噪音暴露健康危害

吳聰能

2008.03.29

台灣相關領域文章數量(in WOS)

Year	1997					
Subject	Noise		Hearing loss		Auditory	
Tag	title	topic	title	topic	title	topic
Sub-Total	21	104	0	1	3	11
Year	2002					
Sub-Total	30	215	1	9	6	15
Year	2007					
Sub-Total	79	487	4	25	13	43

p.s.-topic包括在title、abstract、keyword

何謂噪音？

Unwanted sound or undesirable sound

噪音的定義

- 一般正常耳朵覺得聽不習慣的強大音響
- 使人覺得不愉快的音響
- 妨害聽取會話的音響
- 妨害思考能力的音響
- 妨害睡眠或休息的音響
- 引起生理上障礙的音響
- 超過噪音管制標準的音響

噪音擾鄰眠 判賠28萬元

- 4樓自92年初就日夜使用馬達、或不時用球在地板撞擊滾動、拖挪桌椅、發出鐵鎚敲打聲等
- 告訴人花費金錢，在天花板加裝隔音板、隔音棉，又有環保人員多次前往測量記錄等，高院認定4樓確有製造噪音，噪音雖未超過管制標準，但合議庭引述專家學者研究文獻，認為該噪音管制法標準屬行政單位管理、取締的平均值，不能說一般人就能容忍，何況告訴人已因此罹病，依此判決告訴人勝訴。

自由日報2007/10/15

何謂Noise？

即其向位、波長、能量皆為亂數

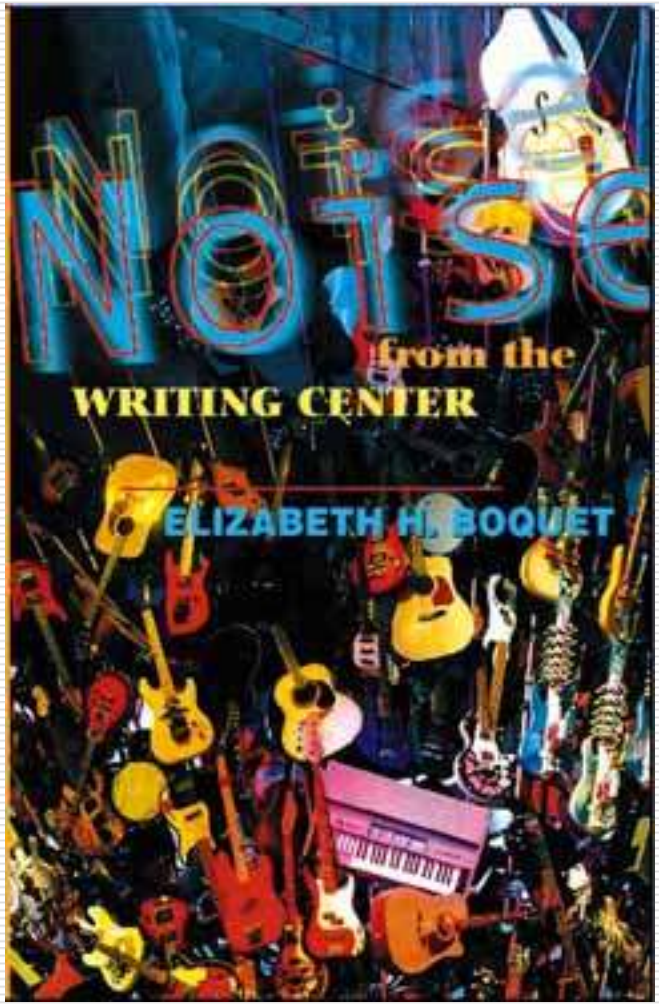
噪音的單位

dBALeq24

The most common stressor

- Noise is one of the most widespread pollutants in the workshop environment.
- Noise is a persistent environmental problem.


Division 44
Environment and Infrastructure
Sector project "Transport Policy Advice"


