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On the temporal evolution of the overestimation in loudness of increasing vs. decreasing sounds

Emmanuel Ponsot
E-mail: *emmanuel.ponsot@ecl2011.ec-lyon.fr*

Institut de Recherche et Coordination Acoustique/Musique (IRCAM-CNRS),
1 place Igor Stravinsky,
Paris, France

Directeurs de stage : MEUNIER Sabine - SUSINI Patrick

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Résumé

Des recherches récentes se sont consacrées à l'étude de la perception des crescendo et des decrescendo, et ont constaté des asymétries ayant lieu dans la perception en sonie globale et en variation de sonie pour ces deux types de sons. Par ailleurs, les jugements des crescendo se sont révélés fortement dépendants de leur niveau de fin.

Nous avons mené plusieurs expériences afin d'approfondir la connaissance de ces phénomènes. Tout d'abord, nous avons pu montrer que cette dépendance du niveau de fin des crescendo n'est pas due à un biais perceptif, mais traduit bien d'un jugement réel et persistant dans le temps. D'autre part, d'autres résultats nous ont permis de comprendre que l'asymétrie en sonie globale entre crescendo et decrescendo semble due à une sous-estimation des decrescendo qui tend à disparaître dans le temps, contrairement aux études précédentes qui expliquaient cette asymétrie perceptive par soit par un "biais du niveau de fin des crescendo", soit par une "surestimation des crescendo".

Abstract

Recent research have been focused on the perception of crescendo and decrescendo, and have found asymmetries in terms of global loudness and loudness variation for these two types of sounds. Moreover, judgments of crescendo have been found to be strongly end-level dependent.

We conducted several experiments to understand deeper these phenomena. First, we showed that this end-level dependency of crescendo is not due to a perceptual bias, but reflects a real time-persistant judgement. On the other hand, other results have enabled us to understand that global loudness asymmetry between crescendo and decrescendo seems due to an underestimation of decrescendo which tends to disappear over time, whereas previous studies explained this perceptual asymmetry either by the "end-level bias of crescendo" or the "overstimation of crescendo".

Contents

Chapter 1

First assumptions

In this chapter, we first mention some results that deal with the perception of increasing and decreasing sounds, in terms of duration and loudness. Then, we present hypothetical results as we plan to run some experiments close to the one of Lu et al.[4]. Therefore, results that will be presented in the second chapter will not consider these assumptions as true, as mentionned in the conclusion of this chapter.

1.1 Context of this study

1.1.1 Dynamic stimuli

Many studies and models on sounds of constant intensity (*static stimuli*) have been written and built for decades, and this problem is now quite well known. But the study of loudness (the subjective perception of acoustic intensity) of *dynamic stimuli* is more recent and currently in progress. Most of studies have been about sounds that linearly increase (up-ramp) or decrease (down-ramp) in intensity (in dB SPL). Comparing sounds that increase or decrease in intensity, studies have revealed asymetries in different judgements. For instance, the subjective duration of increasing sounds is percieved as more important than for decreasing sounds (Grassi et al., 2006) [13]. They suggest that, as sounds with an abrupt onset (down-ramps increase from 0 dB to 80 dB in few miliseconds) are often followed by a prolonged decay from enviromental reverberation, listeners may attribute the last part of deacreasing sounds to natural reverberation, and thus they do not consider the latter part of damped sounds in their perceptual time evaluation. Otherwise, perceptual loudness of increasing versus decreasing sounds also reveal asymetries. It is the item of the study.

1.1.2 About the "Bias for rising tones"

People overestimate the loudness of rising tones compared to decreasing tones. This effect has been discovered by Neuhoff [4]. The explanation he has suggested deals with the importance of a rising intensity in a natural environment. There are many cues that inform a person of the arrival of a looming sound source: perceived spectral components evolutes, and Doppler effect (interaural temporal differences) appears. But compared with all other cues that change when a sound source is approaching, acoustic intensity is the most informative to judging arrival time of a looming acoustic source (Rosenblum, 1987).

1.1.3 Values and parameters

Studies have considered different parameters like sound duration, start and end level of ramps and spectral composition for characterizing the "Bias for rising tones". Recent works (Trapeau, R., 2009) have revealed that overestimation exists with three different judgements: direct global loudness rating, indirect global loudness rating and loudness change rating. And using these ranges of parameters [4], the overestimation effect always appears:

- *Duration*: between 1,8 and 20 s [5].
- *Spectral composition*: pure tones of 1000Hz or synthetic vowel tones.
- *Levels*: ramps with start and end levels between 60 and 90 dB.
- *Dynamic ranges*: 15 and 30 dB.

1.1.4 Intuitive idea of our study

In all previous studies where overestimation has been found, the way the judgement is made does not take account these parameters:

- The time between the end of the stimulus and the moment the answer is given (loudness of this stimulus) when this is a rating only based on one sound (a number assignation on a given scale for example).
- The ISI (time between two stimuli in pairs) when this is a judgement of comparison between an increasing and a decreasing ramp, like in Neuhoff first experiment for example.

But in our study, these parameters are crucial. The first intuitive idea of what could be our experiment is represented on Figures 1.1 and 1.2:

Description

"To know how the overestimation evolves across time after the end of the stimulus, we could ask the subject to make an answer at a given delay after the end of the stimulus.
For example, subjects would listen isolate ramps. The experimental task could be to give a number that corresponds to the global loudness perceived; and answers would be made at 0, 2, 4, ... 15 s (example values) after the end of the ramp. The task would be made for both, up-ramp and down-ramp. The overestimation could be defined as the difference between answers for up-ramp and down-ramp, at different given delays".

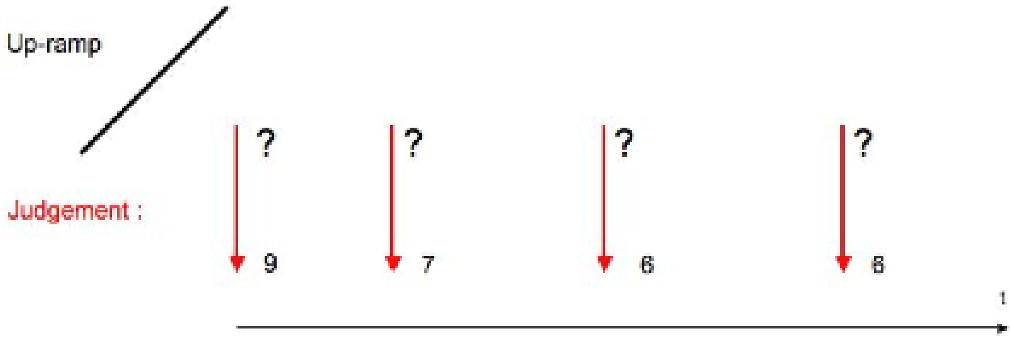


Figure 1.1: Intuitive example of rating an up-ramp

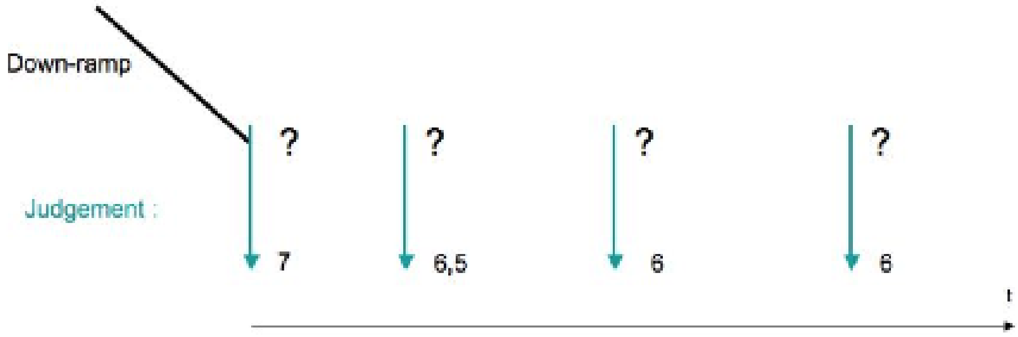


Figure 1.2: Intuitive example of rating a down-ramp

This general idea of an experiment appears really simple and clear but here is a main problem, which makes it not possible. If the answer is asked a few seconds after the end of the ramp, the subject would actually remember the number chosen just at the end of the ramp. And the judgement would be biased, so evolution of overestimation could not be observed.

1.1.5 Conclusion

In this paragraph, we have presented the loudness asymetry that exists between ramped and damped sounds, and which parameters for ramps were to be used in order to provide overestimation between their loudness ratings. But the critical point is methodological. Another way of characterising the evolution of loudness judgements has to be thought, to avoid a remembered premium rating, as we want to describe an evolution of it across time.

1.2 Objectives and hypothetical results

In this paragraph, we present what has been the adapted method to our first set of experiments (Experiment 1 presented in the second chapter), in order to know how the overestimation effect evolves across time, avoiding the different problems that appeared in other methods mentioned previously. We have based our study on an article published in 1992 by Lu et al. [8], because the evolution of judgement in loudness we want to describe probably deals with sensory and long-term auditory memories. First we describe the overall experiment made by Lu et al., and then we explain why and how this method can be useful if adapted to our problem. Finally, we analyse the results we suppose to obtain.

1.2.1 Presentation of an article (Lu et al., 1992)

In order to characterize human auditory sensory, Lu et al. have made an experiment that reveals interesting results. They showed that “memory of a loudness of a specific tone is lost” across time but “the remembered loudness decays toward the global mean of all of the loudnesses to which a subject is exposed in a series of trials.” This conclusion has not only been based on the psychophysical experiment made but also confirmed by magneto encephalography (MEG) [8] results of neuronal activation trace in primary auditory cortex. In previous studies, echoic memory was said to be about 2 to 5 s, and this experiment has confirmed this range of values.

Experiment

In the experiment, subjects listened to pairs of sounds and were asked to press the correct button to answer how they perceive these two sounds. In each pair of sounds they heard, they had to press one button if the first sound (the *test tone*) was the loudest, or the other button if it was the second sound (the *probe tone*). 6000 trials (pairs of sounds) have been collected for each subject. For each pair, the fist sound was presented monaurally to one ear and the second sound monaurally to the other ear (the first ear changing across session). This condition is mentionned later as the *monaural contralateral* condition.

Every sound were pure tones at 1 kHz and last 200 ms (see Figure 1.3). Only the intensity of the probe tone and the duration between both sounds of each pair, the inter-stimulus interval (ISI), were randomly chosen in an established list of values (see [8] for details).

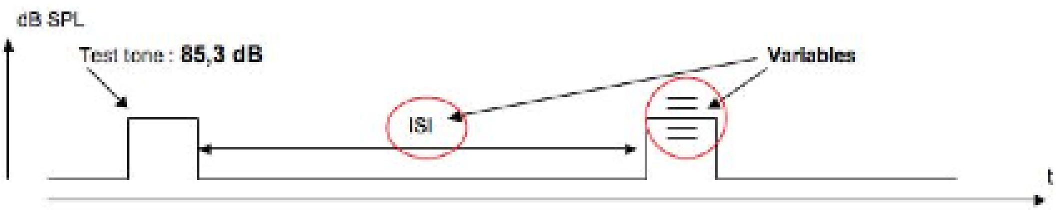


Figure 1.3: Lu et al. experiment

Results

The results and the analyses were “based on the data collected for each subject after exclusion of the first 20 percent of the trials of every session”. These first answers in each session were excluded because “it was during the first sets of presentations that the range of the loudness in the session was established”.

For each subject and ISI, a psychometric function was fitted to the data of loudness judgements. So, each curve for each ISI was a psychometric fit of the data collected: the percentage of probe tone perceived louder in function of his level in all the trials of the experiment. The point of subjective equality (PSE) was defined as the point at 50 percent on each psychometric function (i.e. the mean of the Gaussian distribution associated). Figure 1.4 shows the evolution of the PSE in function of ISI's values, based on data collected for one subject and for two lists of ISI's and probe tone levels (A and B).

Interpretations

They have drawn two important conclusions with these data.

The first one is the exponential decay of echoic memory (also shown with MEG [8]). The second one is the attraction of the PSE toward the mean loudness of all previous tones.

- When the ISI is really short (500 ms), the PSE is quasi-equal to the level of the probe tone (85,3 dB). This means that the subject is able to compare levels of test and probe tones correctly in every pair.
- But this PSE increases (A) / decreases (B) exponentially with ISI, to the global mean loudness of all previous tones. When the mean loudness is chosen 2,5 dB greater (Figure 1.4A) or 2,9 dB lower (Figure 1.4B) than the probe, the PSE always converge toward this global mean. And this is a non-intuitive point. One could imagine that this is because answers are made by chance. But this is not true. "The loss of sensory memory and the growing dominance of a longer term memory are not accompanied by a marked increase of the uncertainty for the loudness of the probe tone that best matches the test for a given delay" [8]. The mean loudness really attracts subject's answers toward its value, and that also reveals a long-term memory judgement more than a sensory echoic judgement after few seconds ("the individual memory lifetimes range from 0.8 to 3 s").

