音頻系統的聲音品質
Sound Quality of Audio Systems

Part 9: 可聽的信號失真
Part 9: Audibility of Signal Distortion

2024

Klippel GmbH

主觀評估與客觀量測間的關係
Relationship Between Objective Measurement and Subjective Evaluation

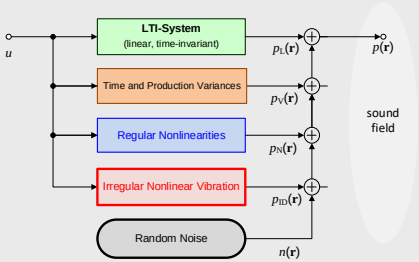
客觀量測 Objective Measurement

- 模擬的基礎與限制
  based on and limited by modeling
- 特性只反應在特殊性質
  Characteristics reflect selected properties only
- 太複雜的以及激發信號,揚聲器,室內,耳朵,以及聆聽者的期盼間的影響皆無法考慮
  can not consider full complexity and interaction between stimulus, speaker, room, ear, listener 's expections

聆聽測試 Listening Test

- 反應聆聽者的感知與喜好
  reflects listener 's sensations and preference
- 須要測試的方案
  requires test strategy (double-blind, psychometrics, ...)
- 消耗時間
  time-consuming→ expensive
- 結果取決於聆聽的條件,聆聽者的經驗與訓練,
  results depends on listening condition, listener 's training & experience

基於輸出的測量 IEC 60268-21
Output-Based Measurements IEC 60268-21



Neglecting distributed nonlinearities
(e.g. nonlinear break-up modes)

Sound Power $H_\Pi(f,r)$ response (IEC 60268-21)

Room Transfer Function $H_{room}(f, r)$ (IEC 60268-23 in progress)

Rated maximum SPL (IEC 60268-21)

Max SPL

Rated maximum input signal (IEC 60268-21)

u_{max}

Amplitude Compression C(f) (IEC 60268-21)

$H_\Pi(f)$ → Π → $H_{room}(f,\mathbf{r})$ → $p_{room}(\mathbf{r})$

u → $H_V(f\,|t)$ → $H_L(f,\mathbf{r})$ → $p_{dir}(\mathbf{r})$ → $p(\mathbf{r})$ sound field

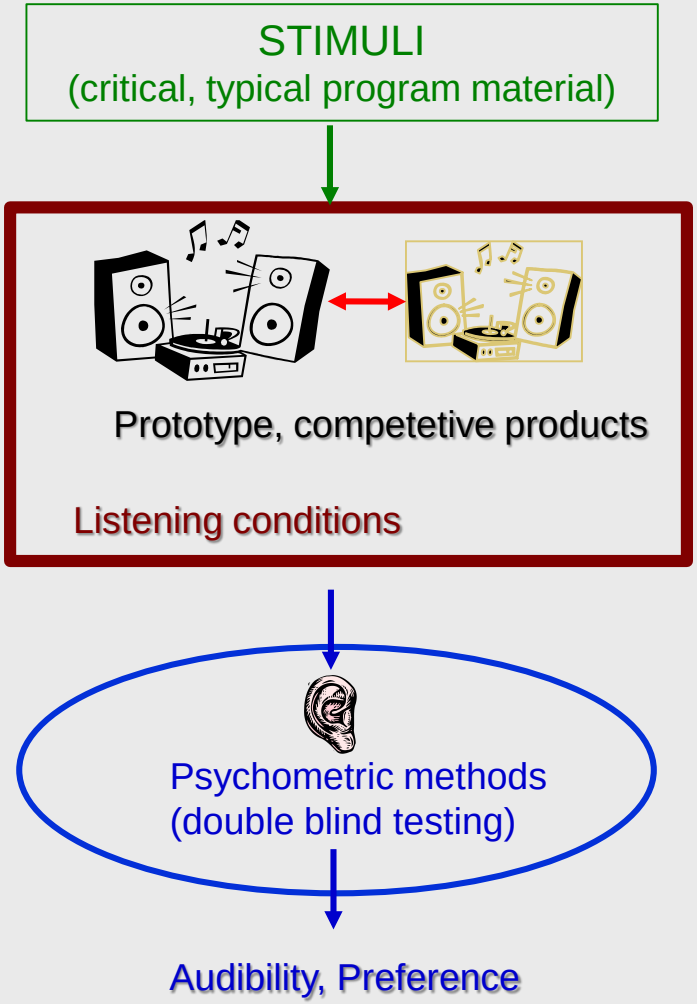
Spatial transfer function $H_L(f,r)$ (IEC 60268-21)