Noise
from the
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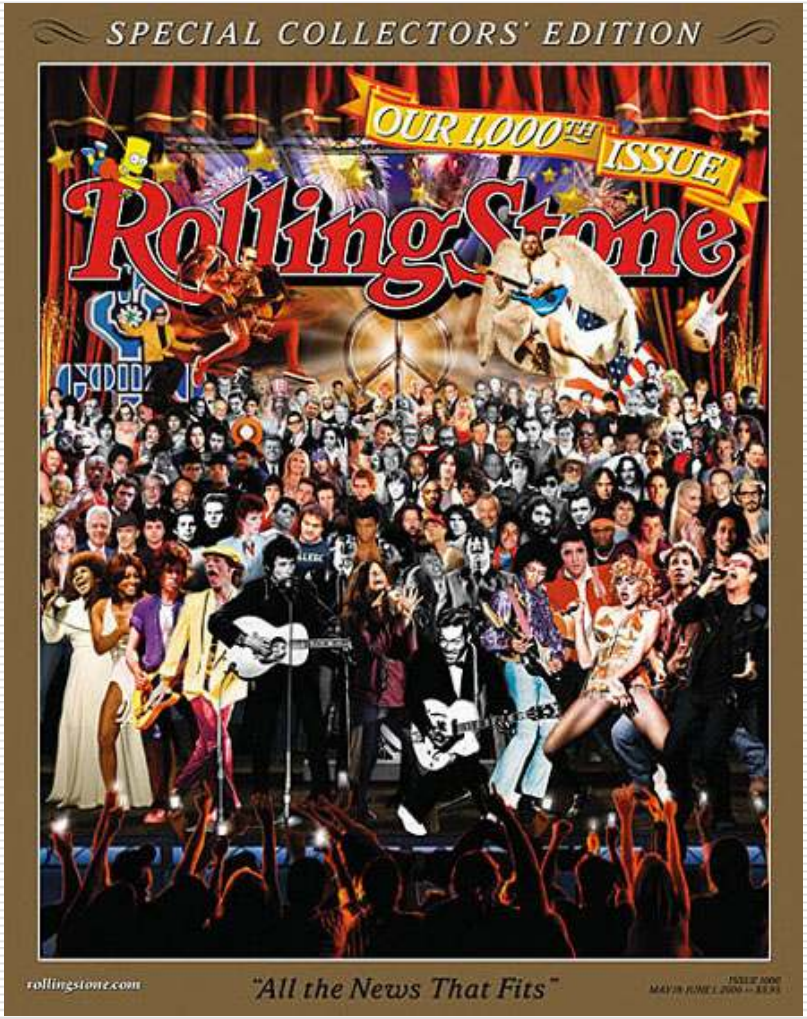
ELIZABETH H. BOQUET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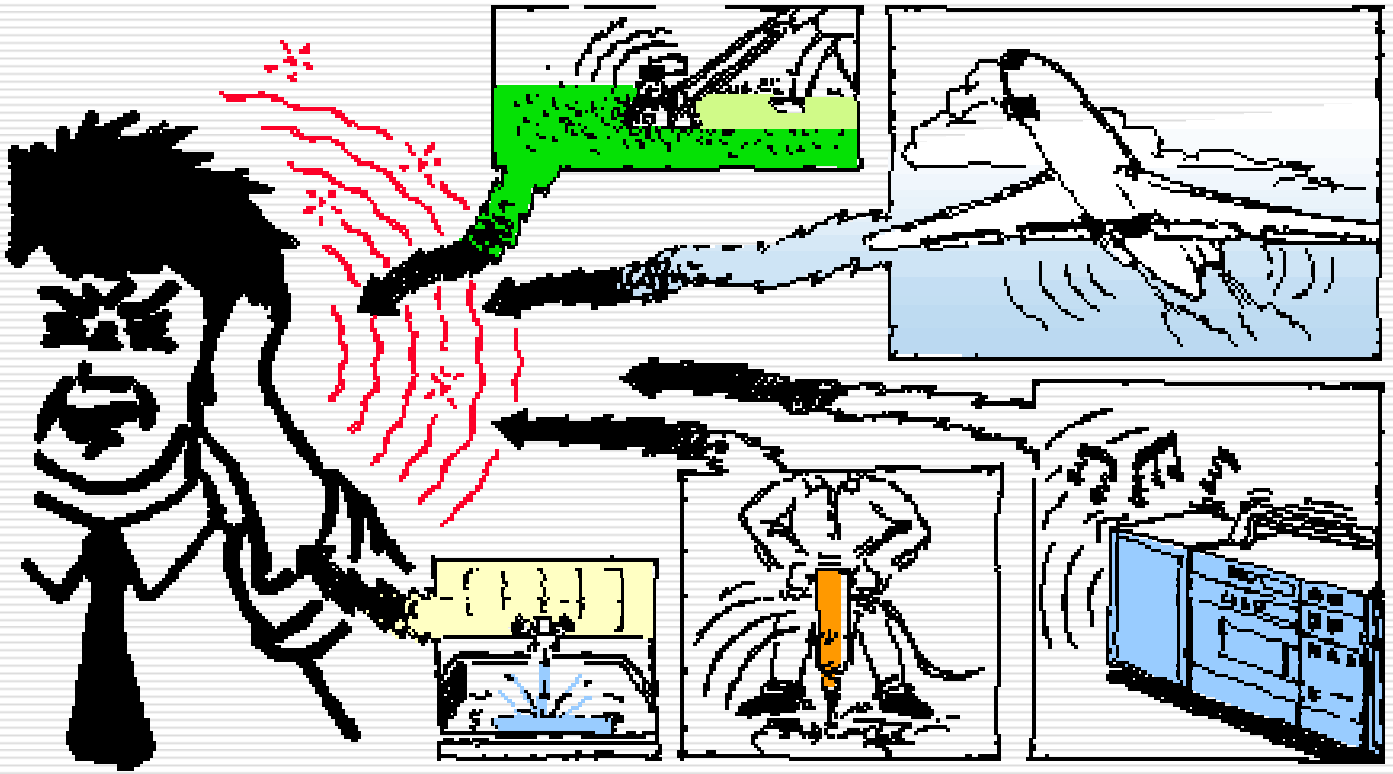
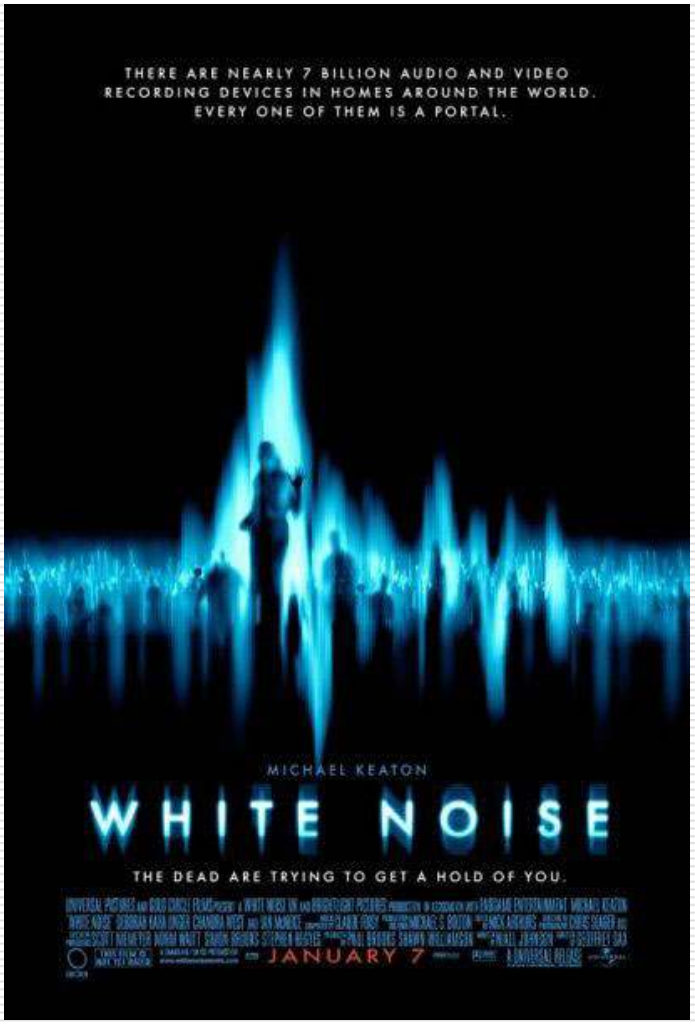
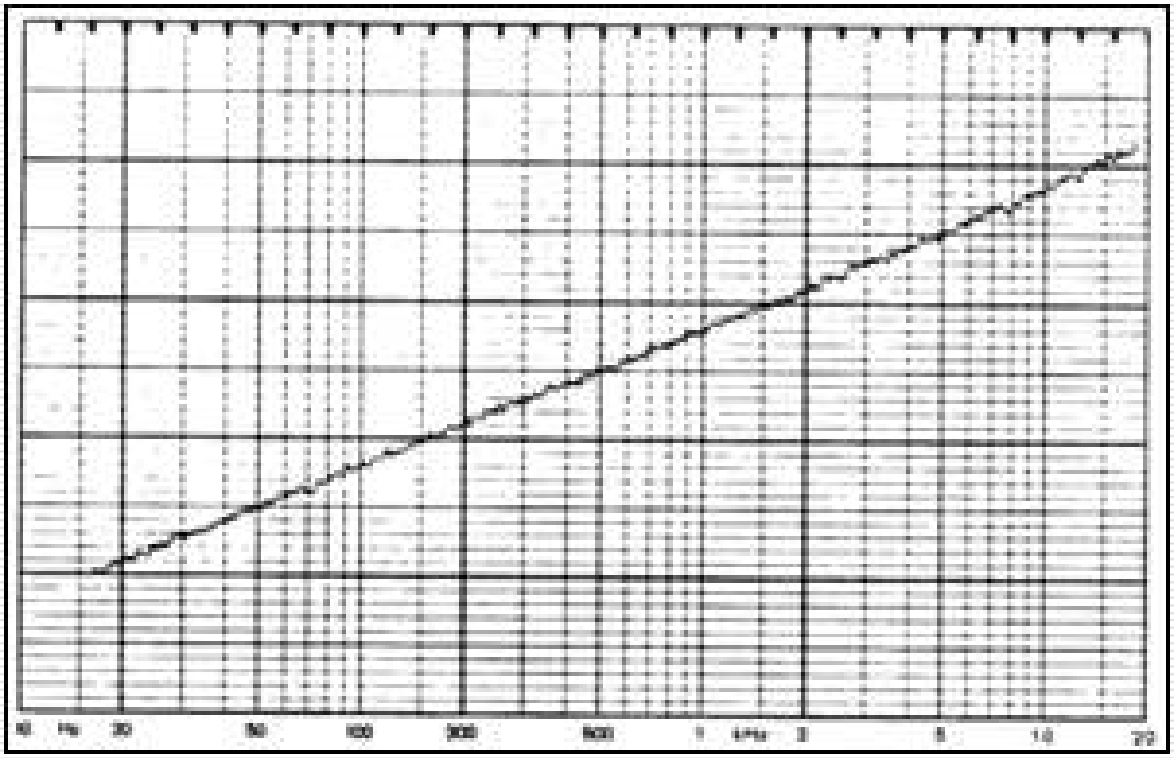