In our case, we also have to consider these conclusions on exponential decay of echoic memory. Moreover, the method used in this experiment can really help to define ours, as we will see in the next paragraph.

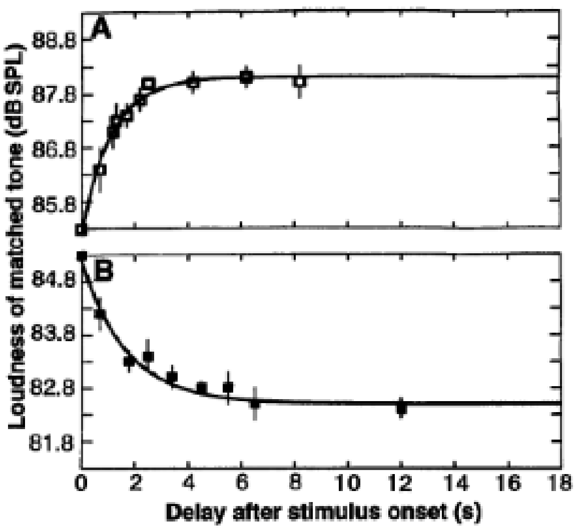


Figure 1.4: Lu et al. results

1.2.2 Our experiment

The method used in Lu et al. experiment is the *constant stimuli method* with a *two-alternative forced-choice* task. We will use the same method and task for our experiment. We will organise three kinds of sessions.

There will be *"up-ramp sessions"*, where the test tone will be an up ramp and the probe tone a constant tone of 600 ms (enough time to avoid temporal integration which appears in loudness of short tones); and *"down-ramp sessions"* where the test tone will be a down-ramp. The level of the time-constant probe tone and the ISI value will be both randomly chosen in a series of defined values. Figure 1.5 shows one trial of an up-ramp session. Last kind of sessions will be very similar to those in Lu experiment. We will speak about *"Lu sessions"*. The test tone will be a constant sound of 600 ms with a level of 80 dB SPL (corresponding to the beginning level of down-ramps and to the end level of up-ramps). Probe tones will be the same as in down-ramp and up-ramp sessions, randomly chosen in a defined list of values.

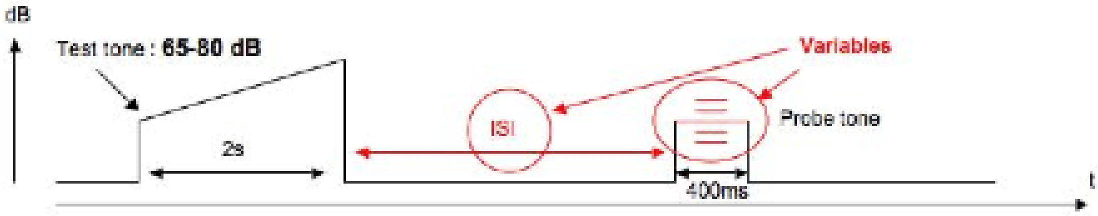


Figure 1.5: One trial in an up-ramp session

For each trial, the subject will be asked to compare the *global loudness* (in which overestimation effect appears) of two sounds heard. As echoic memory has an individual lifetime range, results would be analysed separately for each session (up-ramp or down-ramp) and for each subject.

1.2.3 Hypothetical results

We can suppose that our results will also deal with the exponential echoic memory decay revealed by Lu et al. On Figure 1.6 are presented three different hypothetical results. This is not an exhaustive presentation of all the possible results we can obtain, but the idea is more to focus on three global interpretations of them. We have defined overestimation as the difference between global loudness judgement for up-ramps and down-ramps.

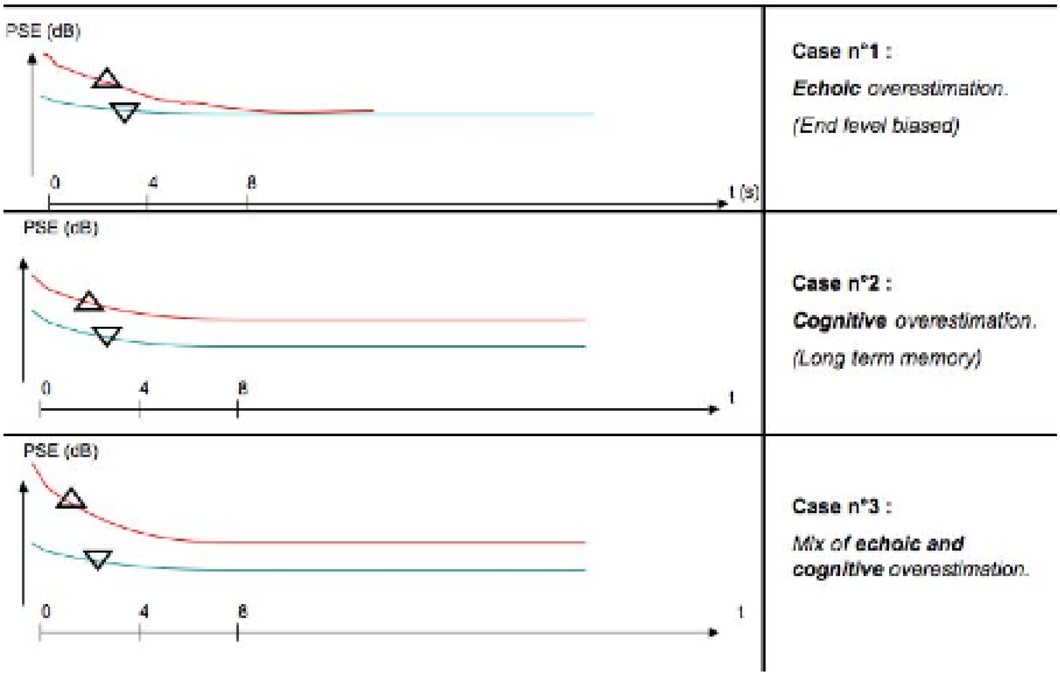


Figure 1.6: Different hypothetical results

Results

Figure 1.6 shows three different cases we can imagine. These curves are not based on real obtained results but just imaginary. These could be obtained when the mean loudness of all the session is lower than the loudness of an up-ramp and a down-ramp (this explains why these curves have been drawn with an exponential decay).

Interpretations

- **Case n°1**: Both of the PSE curves (functions of ISI) converge toward the same value. This common asymptote reveals that the long-term loudness for an up-ramp and a down-ramp is the same. Overestimation revealed in previous studies is due to the "bias of the end level" of the up-ramp and converge toward zero. This case deals with an *echoic overestimation* of up-ramps, a *sensory effect* caused by the end of its later part.

- **Case n°2**: The PSE curves for increasing and decreasing ramps converge toward different values, but are parallels. This means that the overestimation persists (stays constant) in judgement across time after stimulus. We can also conclude that the global loudness of an up-ramp is higher than the global loudness of a down-ramp. This other case deals more with a *biological effect* (supported by Neuhoff), or a *long-term memory*.

- **Case n°3**: The PSE curves for increasing and decreasing ramps converge toward different values, and are not parallels. This also means that the overestimation persists (stays constant) in judgement through time after stimulus, but that the overestimation at the first milliseconds is greater because of the *end-level bias*. We can also conclude that the global loudness of an up-ramp is higher than the global loudness of a down-ramp. This other case deals more with a mix between both: a *sensory effect*, which disappears in few milliseconds, and a *biological/emotional effect*, which stays constant through time.

1.3 Conclusion

In this chapter, we have described what were our first assumptions. We believed that our results would be close to those of Lu et al. But we did not consider the importance of the listening procedure. In the following of this report, we will not take into account all these previous assumptions anymore: experiments will use a *binaural listening* and not a *monaural contralateral listening*; which will not allow us to compare our results with those of Lu et al.

Chapter 2

Global loudness of up-ramps

A set of two experiments was conducted to examine how the global loudness of an increasing sound (an up-ramp) evolves after the end of the stimulus. Previous studies have revealed that global loudness of up-ramps was strongly end-leved dependent (Susini et al. 2010). Is this effect an end-level bias or does it really account for a true global loudness perception of up-ramps ?

Experiment 1 was a paired comparison where subjects compared the global loudness of a test and a probe tone at different interstimulus intervals (ISIs). The test tone was either an up-ramp [65-80 dB] or a constant tone corresponding to its end-level (80 dB). Probe tones were constant tones varying in level. As results, the point of subjective equality (PSE) of constant tones decreased with the ISI, which confirms results of previous studies (Yoshida et al., 2004). Moreover, the PSE of up-ramps was set around 1.4 dB lower than the one for the 80 dB constant tone whatever the ISI was. Global loudness of up-ramps seems to be an integration of their latter part which persists over time, and not a bias caused by their end levels.

We conducted **Experiment 2** with the same subjects as in Experiment 1 in order to check if this 1.4 dB offset down of up-ramps PSEs could be found again by another procedure. Constant tones and both up-ramps and down-ramps were presented to subjects who were asked to make a global loudness estimation after each stimulus. Constant tones at 80 dB were judged overall louder than [65-80 dB] up-ramps and this emphasizes our conclusion to Experiment 1. Moreover, up-ramps were judged louder than their opposite down-ramps for each conditon. This recovers the overestimation effect revealed in previous studies (Neuhoff, 1998).

2.1 Introduction

Some recent studies have been focused on the loudness of increasing and decreasing sounds (Neuhoff, 1998; Susini et al., 2007). Asymetries in loudness change or global loudness between increasing and decreasing sounds have been revealed: up-ramps are perceived to change more in loudness (Neuhoff, 1998) and also as being greater in terms of global loudness than down-ramps (Olsen et al., in press). As mentionned in previous research using direct ratings procedures (Teghtsoonian et al., 2005; Susini et al., 2010) the over-estimation of up-ramps has been found to be strongly dependent of their end levels. The purpose of this study is to know if this end-level basis for judgement corresponds either to a perceptual bias or if global loudness is really influenced by end-levels when subjects are asked to make these ratings longer after the end of the stimulus. So we led two experiments to study if the end-level dependency for the global loudness of up-ramps is a bias due to their latter part or rather if this phenomenon persists over time.

In a first part, we will investigate an experiment in which subjects will have to compare in loudness a 80 dB constant test tone with another constant probe tone that will vary in level at different ISIs. Similar experiments have been led with longer and softer sounds with a binaural listening (Yoshida et al., 2004) and revealed that the equal-loudness of a constant tone decreased with the ISI. Our first assumptions are a) that the loudness of the 80 dB constant tone will also decrease with the ISI in our experiment; and b) that the difference limen (DL) will have a logarithmic growth with the ISI, as in their study. In a second part, we will repeat this experiment but changing the constant 80 dB test tone by a [65-80 dB] up-ramp. In each trial of these sessions, the subject will have to compare the up-ramp with a constant probe tone in terms of global loudness. The third hypothesis we made is c) that the loudness of the up-ramp will be lower than the corresponding 80 dB end-level and its evolution with the ISI will follow the same trend as its end-level presented as the test tone. These two parts of the experiment will allow us to confirm if the end-level dependency of up-ramps global loudness persists over time.

In a second experiment, we will ask the same subjects to rate constant tones and up and down-ramps in order to know if their up-ramps ratings are close but lower than the end-levels presented alone (which correspond to the assumption c) made for the first experiment).

2.2 Experiment 1

2.2.1 Subjects

In this experiment, 4 participants (2 men: age 29 and 34 years; 2 women: age 25 and 38 years) took part. They did not mention to have hearing deficiency. They gave their inform consent prior to the experiments and were paid for their participation.

2.2.2 Stimuli

We examined only one type of spectral composition for all sounds. All (test and probe tones) were pure tones at 1 kHz and had linear onset and offset of 12 ms. The test tone was either a linear ramp with a dynamic range of 15 dB: 65 to 80 dB for *"Up-ramp sessions"* or a consant tone of 80 dB in *"Lu sessions"* corresponding to the end-level of up-ramps. The up-ramp had a duration of 2 s (onset anf offset excluded). The probe tone and the test tone in *"Lu sessions"* had a duration of 600 ms (onset anf offset excluded).

In the experiment, varying parameters were the level of the probe tone and the ISI (time between the end of the test tone and the beginning of the probe tone) respectively randomly chosen in a list of values. Probe tone levels are chosen so the mean of all the stimuli listened during a session (included test tones) is 79.35 dB (arithmetic mean), which is lower than the 80 dB test tone.