u_{EID} → $\mathbf{N}_I$ → Irregular Distortion

Equivalent input distortion for multi-tone stimulus (IEC 60268-21)

impulsive distortion measurement with chirp stimulus (IEC 60268-21)

聆聽測試
Listening Tests



如何讓聆聽測試更有效率?

How to make listening test more effective ? (meaningful, valid, reliable data in a shorter time !!)

如何解決處裡聆聽環境的影響?

How to cope with the influence of the listening conditions (stimuli, room, location) ?

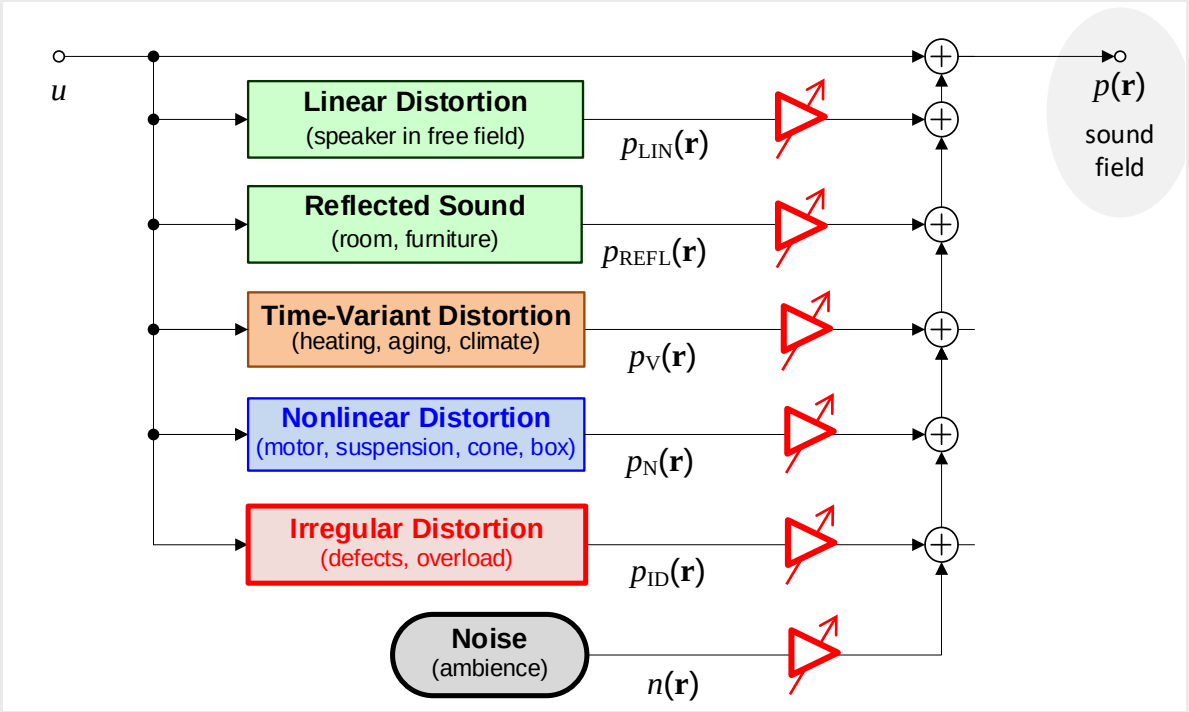
如何了解物理上、失真聽趕上以及產品特色上的關係?

How to understand relationship between physics, audiblity of distortion and preferance of the product ?

