan, this problem has been solved by installing push button electronic noisemakers inside the womens room stalls. These devices make the sound of a loud flushing toilet when pressed. Formerly, Japanese women were known to flush the toilet as many as three times to provide covering sounds, resulting in a great waste of water.

[http://americanrestroom.org/
design/ipa_rd.htm](http://americanrestroom.org/design/ipa_rd.htm)



OTOKESHI no TSUBO

Japanese Acoustic Camouflage from Edo Period



Edward T Hall: Personal Space, Proxemics

- *Intimate distance*: which he ranges from actual physical touch to 8 inches, is “one of wrestling, making love, and comforting” (Porteous 1977:37). The accustomed utterance at this distance would be kept to a whisper.

Personal distance is equated to 1.5 – 2.5 feet, roughly an “arms length”.

Within such propinquity, he surmises that cultural norms would prescribe that voice level is maintained at a moderate speaking level.

Social distance: regarded as 4-7 feet, “voices are louder, but shouting may have the effect of reducing social distance, with the resulting problem of social-space violation.” (1977:37)

Socio- territorial Soundscapes

- “An **acoustic arena** is centered at the sound source; listeners are inside or outside the arena of the sonic event.”

“The **acoustic horizon** also delineates an acoustic arena, a region where listeners are part of a community that shares an ability to hear a sonic event.” i.e. who gets to hear what.

Barry Blesser. *Spaces Speak, Are You Listening?: Experiencing Aural Architecture.*

Cambridge, MA, USA: MIT Press, 2006. p 22.

Concert Hall Acoustics (Beranek / Barron)

Need for Similar Criteria for WCs?

- Reverberation Time (W.C. Sabine)
- Clarity
- Intimacy - initial- time-delay-gap
- Liveness - mid-frequency reverberation time
- Warmth - bass/mid-frequency reverberation time ratio
- Loudness of direct sound
- Reverberant Level - reverberation time/volume
- Balance and blend
- Diffusion
- Ensemble
- Apparent Source Width - Source broadening

Norbert Elias - 'excretory experience'

- German sociologist Norbert Elias (*The Civilizing Process*, 1939) developed, with an acknowledged debt to Freudian psychoanalytical theory, the seminal notion of a historically documentable European 'civilizing process,' a process very much concerned with the scatological. Most pertinent to this collection, Elias zeroes in on what he considers to be the beginnings of an historical shift in modes of social behavior in Early Modern Western European society concurrent with the literary and artistic works examined in this volume. ... It is worth noting here that all three trends focus on varying forms of private and public control of excrement and excretion — the overall 'excretory experience,' as one author would have it — as essential to a given society's cosmology, whether literal and physical or symbolic and moral. Elias's postulation of a 'civilizing process' for Early Modern Europe hinges on this.

Experiencing Architecture

- ..a man tends to whistle or sing when he enters the bathroom in the morning. Though the room is small in volume, its tiled floor and walls, porcelain basin and water-filled tub, all reflect sound and reinforce certain tones so that he is stimulated by the resonance of his voice and imagines himself a new Caruso. What a flat feeling it gives when you come into a bathroom that has been given the favorite modern acoustical treatment which has the very one-sided aim of smothering all such cheerful noises. M.I.T.'s Faculty Club has one of the most perfectly equipped lavatories in the world. You enter it happily for a refreshing wash before lunch. A benefactor donated so much magnificent marble that it glistens with hard elegance and you say to yourself: 'Here my voice is going to ring out marvelously.' But the first joyous note from your lips falls as flat and muffled as your ears as it would in a heavily upholstered living-room. To put the finishing touch on this perfect marble washroom, the architect has given the ceiling the most sound-absorbing surface it is possible to attain!
- *Experiencing Architecture* (Rasmussen 1997:236)

Role of Sonic Art

- *Litany of the Hand Dryers* by Drever
- <http://soundcloud.com/john-levack-drever/litany-of-the-hand-dryers>
- Comparative Sequence of near-field recordings of different brands of hand dryers

- *sanitary tones: air #1* by Drever
- <http://soundcloud.com/john-levack-drever/air-60mins>
- A sonic study exploring the full range of audible spectrum of sound energy of a Dyson Airblade™

Conclusion

- 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.
- 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.
- 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**.

Two Closing Questions

- Are people opting not to dry their hands in order to eschew hand dryer noise?
- If so, what is the epidemiological knock-on effect?

A Preliminary Answer





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