ISI values
List 1a: [0.25, 1, 4, 8 s]

Probe tone levels
List 1b: [75, 76, 77, 77.8, 78.6, 79, 79.4, 79.8, 80.5, 81, 82 dB SPL]

2.2.3 Procedure

Sounds were all made with **MAX-MSP**, and calibrated to the required level: values in dB SPL for test and probe tones mentioned above were heard binaurally (77 dB SPL means 77 dB SPL in the right ear and 77 dB SPL in the left ear at the same time). This was the same listening in Yoshida et al. experiment. Subjects listened these sounds in anechoic room with Sennheiser HD250 Linear 2 headphones. The soundcard used was a RME Fireface 800 with a Lake People G-95 Phoneamp amplifier. Subjects gave their answers by clicking on the button they chose on the computer screen interface. The progress of the experiment and the interface was developed with **PSIEXP**.

For each subject, the whole experiment was divided into sessions on different days. Sessions were *"Up-ramp sessions"* or *"Lu sessions"*. A session lasted approximately one hour and each subject had to do 5 session of each type. Thus, each subject did 10 different sessions in the whole experiment. In a session, each couple of ISI value and probe tone level (ISI, PT level) was randomly chosen and presented 8 times. So, a session was made of 352 trials (4 ISIs * 11 PT levels * 8 presentations); where a trial consisted of the test tone followed by the couple ISI and probe tone randomly chosen (with PSIEXP). Two trials were separated by a 4 s interval between the answer for one trial and the beginning of the next one (value based on [8] and[9]). Before the first experimental session, they did a training session with 10 test and probe tones (where the test tone was randomly chosen between an up-ramp, a down-ramp or a constant tone) in order to familiarize them with the task.

Before the training session, they read instructions and could ask questions if they wanted so. A short 'pause' of few minutes was proposed to subjects at the mid-experiment, so they could keep their attention for all time. In each trial of a session, subjects were asked to judge which sound (test or probe tone) of both was the loudest. This was a *two-alternative forced choice*: they had to answer (by clicking) the question that appeared constantly during a session:

> *"Quel son était le plus fort?"*

- If they judged the first sound (test tone) louder than the second sound (probe tone), they had to click on the left button on the interface labelled *"Le premier"*.
- If they judged the second sound louder than the first one, they had to click on the right button on the interface labelled *"le second"*.

2.2.4 Analysis

Results of Experiment 1 obtained with these 4 subjects are examined in the next paragraph. They have been made after 5 *"Up-ramp sessions"* and 5 *"Lu sessions"* with the List 1a of ISI values for each subject, as mentioned above. All the answers given across sessions have been put together for each condition (i.e. each couple of values (ISI; PT level). Thus, for each condition, 40 answers (5 sessions * 8 presentations) have been collected running the whole experiment.

Answers given by subjects during each session have been saved in excel data files. The 40 answers given for each condition have led to sequences of 11 points, for each ISI and type of session. These points are represented with 'The percentage of probe tone percieved louder than test tone' on *y-axis and* 'PT level' on *x-axis*. As it deals with a perceptive detection of auditory parameter (loudness) with a *two-alternative forced choice* around the hypothetical thresholds, these sequences have a psychometric shape. Psychophysic theory and results have usually modeled it by a cumulative gaussian (another model is the *phi-gamma* function, but lead to very close results; (cf. Moore, 1986, for details) . We fitted all sequences of points by a non-linear fitting using **Matlab**(cf. Fig 2.1), in order to obtain the 50 percent point, the Point of subjective Equality (PSE) which represents the statistically defined threshold. This point can also be seen as the equal-loudness of the test tone as a function of the ISI. Thus, we extrated this point for each fitted curve, to observe how it evolves with ISIs.

$$\textit{Expression of a cumulative gaussian:} \quad F(S,\mu,\sigma) = \frac{1}{2}(1 + erf(\frac{S-\mu}{\sqrt{2\sigma^2}})) \tag{2.1}$$

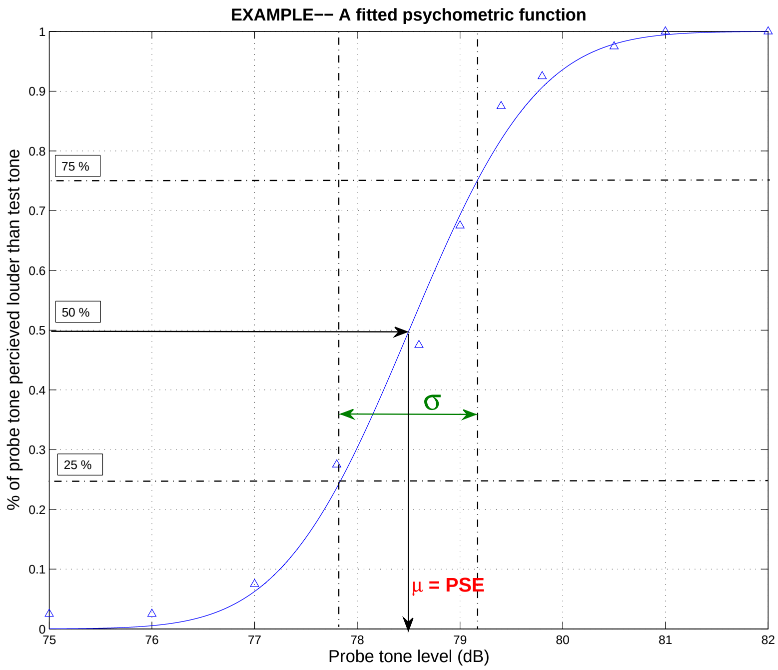


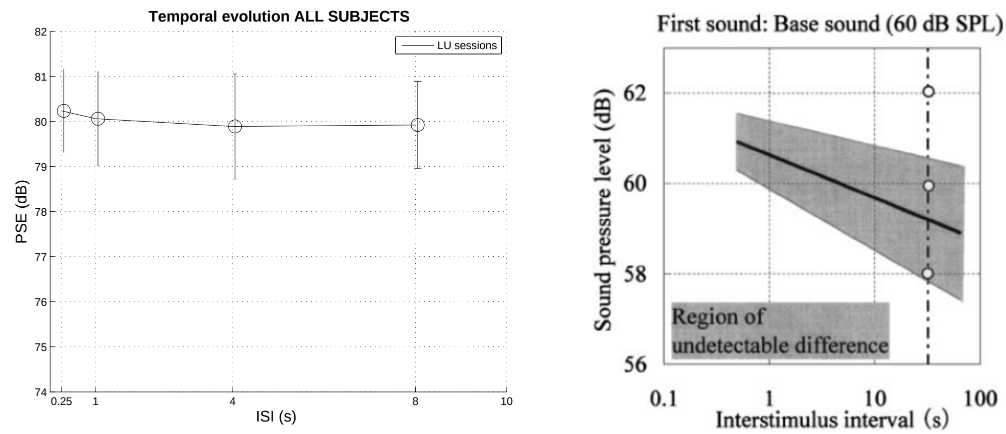
Figure 2.1: Extraction of the PSE fitting data with a psychometric function

2.2.5 Results

We first present the results obtained running *"Lu sessions"* (when the test tone is the 80 dB constant tone). On the same figure are those obtained in Yoshida et al. experiment, in order to be compared with ours. Secondly, we analyse the correlation of our results when the test tone is either the up-ramp (*"Up-ramp sessions"*) or the 80 dB constant tone (*"Lu sessions"*).

ISI dependency for the loudness of a constant tone

Fig. 2.2(a) show the equal-loudness evolution with ISI we obtained when the test tone was a 80 dB 600 ms constant tone. As results, the PSE was higher than 80 dB for short ISIs and lower than 80 dB for longer ISIs. SD was nearly the same with the different ISIs. On fig 2.2(b) are the results of Yoshida et al. previously published: the Order Effect and the DL are respectively correlate to the PSE and the SD in our case (see ref Yoshida for analysis). Even if they studied longer sounds (3000 ms) and a softer test tone (60 dB), they also obtained a similar trend for the equal-loudness dependency with the ISI. In their case, the equal loudness was higher than 60 dB for ISIs smaller than 8 s and lower for longer ISIs; but to a greater extent. However, they obtained a logarithmic evolution of the DL with the ISI that we have not recovered in our results. We believe that those differences can be explained, in one hand by the sounds they studied which differed from ours in level and in duration, and in the other hand by the longer ISIs they studied. We might have found a significant SD evolution with the ISI using longer ISIs.



(a) PSE and standard-deviation (SD) as a function of ISI - Results of *"Lu sessions"*

(b) Order Effect (thick solid line) and DL (grey region) as a function of ISI - Results of Yoshida et al. experiment, 2004

Figure 2.2: Equal loudness and difference limen ISI dependency - Comparison between our results and those of Yoshida et al.

The end-level basement for the global loudness of up-ramps

We plotted on Fig. 2.3 the extrated PSEs for different values of ISI. Open circles correspond to the PSE when subjects compared constant probe tones with a 80 dB constant test tone (*"Lu sessions"*). These values all set around 80 dB and a small but not significant decrease can be noticed. Upward triangles correspond to the PSE when subjects compared constant probe tones with a test up-ramp [65-80 dB] (*"Up-ramp sessions"*). For each ISI, the PSE of the [65-80 dB] up-ramp is around 1.4 dB lower than the PSE of the 80 dB constant tone (which corresponds to the end-level of the up-ramp). Moreover, the difference between these two curves is significantly constant with the ISI ($F(1,3)=110.7$, $p< 0.005$). This supports previous interpretations: global loudness of an up-ramp is end-level dependent. Furthermore, this offset 1.4 dB lower for the up-ramp than for its end level confirms other previous assumptions: the perceived loudness of the up-ramp seems to be an integration of its latter part. As the offset is constant and persists with the ISI, we assume that this integration process is not a bias but really deals with a long-term perceptive modality.

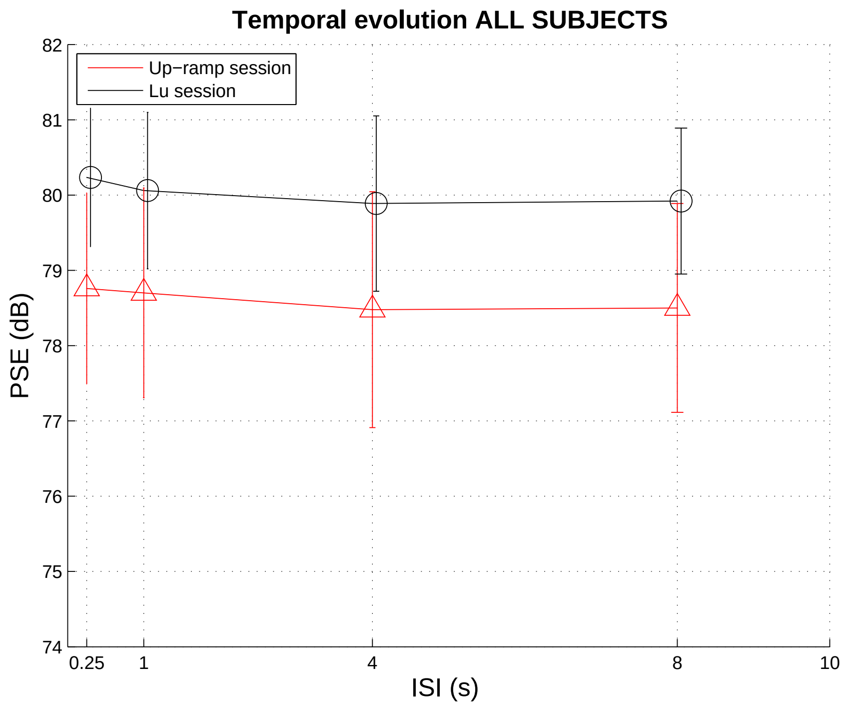


Figure 2.3: The PSE as a function of ISI for both type of sessions: the curve with open circles corresponds to sessions where the probe tone was the 80 dB constant tone and the curve with upward triangles to sessions where the probe tone was the [65-80 dB] up-ramp. The error bars show the standard deviation for each ISI. The difference between the two curves is significantly the same with the ISI ($F(1,3)=110.7$, $p<0.005$). The equal loudness of an up-ramp is around 78.5 dB: judgements of up-ramps in terms of global loudness are really based on their latter part.

2.3 Experiment 2

Another experiment has been conducted with the same 4 subjects as in Experiment 1, in order to know if we were able to found the offset between up-ramps ratings and their end-levels presented alone. Moreover, we are spposed to recover the oversestimation of up-ramps vs. down-ramps with the "classical" *Global loudness rating*, when subjects assign a number to each sound listened.

2.3.1 Subjects

Subjects who did Experiment 2 were the same as in Experiment 1.