→ Auralization Techniques

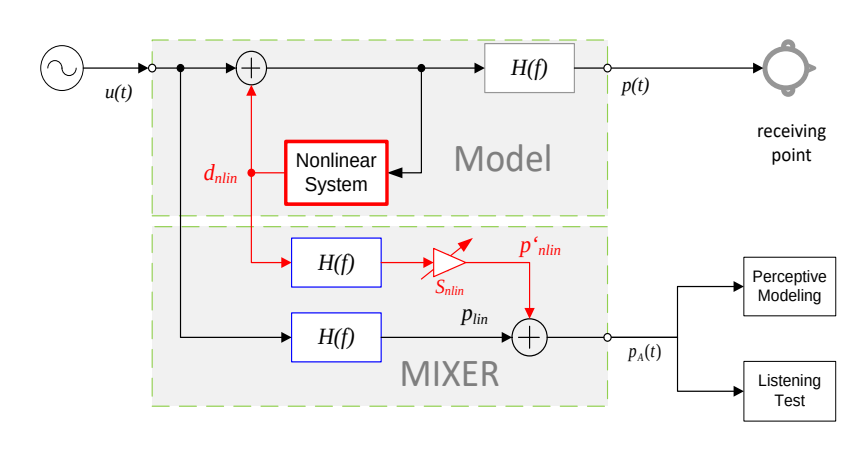
Reduce complexity of the testing
Focus on critical questions, hypothesis
Systematic test using virtual loudspeaker modifications

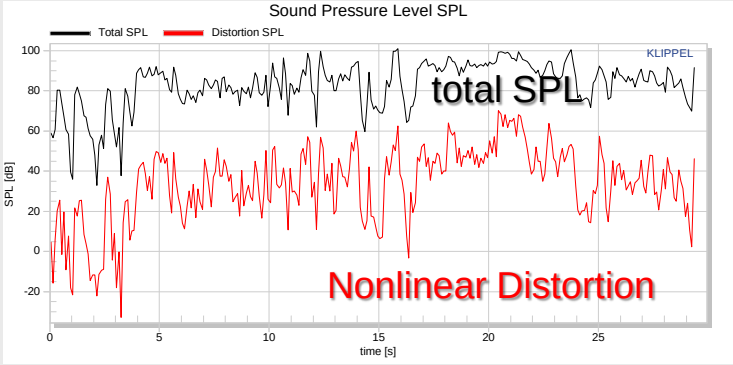
可聽化的訊號失真
Auralization of Signal Distortion



客觀 OBJECTIVE:
失真成份虛擬的強化或衰減
Virtual enhancement or attenuation of the distortion components