THERE ARE NEARLY 7 BILLION AUDIO AND VIDEO
RECORDING DEVICES IN HOMES AROUND THE WORLD.
EVERY ONE OF THEM IS A PORTAL.
MICHAEL KEATON
WHITE NOISE
THE DEAD ARE TRYING TO GET A HOLD OF YOU.
JANUARY 7

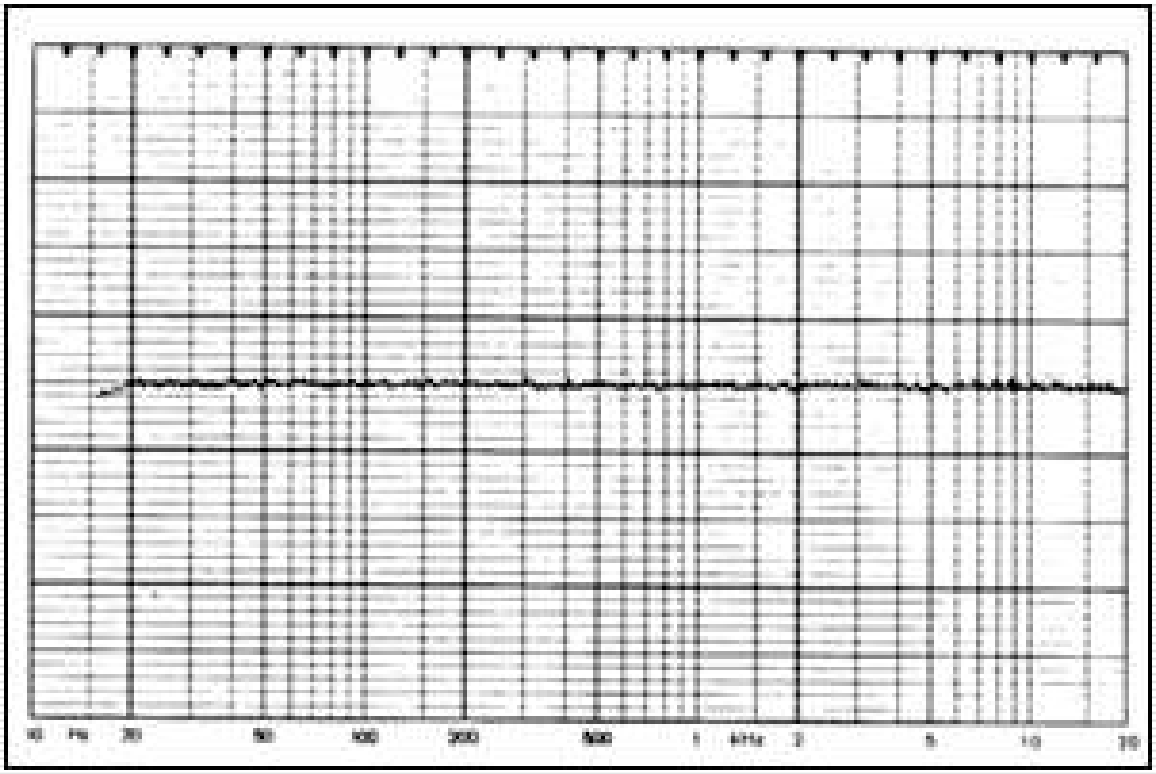
白色噪音 (White noise)

- 一連續的噪音，在八音階頻帶之各頻率有相同的功率
- 各中心頻率所對應之音壓位準均相同
- 聲音是呈指數關係而非線性關係
- 試著自己拿錄音機, 錄一段空白, 倒帶回去聽, 可以聽到"ㄙ~~"的細小聲音, 此即為白色噪音


Hz
30
50
100
300
500
1 kHz
3
5
10
20

粉紅色噪音 (Pink noise)

- 一連續頻譜的噪音，在八音階頻帶之各頻帶有相同的功率。
- 中心頻率每增加一倍，其對應之音壓位準降低3分貝


20
50
100
200
500
1 kHz
2
5
10
20

美國專家找到人類最早錄音檔

- 美國音史學家有了重大發現，最近找到由一名法國發明家於1860年錄下的一段民謠歌曲，同時成功地完成播放。
- 這段聲音比目前所知人類史上最早的錄音，也就是愛迪生（Thomas Edison）所發明的留聲機，還足足早了17年。
- 音史學家吉歐凡諾尼(David Giovannoni)：「真是太神奇了，好像鬼魂在對著你唱歌似的。」
- 實際上應該說愛迪生是第一個成功錄下聲音並且播放出來的人。

路透華盛頓970327電

噪音危害的特質

- 相當的主觀性
- 具時空差異性
- 考量兩種參數

Noise and health effects

- Noise exposure is associated with a number of health effects, including:
  - Biochemical changes
  - Psychosocial responses
  - Physical responses
  - Well-being

Psychosocial responses

- 軀體效應：植物性功能
- 前庭效應：平衡感、暈眩
- 活動妨礙：學習能力、工作表現
- 心理學性效應：認知、注意力
- 睡眠效應：干擾或有助睡眠
- Stress

Biochemical changes

- Endocrinal change
- Autonomic nerve system

Physical responses

- Hearing loss
- Blood pressure change
- Hypertension
- Cardiovascular disease risk

In Europe

- About 450 million persons are exposed daily to equivalent noise levels of at least 55 dBA.
- 113 million persons are exposed to equivalent noise levels of at least 65 dBA.
- 9.7 million persons are exposed to equivalent noise levels of 75 dBA or more.

In US

- 20 million persons are exposed to ordinary and harmful noise level.
- There are more than 28 million persons suffered from hearing loss.
- In them, hearing loss of 10 million persons attributed to noise-induced.