2.3.2 Stimuli

In this experiment, there were constant tones in the first part and ramps in the second and the third part. Constant tones had a duration of 600 ms and ramps lasted 2 s.
Levels of constant tones were from 45 to 85 dB with 5 dB steps. Thus, there were 9 constant tones that only differed in level.
There were 6 type of ramps, increasing or decreasing: 3 with a 15 dB range (60-75, 65-80 and 70-85 dB), 3 with a 30 dB range (45-75, 50-80 and 55-85 dB).

2.3.3 Procedure

Experiment 2 was divided into 3 blocks.

The first block of the session presented each of the 9 constant tones 8 times, so each tone was preceded by a different one each time. This procedure is the one used in Cross experiment (Cross, 1973) and is to reduce assimilation effect (Canévet et al, 2003). Thus 73 sounds were listenened by subjects in this first part of the experiment (9 different tones*8 presentations +1 : the first sound was used only to start the procedure and its estimation is not considered afterwhile).

The second block of the session was made of up-ramps (6 types) listened with the same procedure but repeated 2 times. Thus, 61 up-ramps were listened (6 types*5 presentations*2 times + 1) by subjects.

The third and last block of the session was made of down-ramps (6 types) listened with the same procedure as in the second block. Thus, 61 down-ramps were listened (6 types*5 presentations*2 times + 1) by subjects. In order to avoid any 'context' effect, 2 out of 4 subjects listened the third block (down-ramps) before the second block (up-ramps).

Subjects were all asked to rate the global loudness percieved for each sound using any positive number they wanted, so there was not any forced scale and subjects were free to create their own one (Hellman, 1976). The only consigne given before they did the experiment was to respect the same scale during the whole experiment.

They had to answer the question which constantly appeared on the sceen:

"Entrez un nombre traduisant du niveau sonore global ressenti pour ce son"

They gave their answer entering a number on the interface.

2.3.4 Analysis

As there was no given scale for this experiment, subjects could use any scale they wanted. In order to average results, a standardization of ratings given by each subject is necessary. Standardized answers have been calculated so the mean rating for each subject was set to 2 for the 50 dB constant stimuli (wich corresponds to the amount of 2 sones for a 50 dB tone). Each individual results have been standardized using this method and then have been averaged between all the subjects (cf. Fig 2.4) .

2.3.5 Results

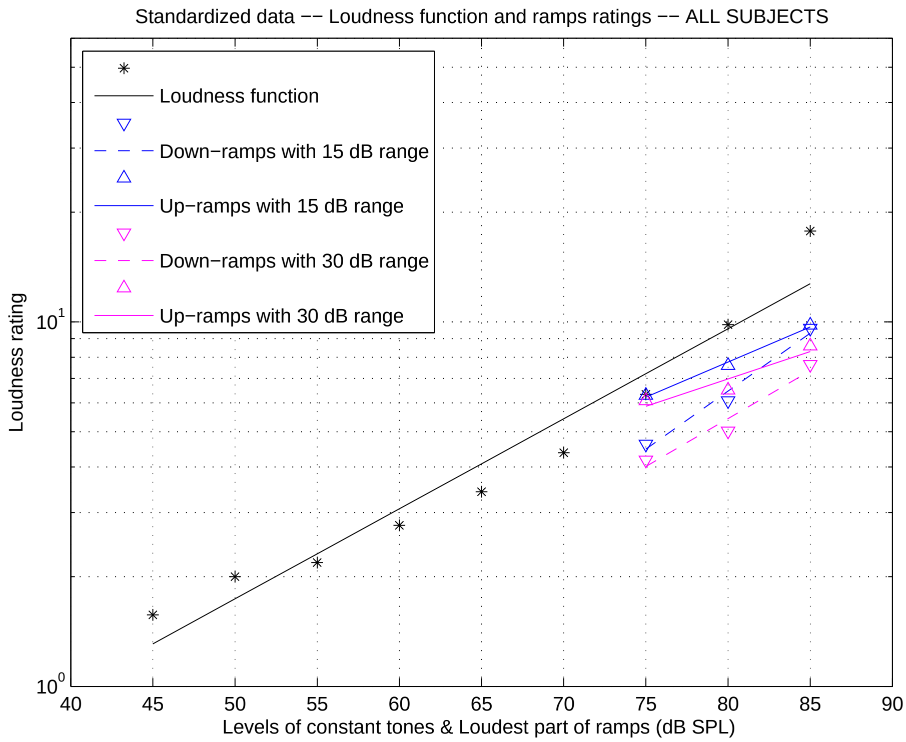


Figure 2.4: Standardized global loudness ratings averaged on all subjects - Crosses correspond to standardized ratings for constant tones so we could fit the loudness function. Upward and downward triangles correspond respectively to ratings of up-ramps and down-ramps, both with two different ranges: 15 or 30 dB. As results, up-ramps ratings were higher than down-ramps ratings for every condition and this effect was greater for ramps with a 15 dB range than for those with a 30 dB range (with the same end-level), which confirms previous results using this procedure (reference). Moreover, up-ramps ratings were lower than their end level presented as constant tones: this upholds the results of Experiment 1.

On Figure 2.5 we plotted the amount of the [65-80 dB] up-ramp ratings and the 80 dB constant tone ratings we obtained with the two procedures used (in Exp. 1 and in Exp. 2). As results, we can remarked that the amount (in sones) for the 80 dB constant tone is similar with the two kinds of procedures. Moreover, the offset down for up-ramp ratings compared to end-levels ratings has been recovered (with the same subjects) in both of the experiments, even if it is true to a lesser extent for Exp. 1. Recovering a similar trend with two different procedures emphazises our conclusion to Experiment 1.

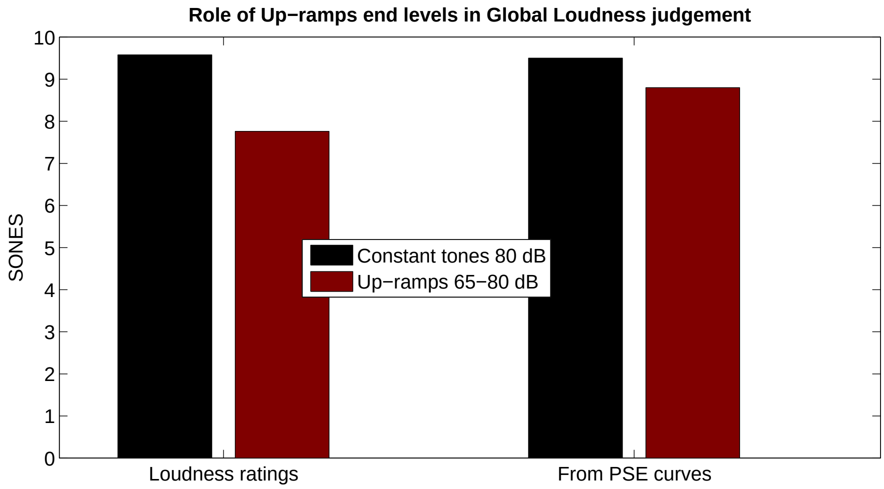


Figure 2.5: End-level dependency for the loudness of up-ramps obtained by two different procedures. On the left are the ratings (in sones) of the [65-80 dB] up-ramp and its end-level (80 dB) presented alone (Results taken from Exp. 2). On the right are the same plots but taken from results of Exp. 1(the correspondance between PSEs (dB SPL) and these amounts in sones have been deduced using the loudness function obtained on Fig. 2.4).

2.4 Discussion and conclusion

2.4.1 Discussion

These experiments allow us to emphasize and to discuss several interpretations that have been made in previous papers.

The assumption a) was supported. Results of *"Lu sessions"* comfort those published by Yoshida et al. and reveal that the loudness of a constant pure tone in a paired comparison depends on the ISI between the test tone studied and the probe tone. For shortest ISIs (ISI = 0.25 and 1 s in our experiment), the equal-loudness (in dB) of a constant pure tone is higher than its real level; and this effect is reversed for a longer ISI (ISI = 4 and 8 s). This phenomenon is similar to the one revealed in Yoshida et al. experiment but was more important in their case. They interpreted this effect as dealing with an auditory adaptation or fatigue for short ISIs. In our case, sounds last only 600 ms but were all louder than those they considered, so this phenomenon could also occur when the ISI was 0.25 or 1 s. For longer ISIs, the decrease of the PSE with the ISI is explained in their study as it follows: "subjects forgot the first sound and the impression of the sound became weaker when the interstimulus interval was long". However, another study working on the evolution of the equal-loudness of a constant tone (Lu et al., 1992) but using a different listening procedure (monaural contralateral listening) found that the evolution of the PSE converged toward the mean loudness of all the stimuli listened across a session, that is why we chose the mean of our stimuli as being 79.35 dB, in order to check if this choice could influence our results. In another paper (Yoshida et al., 2005), Yoshida et al. noticed that a difference in the listening procedure (monaural contralateral, monaural ipsilateral or binaural) completely changed PSEs results. So we suggest that the difference in listening procedure does not allow us to compare our results with those published by Lu et al. and also explained why PSE did not converge toward this mean. Therefore, we also support the interpretation made by Yoshida et al. for long ISIs. As subjects might tend to forget the first sound for long ISIs, the more the ISI is longer the more they tend to chose 'the second sound is louder' answer; because this is the more recent sound listened. Howerever, assumption b) was not recovered: we can not notice any logarithmic evolution of the SD with the ISI. We tend to believe that an higher range of tones levels can be the a plausible explanation for these differences.

Secondly, PSEs of up-ramps obtained with *"Up-ramp sessions"* have to be compared with those of *"Lu sessions"*. As mentionned above, the evolution with the ISI in both cases is significantly the same. This similarity in evolution support the hypothesis c) made in the introduction: end-levels basis for global loudness of up-ramps is not a temporary bias. Moreover, experiment 2 also confirms this hypothesis using a different procedure. The offset down for up-ramp compared to end-level PSEs is also supported by both of the experiments we conducted, even if it was greater in Experiment 1. This offset make us believe global loudness of up-ramps is a continued integration of their latter part which persists over time. There is just a small decrease of the PSE for short ISIs that can be interpreted as an auditory fatigue which infers on PSEs results in the same way as for constant tones (cf. above). It suggests that the remembered loudness of any increasing sound is not a mean of all its energy but rather a mean of its latter part. Even if we obviously need more results to confirm this interpretation, a modelling of the loudness integration of up-ramps could be made in a near future. Such a model would make a breakthrough for the study of the perception of all increasing sounds. Otherwise, the study of decreasing sounds has to be conducted. Results of experiment 2 have also recovered the effect of overestimation of up-ramps vs. down-ramps with a global loudness rating procedure. So as the global loudness of up-ramps seems to persist over time, it make us believe this effect more deals with an "underestimation" of down-ramps (as mentionned in a seminar ref). New studies for decreasing sounds so have to be conducted.

2.4.2 Conclusion

With these two experiments, we are able to reach two important conclusions available: one for the ISI dependency of constant tones equal-loudness, and another one for the global loudness of increasing sounds.

The first conclusion is that the equal-loudness of a 80 dB constant tone seems to be overestimated for short ISIs and underestimated for longer ISIs. We agree Yoshida et al. interpretations: the former is due to an auditory fatigue induced on the probe tone by the test tone when they are close; the latter more deals with a bias of a paired comparison when ISIs are too long.

The second conclusion is that global loudness of up-ramps seems to be an integration of their latter part dealing with a long-term memory process.

Chapter 3

On the temporal evolution of the overestimation effect

Some previous experiments revealed that global loudness of up-ramps was strongly end-level dependent (Teghtsoonian et al. 2005; Susini et al., 2010). A recent study found that global loudness of up-ramps could be explained by a time-persistant integration of their latter part. As far as we know, the temporal evolution of the global loudness of down-ramps have not been studied yet. We conducted an experiment to examine the temporal evolution of global louness of both up-ramps and down-ramps. We are now able to discuss further processes involved in the overestimation effect revealed in many previous studies (Neuhoff, 1998, 2001).

This experiment was a paired comparison in terms of global loudness. All test and probe tones were up-ramps or down-ramps randomly shuffled. The comparison was performed at two different ISI: 0.5 and 8s. The proportion of up-ramps as probe tones judged louder than test tones was significantly the same for the 2 ISIs studied, which confirms the persistance of up-ramps judgements over time. Moreover, the overestimation of up-ramps vs. down-ramps that occured at ISI = 0.5 s was significantly reduced at ISI = 8 s.

3.1 Introduction

Recent works about the loudness of dynamic sounds have been focused on the "Bias for rising tones" revealed by Neuhoff (Neuhoff, 1998). This means people judge louder an increasing sound (an up-ramp) than a decreasing symmetric sound (a down-ramp), in some conditions. For instance, an increasing linear ramp of 1,8 s from 60 to 75 dB SPL will be judged louder than a decreasing one from 75 to 60 dB SPL with the same duration [4], when rating these ramps in terms of *loudness change*. But interpretations of this overestimation in favour of increasing tones differ from a study to another.