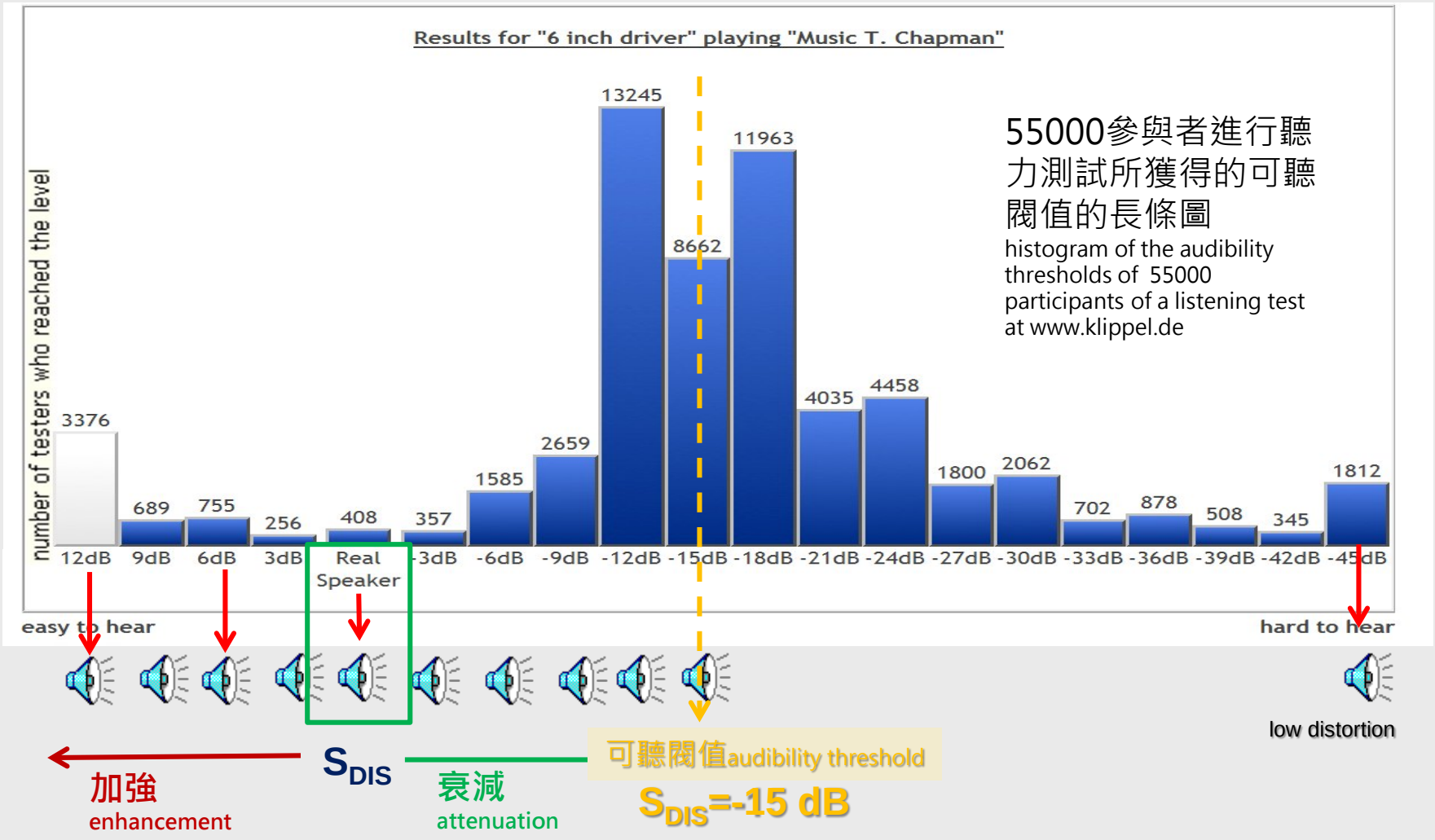
規則非線性失真的聽感
Auralization Regular Nonlinear Distortion
(e.g. related to loudspeaker design)