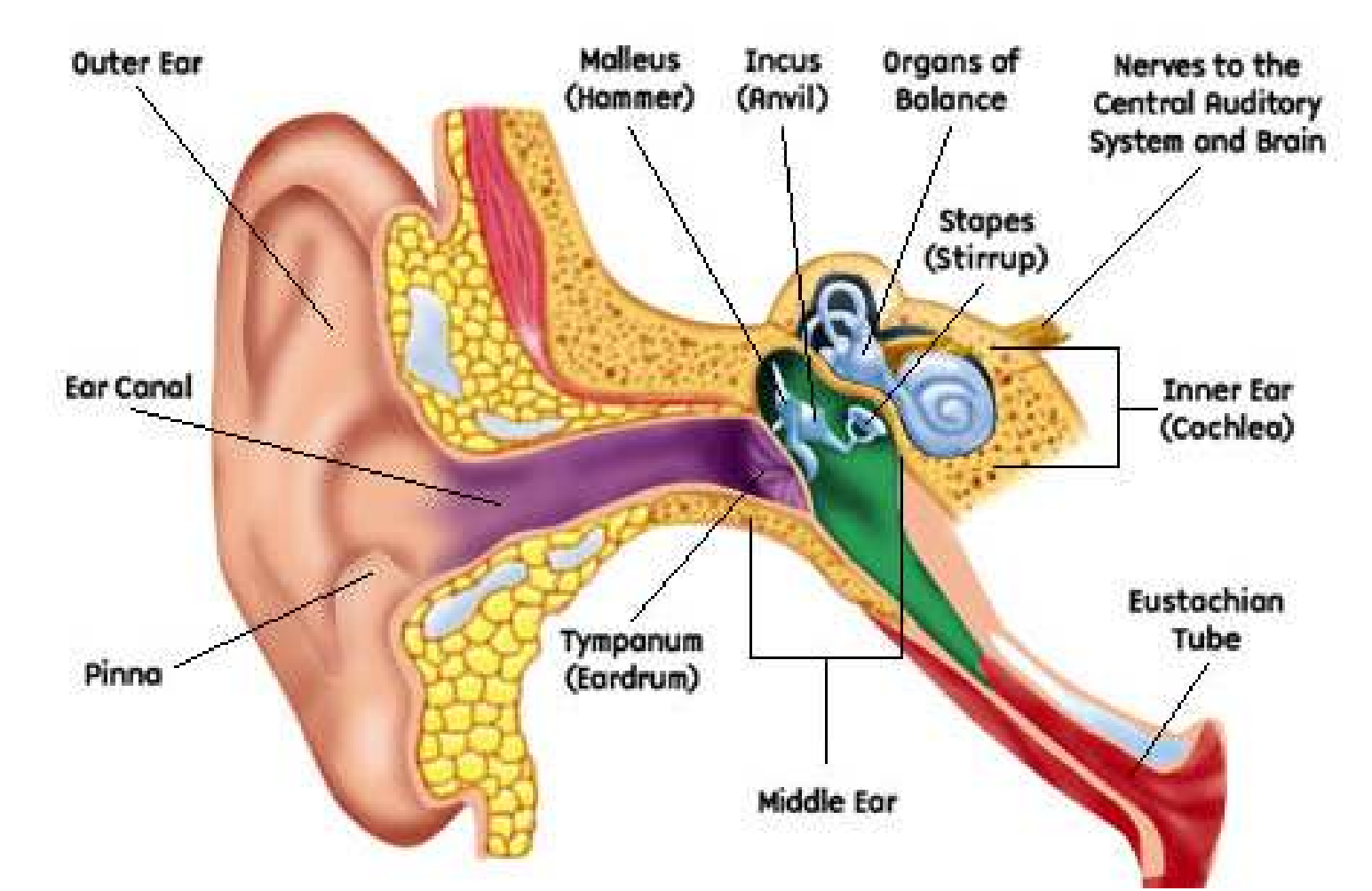
Biologic mechanisms

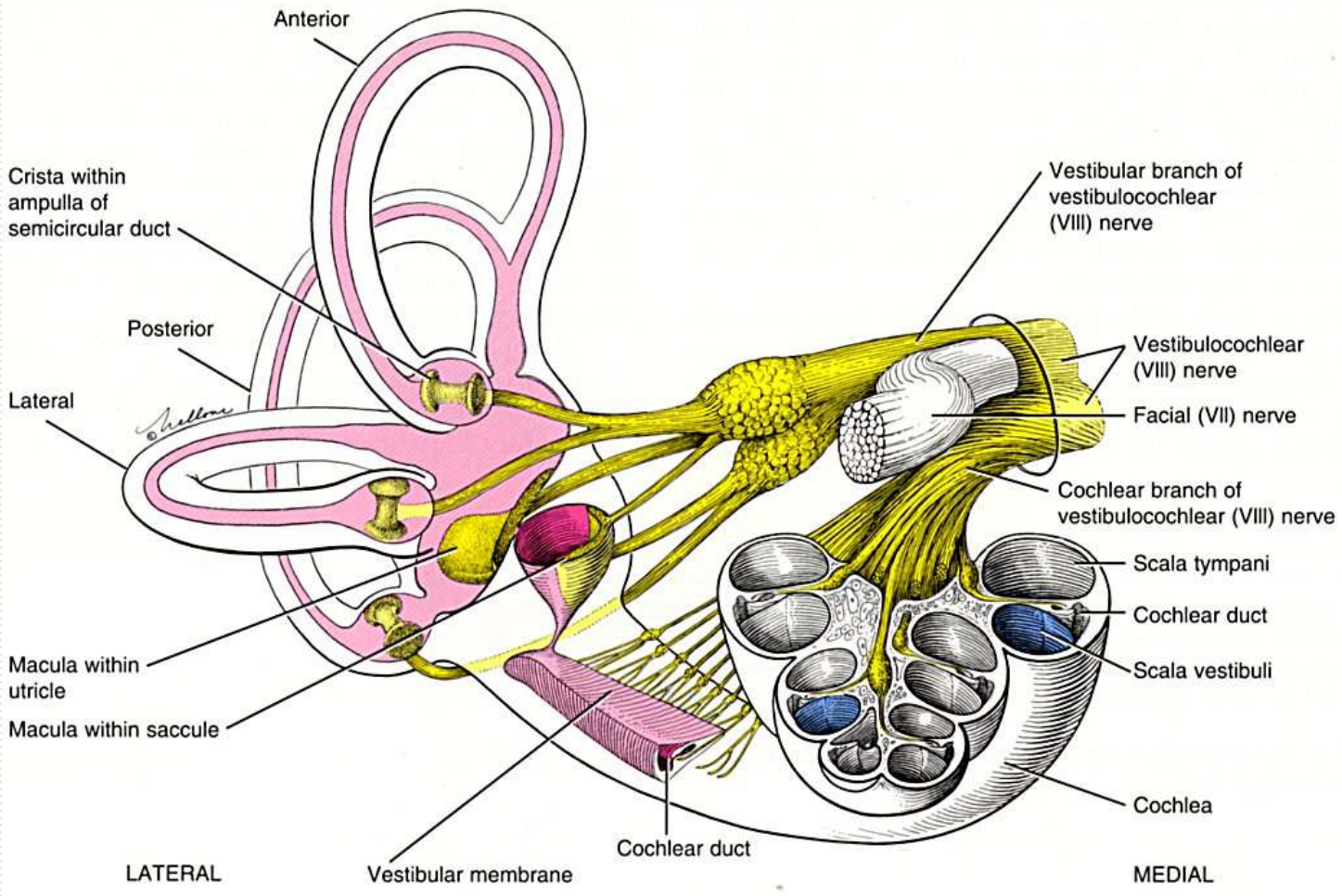
- These mark a common physiologic stress reaction of short duration that occurs as a consequence of the activation of the autonomous nervous and hormone system.
- The effect of noise on the auditory system is transmitted to the Reticular Arousal System and hormonal (hypothalamus-pituitary-adrenal axis) activity may be activated.

Biologic mechanisms

- Stress can be the consequence of the appraisal of noise.
- A stress situation can lead to the following effects, which are primary risk factors for coronary heart disease.