Some argue that this effect is biological/emotional and that an increasing tone is perceived more intense than a decreasing one, in order to provide " a selective advantage" for the listener, "because rising intensity can signal movement of the source toward an organism" (Neuhoff, 1998). Moreover, brain imaging have revealed that diotically (i.e. binaurally) presented, intensity changes alone are sufficient for activating neural parts of the brain associated with auditory motion (Seifritz, 2002). However, neural regions activated with the presence of rising or falling intensity are not identical: "rising, but not falling, sound intensity would activate a cortical network that is concerned with space perception and the allocation of sensory attentional resources". They also found that rising and falling intensity activated the right temporal plane more than constant intensity. This "anisotropic processing" of acoustic intensity can reflect the asymmetry between rising and falling intensities. And this "directional preference for looming sounds, versus receding and stationary sounds" (Tajadura-Jiménez et al., 2008) has also been confirmed with neural results on non-human primates (Ghazanfar, 2007). These studies comfort a biological interpretation and the "survival advantage" of Neuhoff for a perceptual priority toward approaching sounds. Not only perceptual and neural results confirmed this effect, but also emotional results. Tajadura-Jiménez et al. results revealed that tones rising in level create stronger emotional answers on listeners: they are "perceived as more arousing and more unpleasant" [19].

All these results are consistent with a biological/emotional interpretation of this effect. But it has also been suggested that it could be a consequence of a short-term memory effect (Susini et al., 2005 [1]; Teghtsoonian et al.[5]), because global loudness and loudness change judgements could be biased by the end-level of increasing sounds. Results of a recent study (ref) have shown judgements of up-ramps were time-persistant and not end-level biased. In this study, we want to know how judgements of down-ramps elvolve after the end of the stimulus. With this knowing, it will be possible to investigate further the overestimation effect and its prospective persistance over time.

3.2 Experiment 3

3.2.1 Subjects

We led this experiment with 10 subjects (7 men, 3 women).

3.2.2 Stimuli

There were both up-ramps and down-ramps. All were 1 kHz pure tones and had a duration of 2 s. They were gated on and off with 12 ms linear onset and offset.

There were 6 type of ramps, increasing or decreasing: 1 with a 10 dB range (70-80 dB); 2 with a 15 dB range (60-75 and 65-80 dB);1 with a 20 dB range (60-80 dB)1 with a 25 dB range (60-85 dB). This made a total of 12 different ramps (6 up-ramps and 6 opposite down-ramps).

3.2.3 Procedure

Subjects had to compare a test tone and a probe tone. The experiment consisted in 2 sessions that lasted about one hour for each subject (1 session with ISI = 0.5 s and 1 session with ISI = 8 s). Ramps as probe and test tones were randomly chosen respectively in List A and List B in both sessions. So test sounds were either the [65-80 dB] up-ramp in one session or the [65-80 dB] down-ramp in another session (cf. List A below). During one session, a subject listened to 264 sounds (1ISI*2 TestTones*12 ProbeTones*11presentations). So at the end of the second session, each subject had listened each condition *(Test tone; ISI; Probe tone)* 11 times.

ISI values
ISI = 0.5 or 8 s

Test tones
List A: [1 up-ramp: 65-80 ; 1 down-ramp: 80-65 dB]

Probe tones
List B: [6 up-ramps: 60-75, 60-80, 65-80, 70-80, 60-85, 65-85 -80 dB; 6 down-ramps: opposite to up-ramps.]

3.2.4 Direct analysis of results

Direct overestimation

As test tones were [65-80 dB] ramps, we can first analyse the proportion of probe tones percieved louder than test tones when probe tones were also [65-80 dB] ramps. These cases will allow us to consider the influence of two parameters on results: the direction of the ramp, and the ISI.

On Fig. 3.1, when ISI = 0.5 s, the [65-80 dB] up-ramp is more often percieved louder than the [65-80 dB] down-ramp whatever the order is (up-ramp either as the test tone: 75%; or as the probe tone: 71%). This effect is also true in both cases when ISI = 8 s (up-ramp either as the test tone: 51%; or as the probe tone: 66%). We will call this effect the *direct overestimation*. It confirms many previous published results (refs) where up-ramps are overall judged louder than opposite down-ramps (Olsen et al.; Neuhoff 1998). We have to mention that this *direct overestimation* effect is significantly reduced when the ISI = 8 s in both cases.

We can also look at these amounts when the same ramp is presented as test tone and probe tone. When test and probe tones were both the [65-80 dB] up-ramp, the second one was more often percieved louder than the first. This is true when ISI = 0.5 s (65%)and also when ISI = 8 s (62%). Whereas when test and probe tones were both the [65-80 dB] down-ramp, the second one was less often percieved louder than the first one. This is true when ISI = 0.5 s (37%) and also when ISI = 8 s (46%).

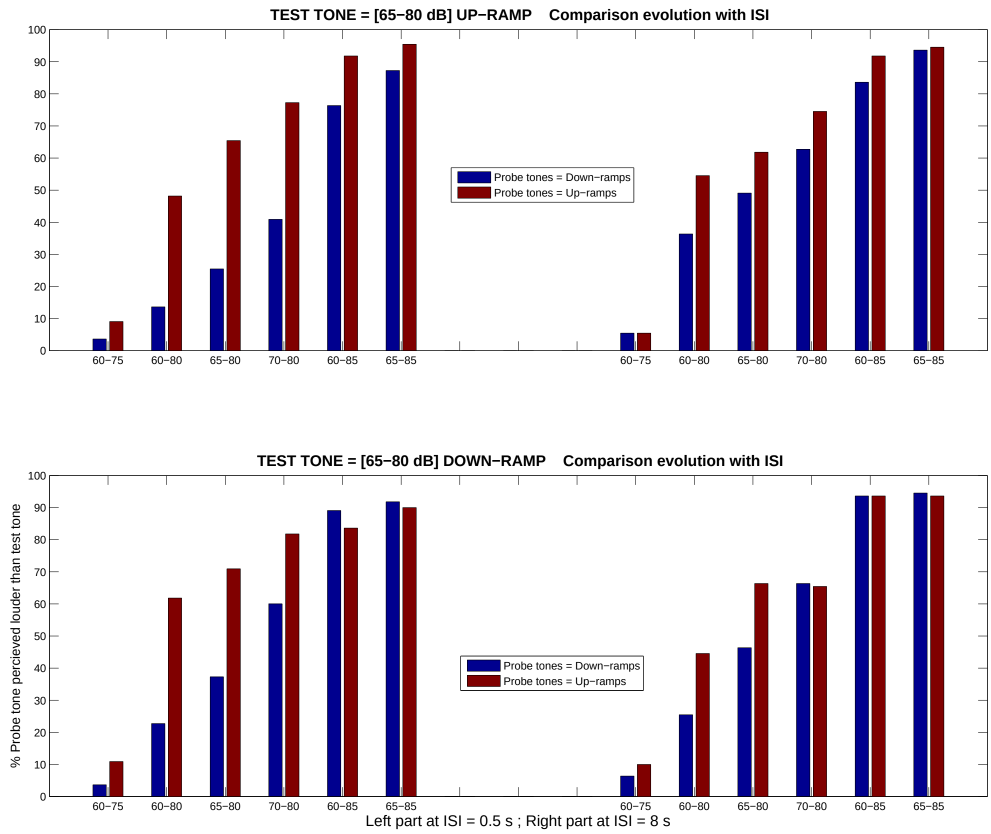


Figure 3.1: Proportion of probe tones percieved louder than test tones at ISI = 0.5 and 8 s, taking into account the direction of the test tone. Data presented for each ramp condition.

3.2.5 Indirect analysis of results

Effect of ramp dynamics

Some ramps as probe tones had same direction and end-levels but only differed in dynamics. The [60-80 dB], the [65-80 dB] and the [70-80 dB] ramps in one hand; the [60-85 dB] and the [65-85 dB] ramps in the other hand. As results, the dynamic as a significant effect in both cases (ANOVA on 3.6 and 3.7). The less important the dynamic is, the more often the ramp is perceived louder. It confirms other previous results that showed similar effects (refs).

Effect of end-level

Some ramps as probe tones had same direction and dynamics but only differed in range. The [60-80 dB] and the [65-85 dB] ramps in one hand; the [60-75 dB] and the [65-80 dB] ramps in the other hand. As results, the end-level as a significant effect in both cases (ANOVA on 3.4 and 3.5). The more high the end-level is, the more often the ramp is perceived louder. It also confirms other previous results that showed similar effects (refs).

Indirect overestimation

First of all, we can compare the amount of probe tones percieved louder than test tones regardless of the direction of the preceeding test tone (the up-ramp or the down-ramp). On Figure 3.2 we plot these amounts at two different ISI. For each ISI, the left bar corresponds to down-ramps as probe tones and the right bar to up-ramps as probe tones. Even if up-ramps and down-ramps only differed in direction (same energy), up-ramps are percieved more frequently louder than down-ramps when the ISI = 0.5 s (66% vs. 46%)(ANOVA). This effect corresponds to an *indirect overestimation* of up-ramps vs. down-ramps. However, when the ISI = 8 s, this difference between up-ramps and down-ramps amount is significantly reduced (63% vs. 55%) (ref ANOVA). And this decrease in *indirect overestimation* is not really caused by up-ramps: up-ramps bars have a small but significant decrease between ISI=0.5 s and 8s; but the down-ramps bar increasing is more significant between ISI = 0.5 s and ISI = 8s (cf. ANOVA).

We can also see the effect of the test tone on this comparison. We plot a similar graph but taking into account each direction of the test tone (cf. Figure 3.3). We can notice that the overestimation of up-ramps vs. down-ramps appears in both cases: the up-ramp or the down-ramp as test tone. But this overestimation is higher when the test tone is a down-ramp (ref ANOVA). Moreover, the proportion of up-ramps percieved louder than the test tone is significantly the same for the 2 ISIs, and this result is true in both cases, when the test tone is either an up-ramp or a down-ramp (ref ANOVA).

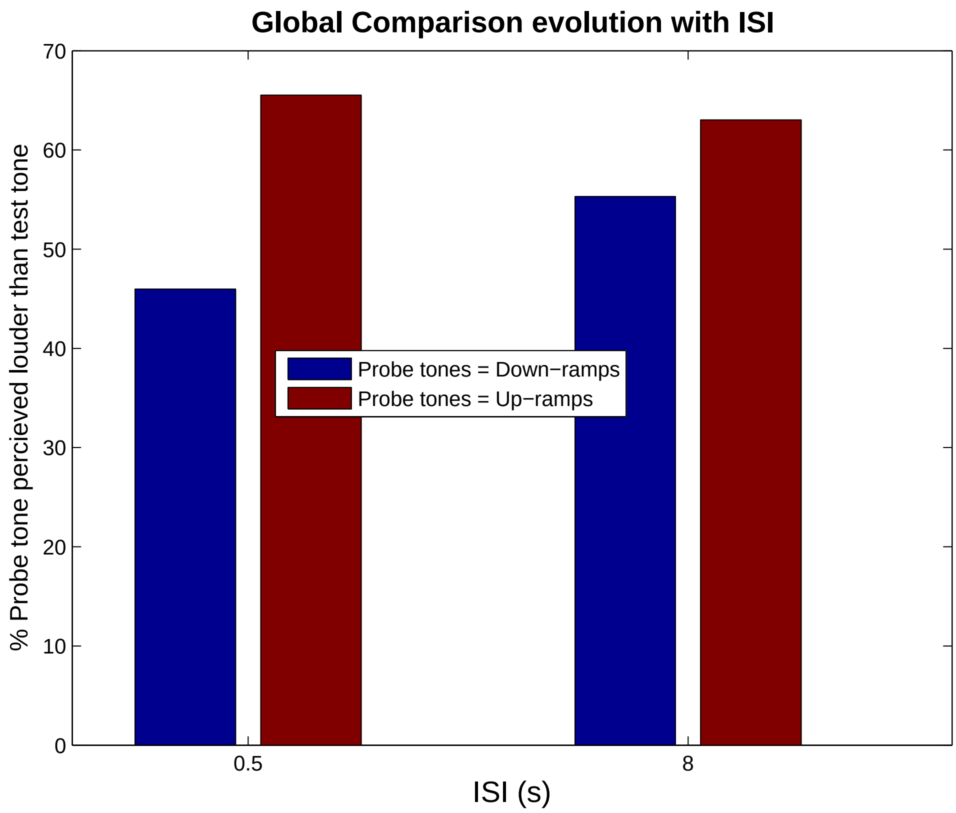


Figure 3.2: Proportion of probe tones percieved louder than test tones at two ISIs: 0.5 and 8 s. For each ISI, left bars represent this amount for probe tones = down-ramps and right bars for probes tones = up-ramps (the effect of the direction of the test tone (up vs. down) is not taken into account on this graph). This amount is greater for up-ramps than for down-ramps, which confirms the effect of overestimation also revealed with previous similar experiments (cf. Olsen et al.). But this effect is reduced when ISI = 8s. The ANOVA shows that direction of probe tones have a significant influence ($F(1,2)=17.6$, $p<0.05$) and ISI also to a lesser extent ($F(1,2)=1.1$, $p<0.05$). However, we can notice a significant interaction between them ($F(1,2)=3.3$, $p<0.05$).