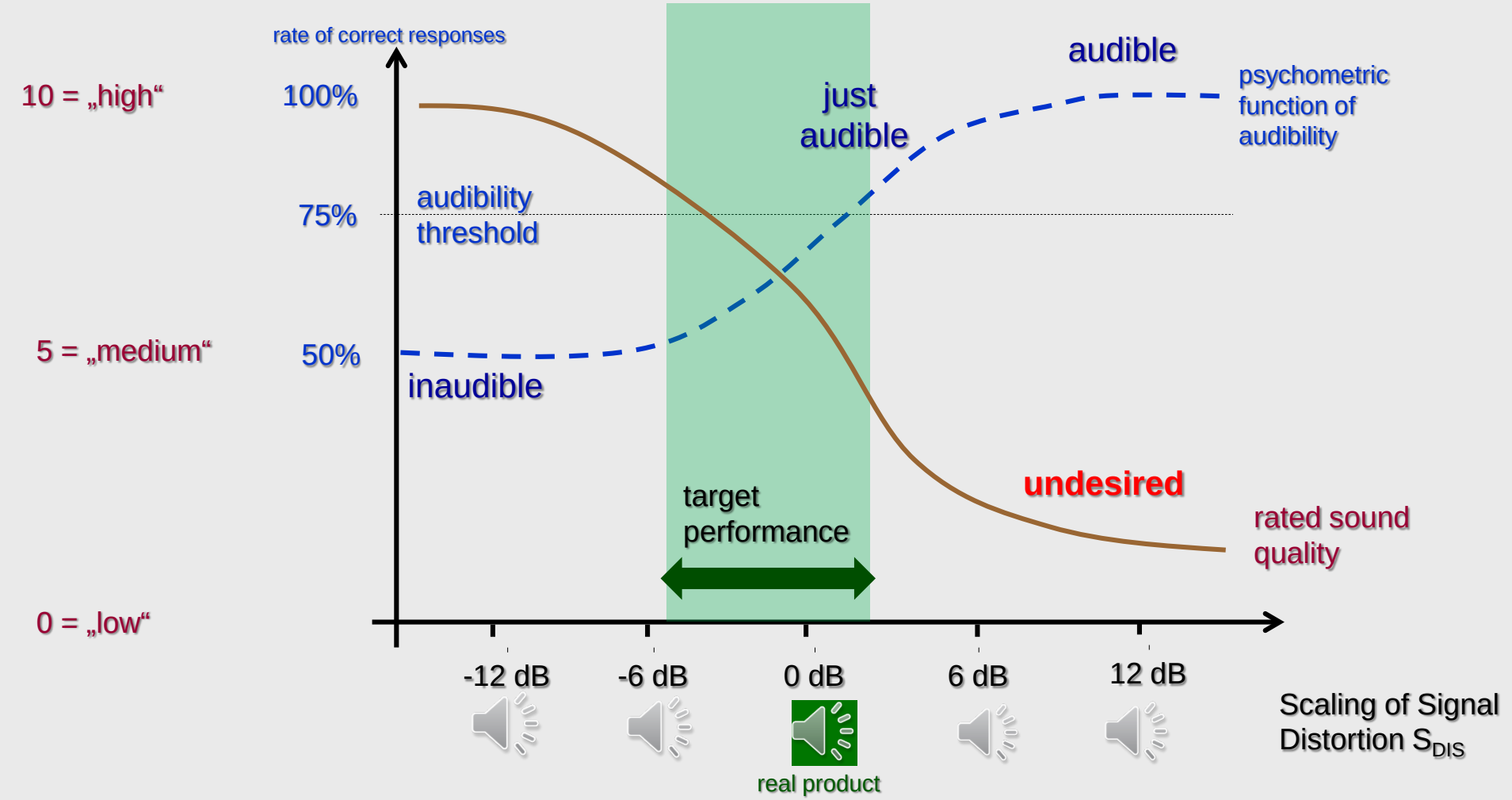


- **分離線性與非線性失真**
  Separates linear signal from nonlinear distortion.
- **定量每種非線性的失真成分**
  Assess the distortion component quantitatively generated by each nonlinearity
- **利用調整失真的大小來產生本質上的輸出訊號**
  Generate virtual output signals by scaling the distortion arbitrary
- **調查聲音品質的聽感與影響**
  Investigate the audibility and impact on sound quality
- **在目標應用的部分，評估揚聲器的聽感表現**
  Evaluate the audile performance of the speaker in the target application.