1. Directly as a result of stress.
2. Indirectly stress may affect human behavior and thus can contribute to cardiovascular disease.


Outer Ear
Malleus (Hammer)
Incus (Anvil)
Organs of Balance
Nerves to the Central Auditory System and Brain
Stapes (Stirrup)
Ear Canal
Inner Ear (Cochlea)
Eustachian Tube
Tympanum (Eardrum)
Pinna
Middle Ear

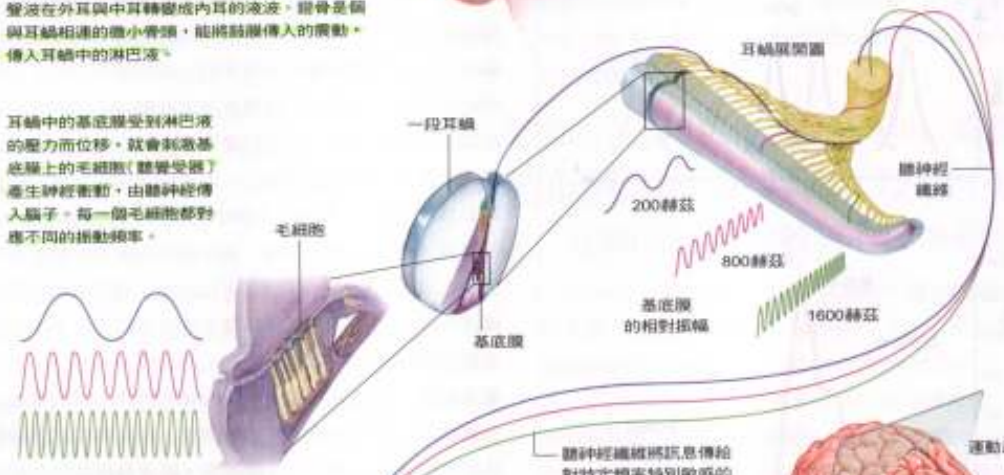


(b) Parts of the vestibulocochlear (VIII) nerve of the right ear

大腦處理音樂的機制

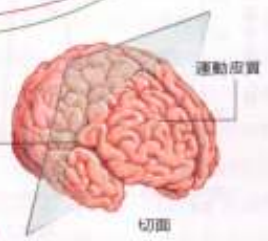
我們聽音樂的時候，腦子的反應涉及聽覺皮質以外的許多區域，其中有些通常涉及其他種類的思考過程。視覺、觸覺和情緒經驗都會影響腦子處理音樂的方式。

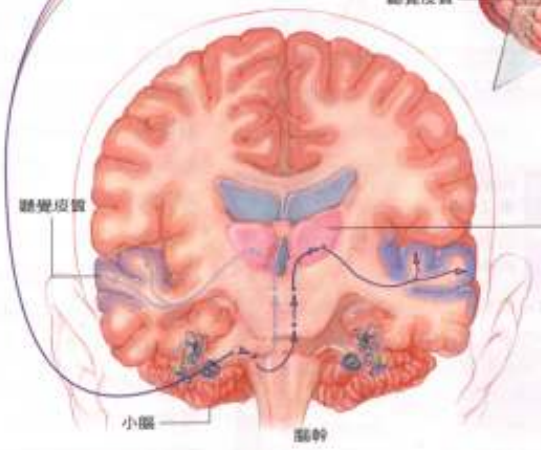
聲波在外耳與中耳轉變成內耳的液波。鎚骨是個與耳蝸相連的微小骨頭，能將鼓膜傳入的振動，傳入耳蝸中的淋巴液。



耳蝸中的基底膜受到淋巴液的壓力而位移，就會刺激基底膜上的毛細胞（聽覺受器），產生神經衝動，由聽神經傳入腦子。每一個毛細胞都對應不同的振動頻率。

聽神經纖維將訊息傳給對特定頻率特別敏感的神經元





腦子有個層級功能組織處理音樂，而且以分散模式處理。在大腦皮質聽覺區中，初級聽覺皮質是第一個處理站，接收耳朵傳來或其他低階聽覺系統經由視丘傳來的訊號，負責音樂知覺的早期階段，例如音高（頻率）與輪廓（音高變化的模式），它們都是樂曲的基礎。初級聽覺皮質會隨經驗而重新定調，對重要的聲音與樂音反應特別靈敏，這種因為學習而重新定調的結果，對後續的處理也會有影響。負責後續處理的區域包括次級聽覺皮質與相關的「聽覺聯合區」（處理比較複雜的音樂模式，例如和聲、曲調以及節奏）。

音樂家演奏的時候，腦子其他區域也會活躍，例如運動皮質與小腦，它們負責規劃與執行講究精確順序的特定動作。

聽力的範圍

頻率

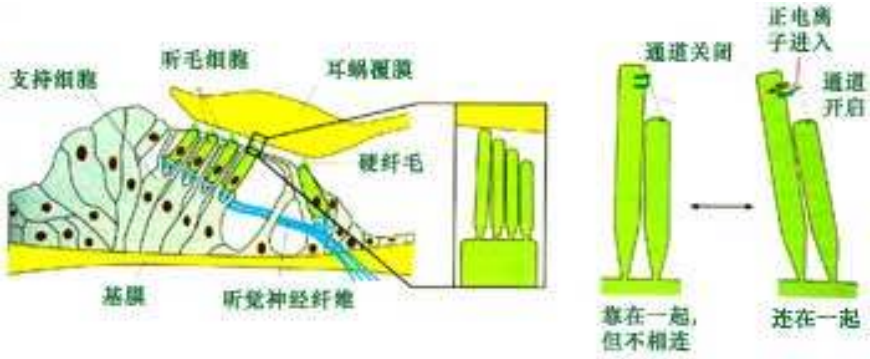
- 健康成年人 20-20,000 Hz
- 較敏感頻率 1,000-4,000 Hz