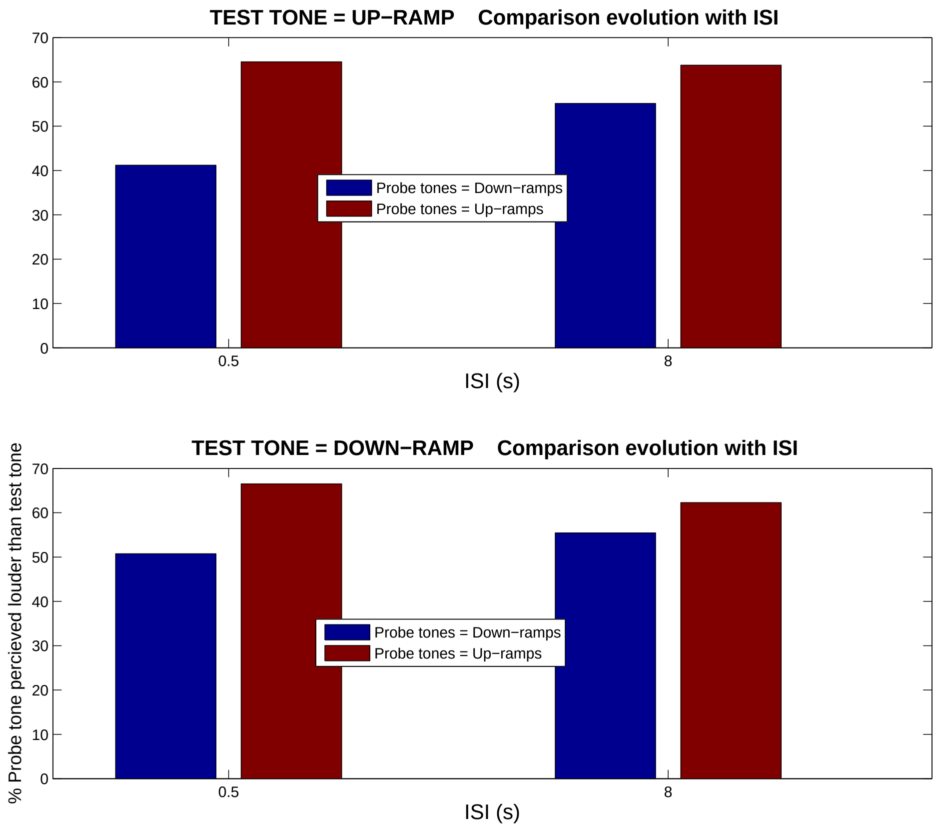


Figure 3.3: Proportion of probe tones percieved louder than test tones at ISI = 0.5 and 8 s, taking into account the direction of the test tone. The effect of overestimation is greater when the test tone is a down-ramp than when it is an up-ramp: this was also a result in Olsen et al. experiment. Furthermore, in both of the test tone directions, this effect of overestimation was also smaller when the ISI was 8 s. The ANOVA shows that there is not any significant interaction between probe tone and test tone in one hand, and between ISI and test tone in the other hand.

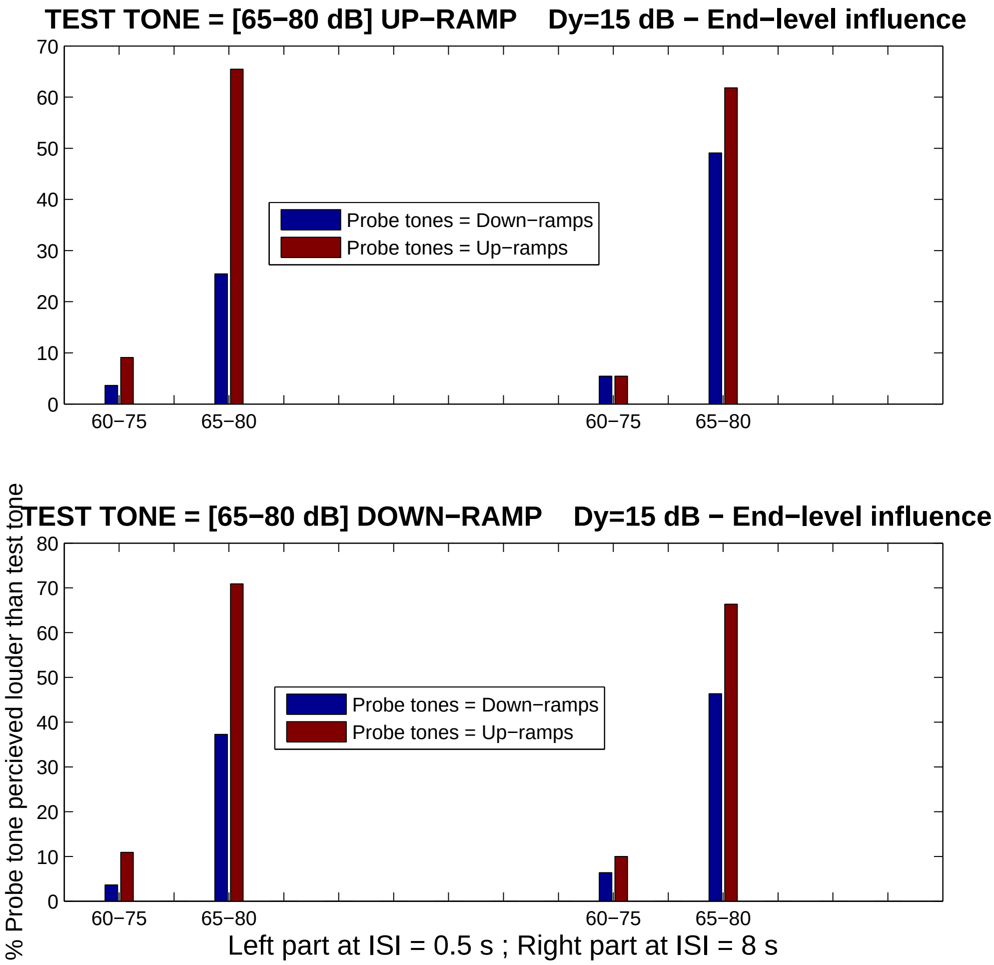


Figure 3.4: Proportion of probe tones percieved louder than test tones at ISI = 0.5 and 8 s, taking into account the direction of the test tone. The direction of test tone is not significant. However, the direction of the probe tone is significant ($F(1,4)=27.5$, $p<0.05$) and the ISI also to a lesser extent ($F(1,4)=1.1$, $p<0.05$). But the most significant is the level of the probe tone that we wanted to analyse: $F(1,4)=247.3$, $p<0.05$. We also have to notice significant interactions between probe tones and ISI ($F(1,4)=4.6$, $p<0.05$) and between probe tones and end-levels ($F(1,4)=14.8$, $p<0.05$).

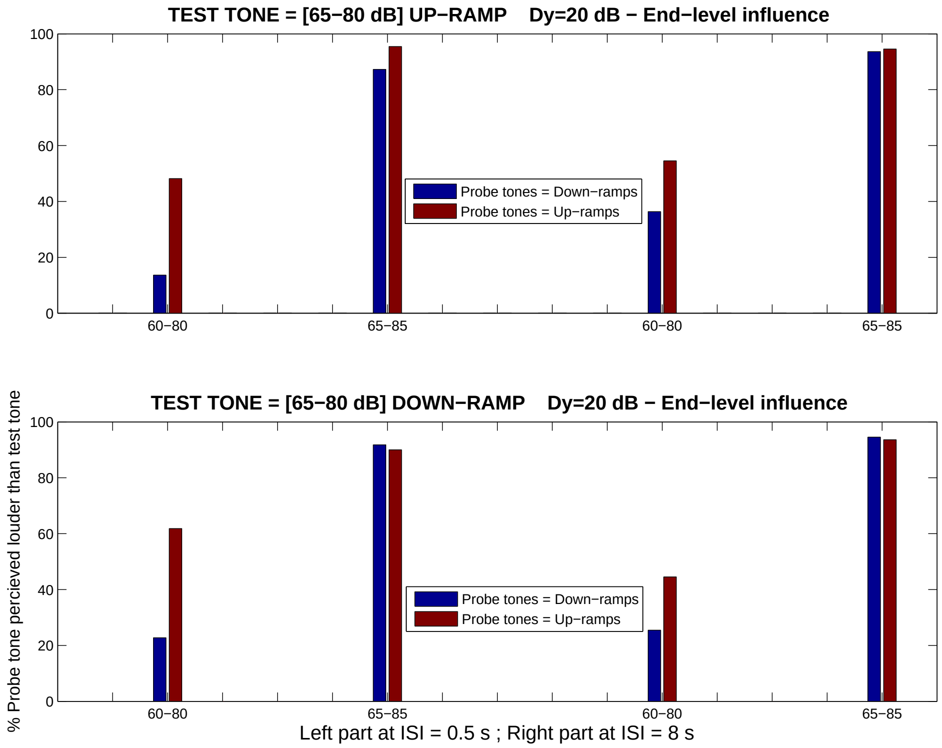


Figure 3.5: Proportion of probe tones percieved louder than test tones at ISI = 0.5 and 8 s, taking into account the direction of the test tone. The direction of test tone is not significant but has a significant interaction with the ISI ($F(1,4)=1.1$, $p<0.05$). Furthermore, the direction of the probe tone is significant ($F(1,4)=23.2$, $p<0.05$) and the ISI also to a lesser extent ($F(1,4)=1.1$, $p<0.05$). But the most significant is the level of the probe tone that we wanted to analyse: $F(1,4)=318.6$, $p<0.05$. We also have to notice other significant interactions between probe tones and ISI ($F(1,4)=3.2$, $p<0.05$), and between probe tones and end-levels ($F(1,4)=18.3$, $p<0.05$).

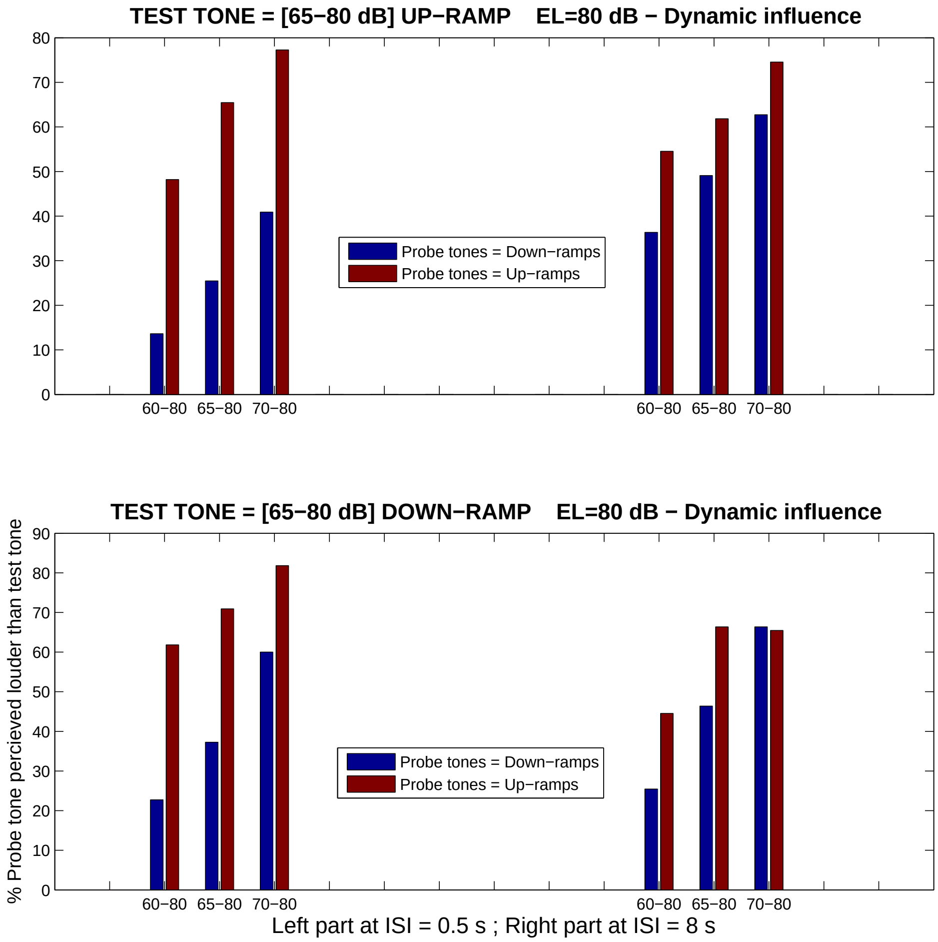


Figure 3.6: Proportion of probe tones percieved louder than test tones at ISI = 0.5 and 8 s, taking into account the direction of the test tone. The direction of test tone has a small but significant influence ($F(1,4)=1.2$, $p<0.05$) and has a significant interaction with the ISI ($F(1,4)=6.0$, $p<0.05$). Furthermore, the direction of the probe tone is significant ($F(1,4)=62.8$, $p<0.05$) and the ISI also to a lesser extent ($F(1,4)=1.8$, $p<0.05$). The dynamic of the probe tone that we wanted to analyse is also significant: $F(1,4)=28.3$, $p<0.05$. We also have to notice another significant interaction between probe tones and ISI ($F(1,4)=11.9$, $p<0.05$).