找到可聞聲的閥值
Finding Audibility Thresholds



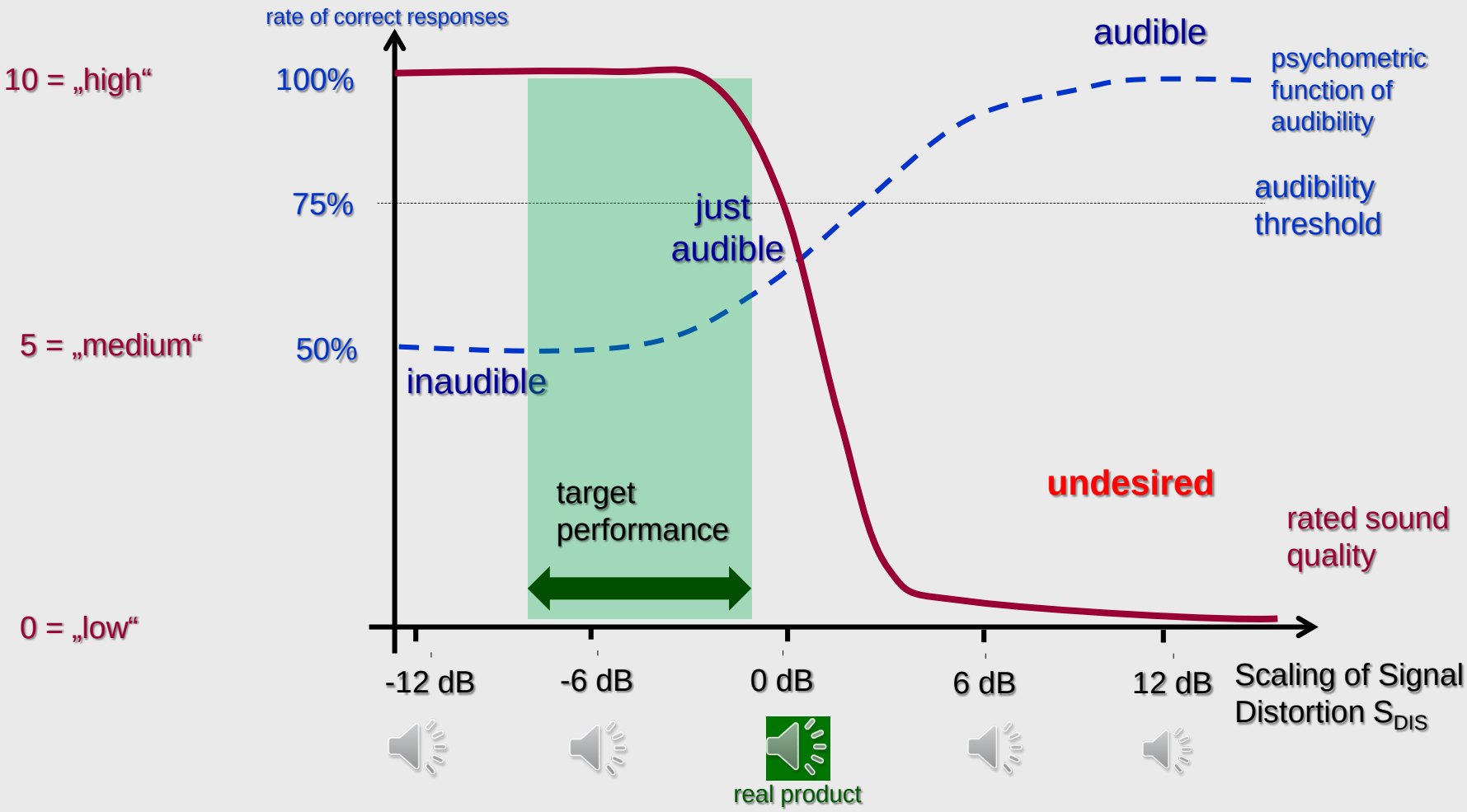
聽感與喜好-來自於驅動與懸吊系統
Audibility and Preference
Distortion generated Motor and Suspension



聽感與喜好-來自於R&B所造成的脈衝失真以及其他缺陷

Audibility and Preference

Impulsive distortion generated by rub&buzz and other loudspeaker defects



總結Summary

- 感知的音頻質量不僅取決於 DUT，還取決於測試條件（刺激、房間、氛圍、測試策略）The perceived audio quality depends not only on the DUT but also on the test condition (stimulus, room, ambience, test strategy)
- 失真分量可以作為建模和測量的殘餘物分離Distortion components can be separated as a residuum of modeling and measurement
- 可聽化技術可以生成具有修正失真率的聲音輸出Auralization techniques can generates a sound output with a modified distortion ratio
- 信號失真的可聽化結合感知和物理評估Auralization of signal distortion combines perceptual and physical assessment
- 可聽化簡化聽力測試並在更短的時間內提供更多信息Auralization simplifies listening tests and provide more information in a shorter time
- 可聽化加速產品開發Auralization speeds up product development