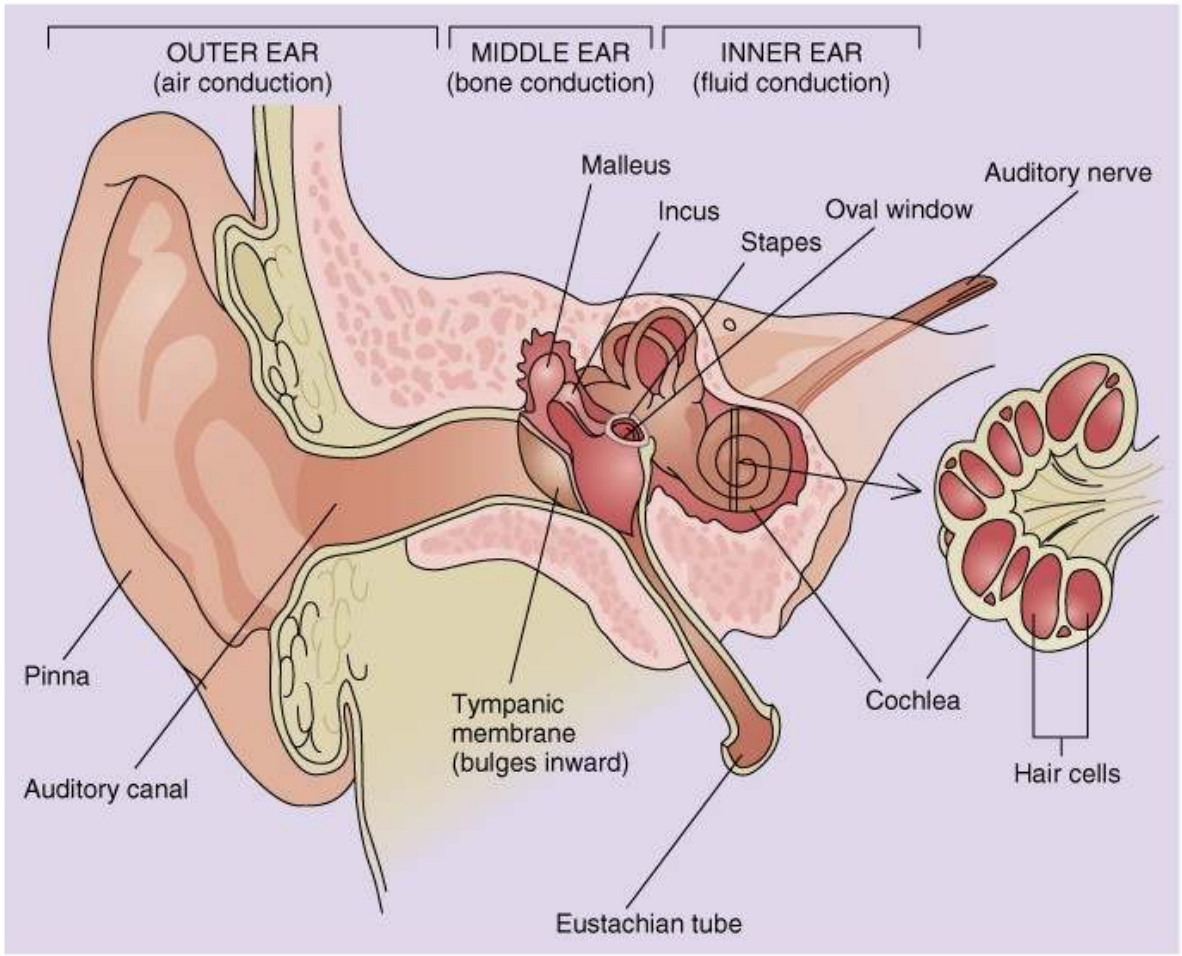
強度

- 0.0002-2000 μbars(dyne/cm2)
- 0-140 dB

聽力損失的結構變化

- 感覺細胞內
  1)微細的細胞內化學變化
  2)聽覺神經隆起
- 感覺細胞外
  1)血管變化
  2)代謝衰竭
  3)實體纖毛(Stereocillia)硬度局部降低
  4)可蒂氏體(Corti organ)剝離
  5)內耳其他結構傷害





何謂聽力損失性社會孤立感？

- 氣音字無法準確聽取
- 背景噪音與雞尾酒效應
- 於社交活動中必須努力集中注意力
- 導致疲勞、焦慮、與壓力
- 開始減少社交活動參與
- 影響個人、朋友與家庭

關鍵音量值

50 dB：引起腦電波圖變化

55 dB：改變睡眠姿勢

70 dB：心率、血壓增高

75 dB：開始影響聽覺，尚不致發生永久性聽力損失

85 dB：勞工必須實施特殊健康檢查

90 dB：勞工每天暴露不得超過8小時

120 dB：勞工不得有任何時間之暴露

140 dB：開始產生痛覺

5分貝原則 (5dB rule)

經由聽力損失的實測調查發現，噪音暴露時間減半能被一5分貝音量的變化所抵消；亦即噪音導致暫時性聽力損失，每增加5dB相當於暴露時間加倍，係為達勞工暴露於噪音之預防目的，而被OSHA採用。

3分貝原則 (3dB rule)

假設總噪音能量是噪音性聽力損失的預測值，依據劑量或暴露的總能量理論來定義；每增加3dB，容許暴露時間減半，亦即為了預測由不同暴露所導致噪音性聽力損失數量之目的而被ISO使用。

物理性工業性聽力損失之成因

- 噪音
- 振動
- 異常氣壓

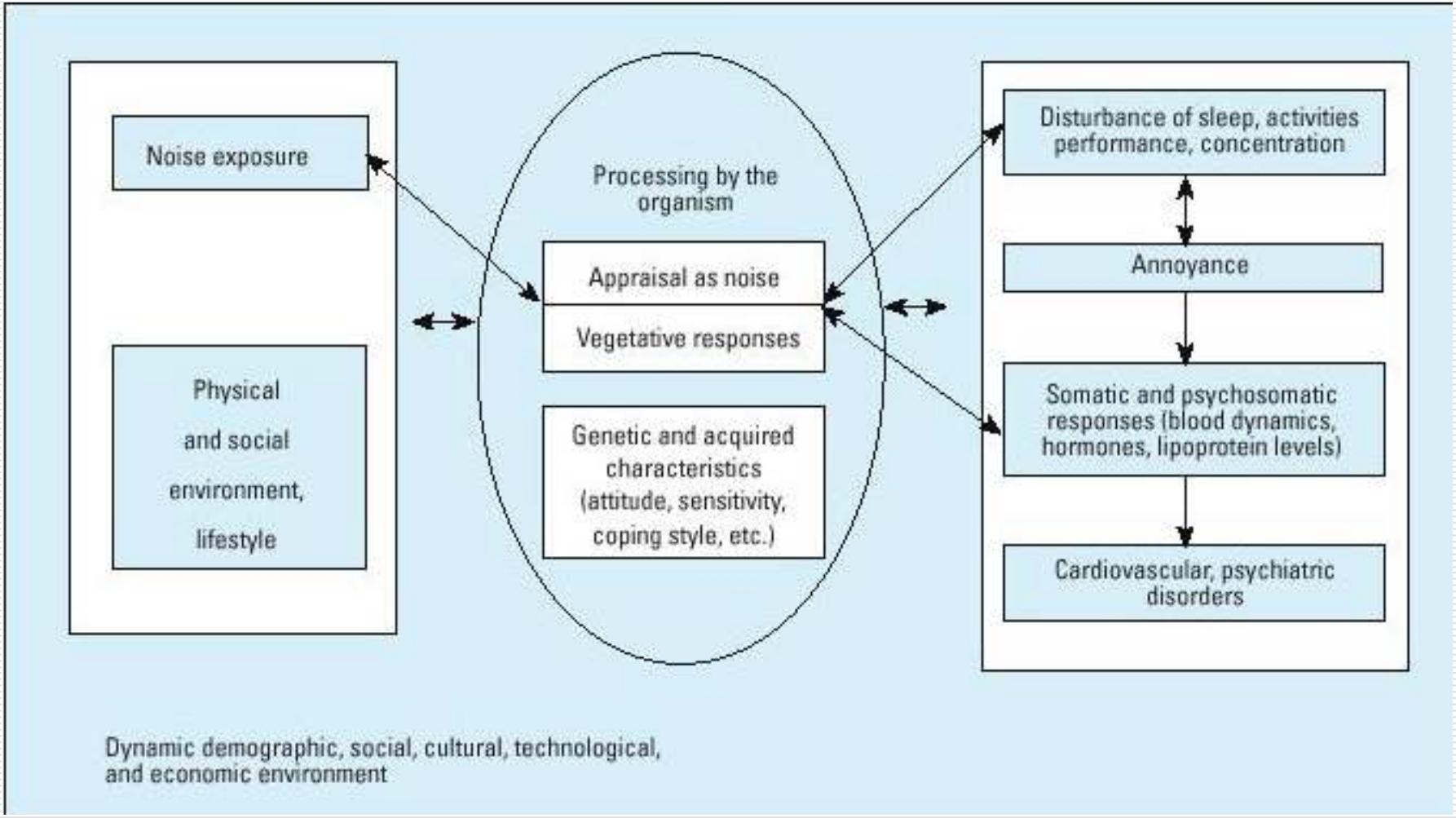
化學性工業性聽力損失之成因

- 有機溶劑
  - Trichloroethylene
  - Xylene
  - Styrene
  - Hexane
  - Carbon disulfide
  - Toluene
  - Carbon monoxide
  - Butyl nitrite
- 重金屬
  - Arsenic
  - Mercury
  - Tin
  - Lead
  - Manganese