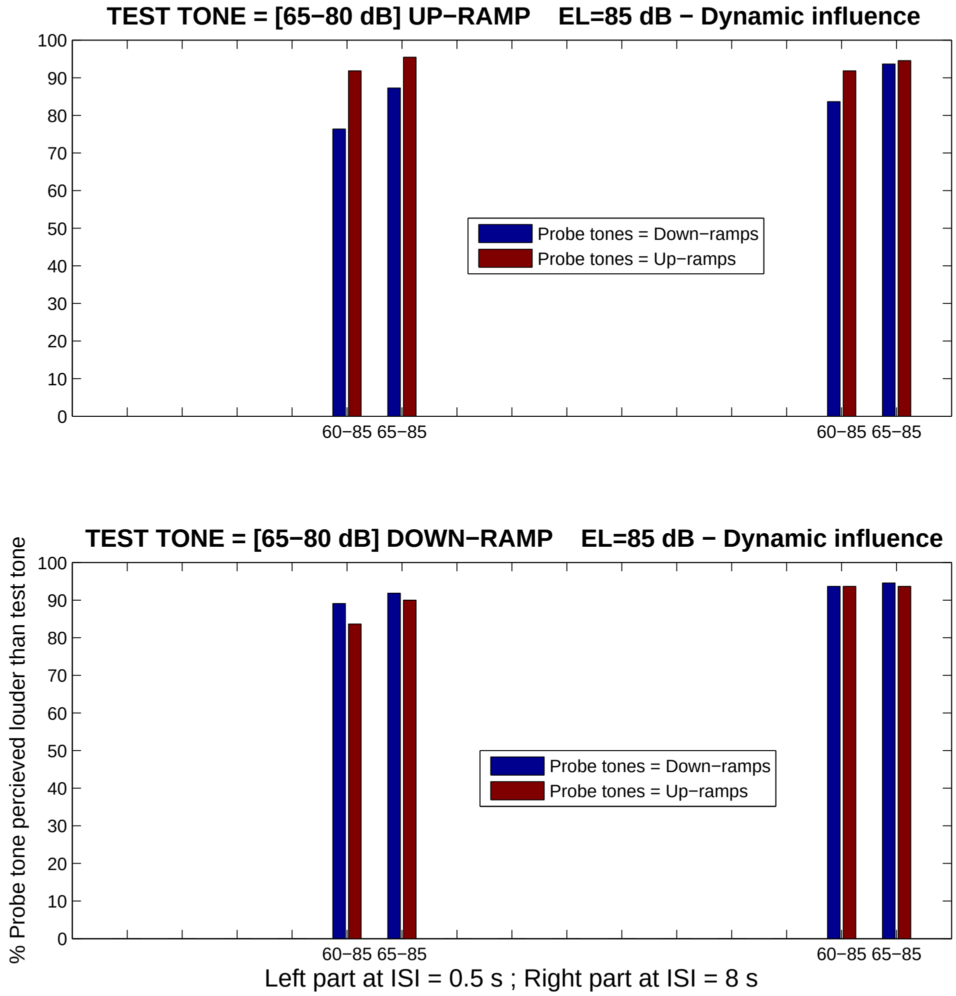


Figure 3.7: Proportion of probe tones percieved louder than test tones at ISI = 0.5 and 8 s, taking into account the direction of the test tone. The direction of the test tone has not any significant influence but has a significant interaction with probe tones ($F(1,4)=4.1$, $p<0.05$). Furthermore, the direction of the probe tone is small but significant ($F(1,4)=1.6$, $p<0.05$) and the ISI also to a greater extent ($F(1,4)=2.7$, $p<0.05$). The dynamic of the probe tone that we wanted to analyse is also significant: $F(1,4)=3.5$, $p<0.05$.

3.3 Discussion and conclusion

With this experiment, we can reach some important conclusions. First of all, we recovered effects of end-levels and dynamics of ramps, which confirms other previous results: the more the end-level or the dynamic of the ramp is important, the more the ramp is percieved louder.

Furthermore, we have to notice that overestimation of up-ramps vs. down-ramps can be analysed in different ways.

Firstly, one can regard the *direct overestimation* of the [65-80 dB] up-ramp as the test tone and the [65-80 dB] down-ramp as the probe tone, or on the contrary the [65-80 dB] down-ramp as the test tone and the [65-80 dB] up-ramp as the probe tone. With this point of view, we have recovered the overestimation of the up-ramp vs. the down-ramp. We have also noticed the significant effect of the presentation order, and a significant reduce of the *direct overestimation* effect with the ISI.

Secondly, we can regard the *indirect overestimation* of ramps, comparing relatively up-ramps and down-ramps as probe tones regardless of the test tone direction. We have also noticed the significant effect of the presentation order, and a significant reduce of the *direct overestimation* effect with the ISI.

This experiment confirmed previous results on global loudness of up-ramps. Up-ramps ratings have just a small decrease (but significant) with the ISI. It makes us believe that up-ramps perception of global loudness is time-persistant. Other results of this study show that overestimation of up-ramps vs. down ramps (both with a direct or an indirect point of view) is actually due to an underestimation of down-ramps that is decreased for long ISIs.

Conclusion

List of Figures

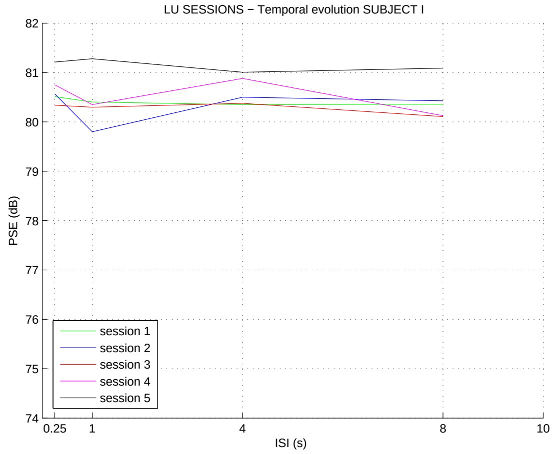
Annexes

.1 Results of Experiment 1

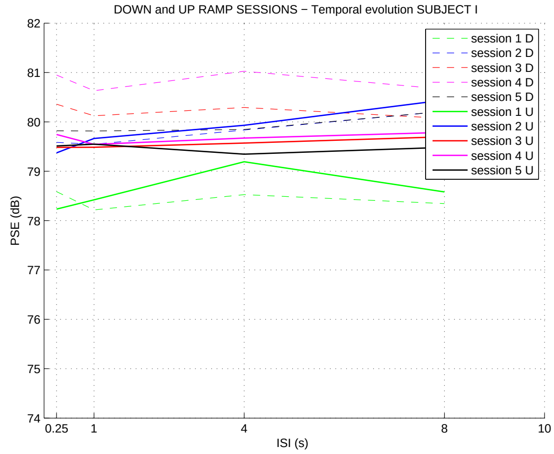
Here are presented the results of the 5 sessions for each subject in order to examine the way they evolve in their ratings. On the left are results of Lu sessions, on the right results of Up-ramp and Down-ramp sessions. Upside are functions obtained for each of the 5 sessions, and below are averaged functions.

Results are fist presented for each subject (SUBJECT I, SUBJECT W, SUBJECT C and SUBJECT L) before being averaged between all subjects.

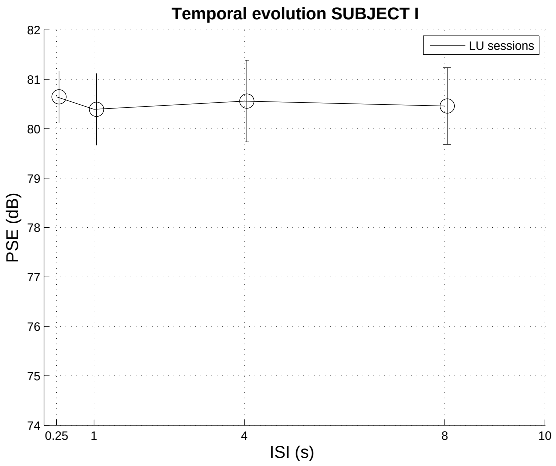
.1.1 Evolution across sessions for each subject