影響聽力損失的因素

- 音量
- 暴露時間
- 頻率特性
- 個人因素

  種族、年齡、膚色、性別、性向、健康情形
- 其他：運動、抽煙、聽覺性毒藥物等等


Noise exposure
Physical and social environment, lifestyle
Processing by the organism
Appraisal as noise
Vegetative responses
Genetic and acquired characteristics (attitude, sensitivity, coping style, etc.)
Disturbance of sleep, activities performance, concentration
Annoyance
Somatic and psychosomatic responses (blood dynamics, hormones, lipoprotein levels)
Cardiovascular, psychiatric disorders
Dynamic demographic, social, cultural, technological, and economic environment

Noise and Blood pressure

Study of noise exposure and high blood pressure in shipyard workers

- A cross-sectional and case-reference study
- Occupational noise exposure in a shipyard company
- Higher noise environment >85dBA; lower noise environment <80dBA
- Adjusted for age, employment duration, BMI
- Subjects: 4500-3748-2730-158-63

Am J Ind Med 1987

- **158 male workers from higher noise environment had higher SBP and DBP than158 matched lower noise exposure workers**
- **Based on 63 matched hypertensive-normotensive pairs from 2730 shipyard workers, RR of hypertension among workers exposed to an over-85-dBA acoustic environment, compared to those under 80 dBA, was 2.38**

Am J Ind Med 1987

Is hearing loss appropriate as a noise exposure index?

Study of noise exposure and high blood pressure in shipyard workers

- A cross-sectional study
- Occupational noise exposure; noise-induced hearing loss
- A dip shape of audiogram at 4000 Hz
- Without family history of hypertension
- Subjects: 300-151
- Adjusted for age, employment duration, BMI

Int Arch Occup Environ Health 1987

- **R^2= 0.16 and 0.12 for SBP and DBP**
- **There was no significant relationship between hearing loss and blood pressure**
- **Multiple regression and analysis of covariance**
- **Hearing loss is not appropriate as a noise exposure index**

Int Arch Occup Environ Health 1987

Subjects standardized?

Effects of noise exposure and task demand on cardiovascular function

- Task demands: abacus and mental arithmetic
- 20 male and 20 female senior high school student with equivalent abacus performance rating
- 6 experimental sessions(60, 85 or 90 dBA white noise and task presence or absence)
- Time limit set for each session was 33 min

Int Arch Occup Environ Health 1988

- **Within-subjects design**
- **Effect of noise exposure on task performance is remarkable**
- **Noise exposure tended to influence the performance of male in abacus arithmetic**
- **Effect of task demand on blood pressure was higher than that of noise exposure**
- **No interaction effect (noise exposure x task demand) on blood pressure was found via analyses of within-subjects two-way ANOVA**

Int Arch Occup Environ Health 1988

Confounding factors

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Preventive Medicine 40 (2005) 138–144

Preventive Medicine

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Effect of smoking on hearing loss: quality assessment and meta-analysis

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Available online 1 July 2004

Alcohol and Alcoholism Vol. 34, No. 5, pp. 741-749, 1999

FREQUENCY SELECTIVE EFFECTS OF ALCOHOL ON AUDITORY DETECTION AND FREQUENCY DISCRIMINATION THRESHOLDS

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Department of Psychology, The University of Western Ontario, London, Ontario, Canada N6A 5C2

Received 9 September 1998; in revised form 13 January 1999; accepted 10 March 1999

Cohort study

A Prospective Study of Noise Exposure during Pregnancy on Birthweight

Am J Epidemiol
1996; 143:792-796

Blood pressure and BMI

Who has lowest blood pressure?

Comparison of BP in deaf-mute and normal children

- A cross-sectional study
- Subjects: 583 normal hearing children and 309 deaf-mute children
- Deaf-mute subjects had lower blood pressure
- R^2= 0.17 and 0.15 for SBP and DBP

Int Arch Occup Environ Health 1993

Hearing ability in Taiwan

Surveillance of Noise-Induced Hearing Loss in Taiwan, ROC

Frequency and Mean of Hearing Ability (dB) at 4K Hz in the Weakest Ear by Sex

Sex	<40 dB *n* (%)	40–55 dB *n* (%)	>55 dB *n* (%)	Total	Mean (SD)[a]
Male	4,267 (60.3)	1,607 (22.7)	1,200 (17.0)	7,074	36.8 (20.1)
Female	1,947 (82.7)	278 (11.8)	129 (5.5)	2,354	29.7 (15.1)
Total	6,214 (65.9)	1,885 (20.0)	1,329 (14.1}	9,428[b]	35.0 (19.3)

[a] SD, standard deviation.
[b] 35 missing data could not be categorized.

Preventive Medicine 1998

Surveillance of Noise-Induced Hearing Loss in Taiwan, ROC

Frequency and Mean of Hearing Ability (dB) at 4K Hz in the Weakest Ear by Age

Age (years)	<40 dB *n* (%)	40–55 dB *n* (%)	>55 dB *n* (%)	Total	Mean (SD)[a]
<20	306 (87.9)	32 (9.2)	10 (2.9)	348	30.7 (11.0)
20–29	1,462 (84.2)	185 (10.7)	89 (5.1)	1,736	26.0 (15.8)
30–39	2,604 (70.3)	692 (18.7)	406 (11.0)	3,702	32.9 (17.5)
40–49	1,439 (55.5)	683 (26.4)	470 (18.1)	2,592	39.4 (19.3)
50–59	330 (39.2)	244 (29.0)	268 (31.8)	842	47.1 (21.2)
≥60	40 (26.3)	34 (22.4)	78 (51.3)	152	58.9 (26.0)
Total	6,181 (65.9)	1,870 (20.0)	1,321 (14.1)	9,372[b]	35.0 (19.3)

[a] SD, standard deviation.
[b] 91 missing data could not be categorized.

Preventive Medicine 1998

Surveillance of Noise-Induced Hearing Loss in Taiwan, ROC

Frequency and Mean of Hearing Ability (dB) at 4K Hz in the Weakest Ear by Industry

Industry	<40 dB *n* (%)	40–55 dB *n* (%)	>55 dB *n* (%)	Total	Mean (SD)[a]
Food processing	235 (69.3)	66 (19.5)	38 (11.2)	339	36.4 (14.6)
Alcohol and cigarette manufacturing	666 (81.0)	110 (13.4)	46 (5.6)	822	30.4 (16.7)
Spinning	522 (77.4)	122 (18.1)	30 (4.5)	674	32.8 (14.7)
Paper products	498 (80.1)	99 (15.9)	25 (4.0)	622	33.5 (10.1)
Oil refining	229 (62.1)	92 (24.9)	48 (13.0)	369	32.8 (20.4)
Chemical industry	318 (83.0)	52 (13.6)	13 (3.4)	383	35.9 (13.1)
Steel making	827 (70.1)	201 (17.0)	152 (12.9)	1,180	34.3 (19.3)
Electric machinery manufacturing	485 (94.5)	21 (4.1)	7 (1.4)	513	31.0 (6.6)
Ship building and repairing	788 (52.3)	430 (28.5)	290 (19.2)	1,508	38.6 (21.1)
Power supplying	425 (73.8)	96 (16.7)	55 (9.5)	576	33.8 (16.4)
Construction	80 (37.2)	52 (24.2)	83 (38.6)	215	48.3 (22.7)
Transportation	276 (87.9)	19 (6.1)	19 (6.1)	314	15.5 (8.3)
Metal working	65 (78.3)	11 (13.3)	7 (8.4)	83	31.5 (20.1)
Weapon manufacturing	43 (72.9)	8 (13.6)	8 (13.6)	59	39.0 (20.2)
Other or missing	1,121 (62.7)	345 (19.3)	324 (18.1)	1,790	37.3 (17.3)
Total	6,578 (69.6)	1,724 (18.2)	1,145 (12.1)	9,447[b]	35.0 (19.3)

[a] SD, standard deviation.
[b] 16 missing data could not be categorized.

Preventive Medicine 1998

Interaction

Lead and Noise on Hearing ability

Table 4.—Multiple-Regression Analysis (Model 2) of Hearing Ability in 200 Lead-Battery Manufacturing Workers

Variables	Hearing ability (dB)		
	Regression coefficient	*SE*	*p*
Sex (males vs. females)	7.17	3.70	.05
Age (+ 1 y)	1.09	0.13	< .01
Smoking (yes vs. no)	3.33	3.71	.37
Alcohol drinking (yes vs. no)	7.84	3.55	.03
Noise level (+ 1 dBALeq)	0.07	0.25	.77
Long-term lead-exposure index	0.02	0.01	< .01

Notes: *SE* = standard error; $R^2 = 0.3197$.

Arch Environ Health 2000

職業鉛與噪音暴露對於聽覺能力影響

- 鉛蓄電池工廠71員工，白領人員51人，全部為男性。
- 非暴露組各頻率與取對數後的血鉛值無統計上顯著意義。暴露組則是在2k、4k與6k有統計上顯著意義（$P<0.05$），且為正相關（$r=0.26\sim0.40$）。
- 在控制噪音暴露量與其他干擾因子後，每增加1個單位的Log PbB 4k與6k頻率的聽力閾值會分別增加12與13分貝，年齡在控制其他干擾因子後每增加1歲，4k與k6頻率的聽力閾值會增加約1分貝。

勞工安全衛生季刊 2005

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ScienceDirect
Science of the Total Environment 387 (2007) 79–85
Science of the Total Environment
www.elsevier.com/locate/scitotenv

A case-control study on the relationship of hearing function and blood concentrations of lead, manganese, arsenic, and selenium

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Hearing Loss in Workers Exposed to Carbon Disulfide and Noise

- In this study we investigated hearing loss in 131 men with exposure to noise [80-91 A-weighted decibels ; dB(A)] and CS2 (1.6-20.1 ppm) in a viscose rayon plant.
- The study suggests that CS2 exposure enhances human hearing loss in a noisy environment and mainly affects hearing in lower frequencies.

Environ Health Perspect 2003

Hearing Loss in Workers Exposed to Toluene and Noise

- 58 workers at an adhesive materials manufacturing plant who were exposured to both toluene and noise [78.6–87.1 A-weighted decibels ; dB(A)], 58 workers exposed to noise only [83.5–90.1 dB(A)], and 58 administrative clerks [67.9–72.6 dB(A)] at the same company.
- results suggest that toluene exacerbates hearing loss in a noisy environment, with the main impact on the lower frequencies.

Environ Health Perspect 2006

行動電話使用者之聽力調查

- 第一個針對17-20歲青年人族群，探討使用行動電話與聽力狀況的研究。
- 研究結果顯示行動電話對使用者聽力閾值之影響為在1kHz。
- 比較有使用耳機接聽與不用者之聽力損失，在右耳500Hz達到統計上顯著意義(P=0.034)，但在其他頻率的迴歸係數均相當高，似乎意味著使用耳機接聽對於聽力損失可能有保護作用。
- 本研究使用受試者的每月平均帳單金額配合費率換算，來評估其電磁波暴露量，此方法比直接引用問卷所填寫之行動電話使用情形有較少回憶性偏。
- 本研究結果顯示，行動電話使用量與聽力損失雖未觀察到具臨床上意義之關聯性，但由於所選擇對象之暴露期間較短(平均1.3年)，仍有做長期之世代追蹤觀察其變化情形之必要。

Pre-occupational training programs

餐廚人員與聽力損失

Table 2. Demographic characteristics of study objects - mixology course

		Mixology course n=129	Non-mixology course n=155	P-value
Age(y)[c]		19.92±0.79	20.38±1.57	0.01*
Gender[b]	Male	34(26.4)	66(42.6)	0.01*
	Female	95(73.6)	89(57.4)	
Hearing Threshold (dB)[c]				
	R1K	12.44±5.56	11.84±5.03	0.34
	R2K	8.49±5.47	6.90±5.68	0.02*
	R3K	6.59±5.66	6.23±5.33	0.58
	R4K	6.09±5.96	5.32±5.60	0.27
	R6K	8.99±8.56	7.90±7.43	0.26
	L1K	11.55±6.05	9.58±6.40	0.005*
	L2K	8.53±6.33	6.74±5.77	0.01*
	L3K	6.94±6.41	7.03±6.21	0.90
	L4K	7.29±7.55	6.19±6.65	0.20
	L6K	8.37±9.13	7.29±8.59	0.31
DMFT(Tooth)[c]		5.88±3.65	4.58±3.72	0.01*
Blood lead level (μg/dL)[c]		3.17±1.20	2.67±0.83	<0.001*

c Independent-sample T test -- mean±SD

b $\chi 2$ test or Fisher-Exact test -- N(%)

* $P < 0.05$

NSC 2005

感想

- The biologic mechanism of the relation between noise exposure and cardiovascular effects seems plausible but is very complex
- The results of meta-analysis are consistent with a slight increase of cardiovascular disease risk in populations exposed to air traffic and/or road traffic noise
- Complexity with regard to noise and health
- Limitations in exposure characterization
- Adjustment for important confounders

噪音危害之預防與管制

- 評估噪音危害程度
- 訂定與實施聽力保護計畫
- 工程改善
- 行政管理
- 工業衛生教育
- 聽力測試評估
- 加強遵循政府有關規定
- 聽力防護設備

有夢最美

悲觀的人看到花謝的悲傷
樂觀的人看到花開的燦爛
達觀的人看到花果的希望