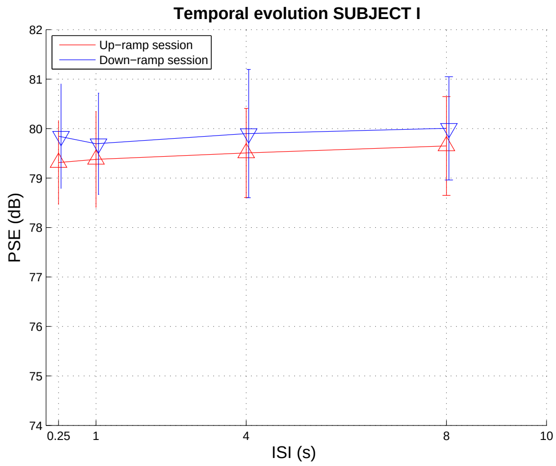
(a) PSE functions for LU sessions



(b) PSE functions for UP and DOWN ramp sessions

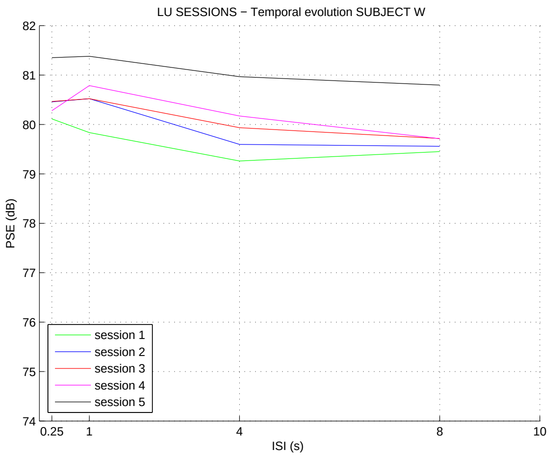


(c) Global PSE function for LU sessions

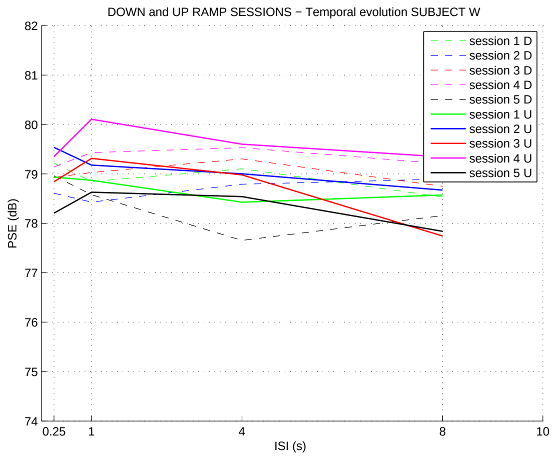


(d) Global PSE function for UP and DOWN ramp sessions

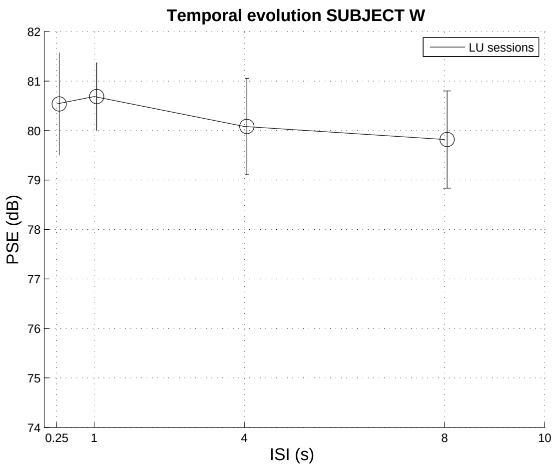
Figure 8: Results - SUBJECT I



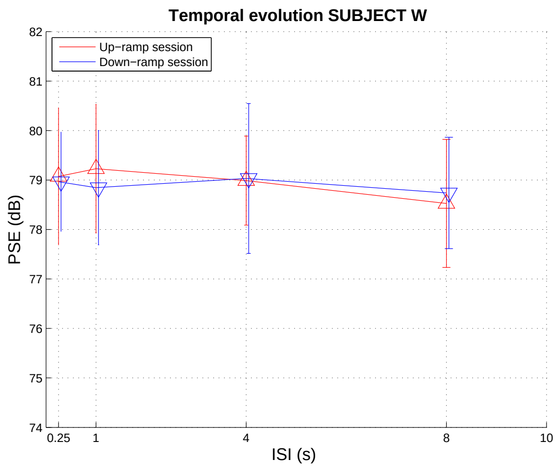
(a) PSE functions for LU sessions



(b) PSE functions for UP and DOWN ramp sessions

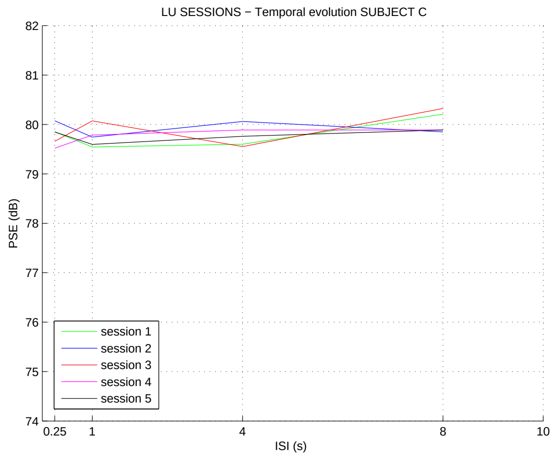


(c) Global PSE function for LU sessions

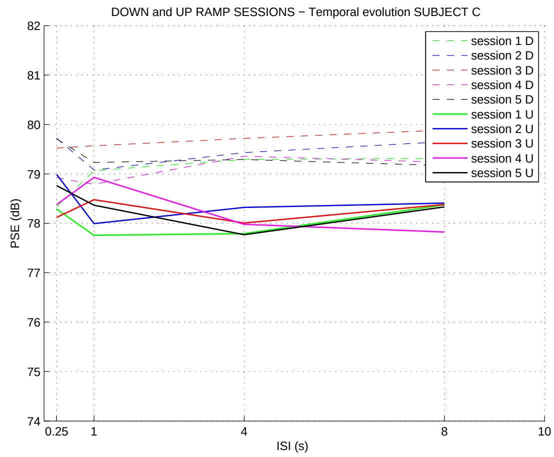


(d) Global PSE function for UP and DOWN ramp sessions

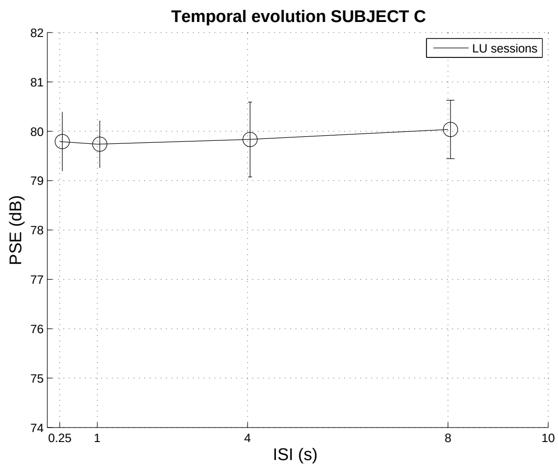
Figure 9: Results - SUBJECT W



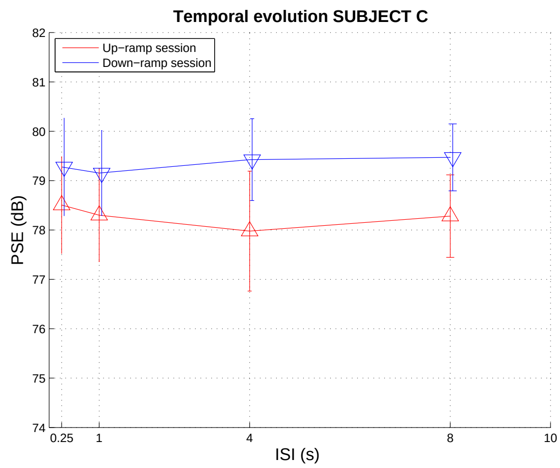
(a) PSE functions for LU sessions



(b) PSE functions for UP and DOWN ramp sessions

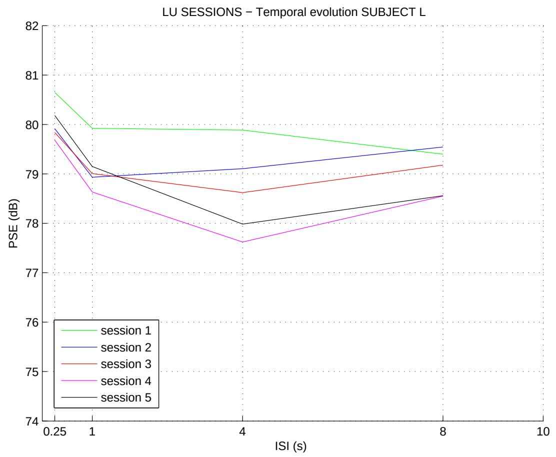


(c) Global PSE function for LU sessions

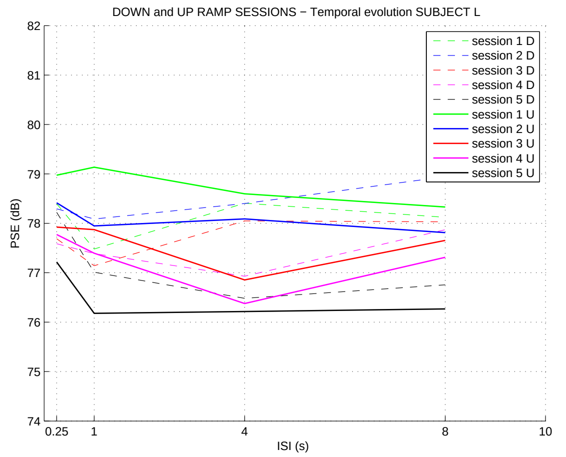


(d) Global PSE function for UP and DOWN ramp sessions

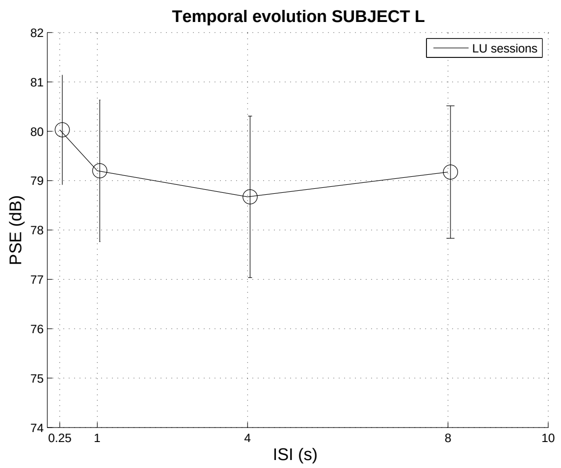
Figure 10: Results - SUBJECT C



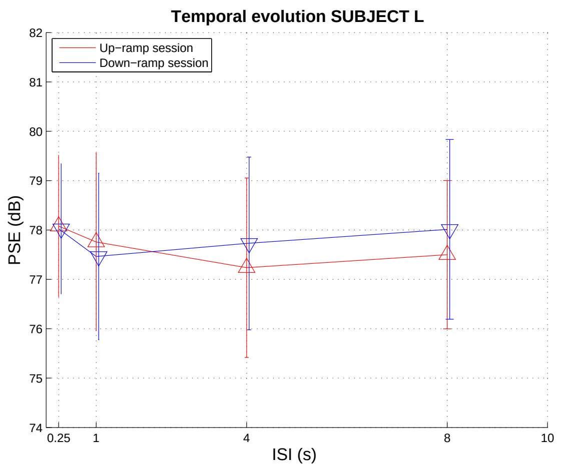
(a) PSE functions for LU sessions



(b) PSE functions for UP and DOWN ramp sessions



(c) Global PSE function for LU sessions



(d) Global PSE function for UP and DOWN ramp sessions

Figure 11: Results - SUBJECT L

.1.2 Mean of all subjects

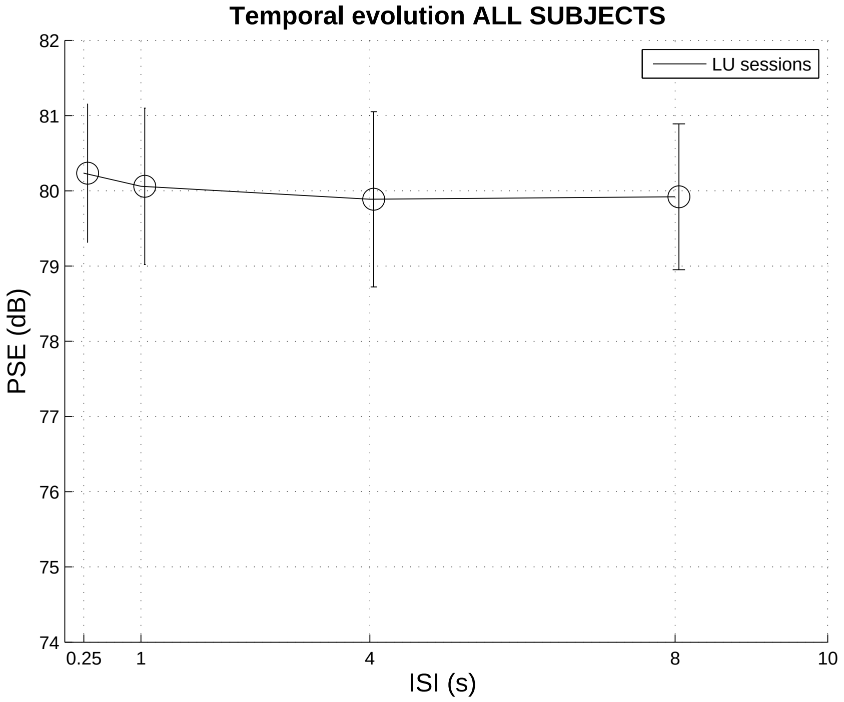


Figure 12: LU results - ALL SUBJECTS

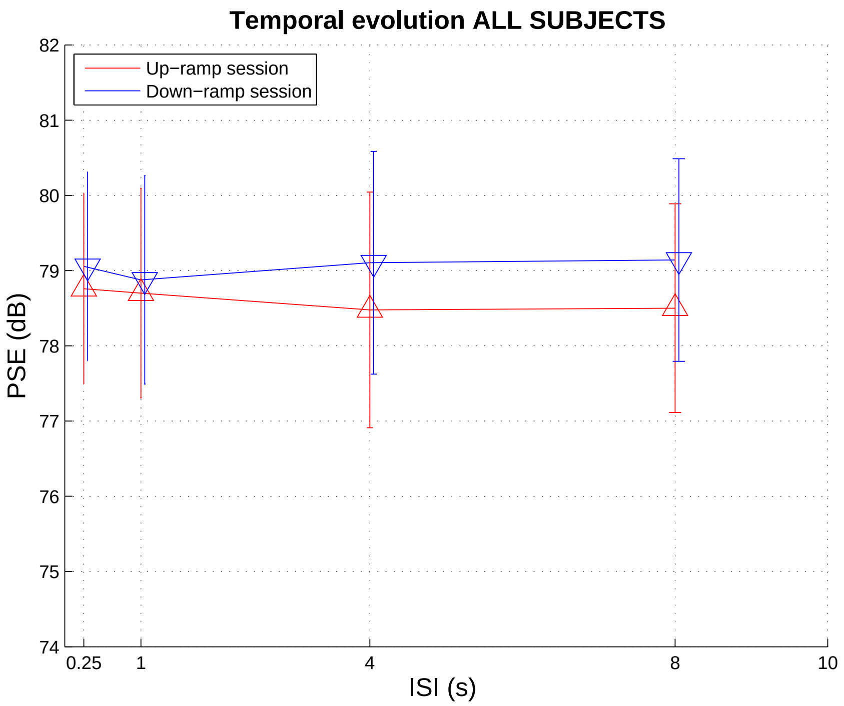


Figure 13: Up and down ramp sessions results - ALL SUBJECTS

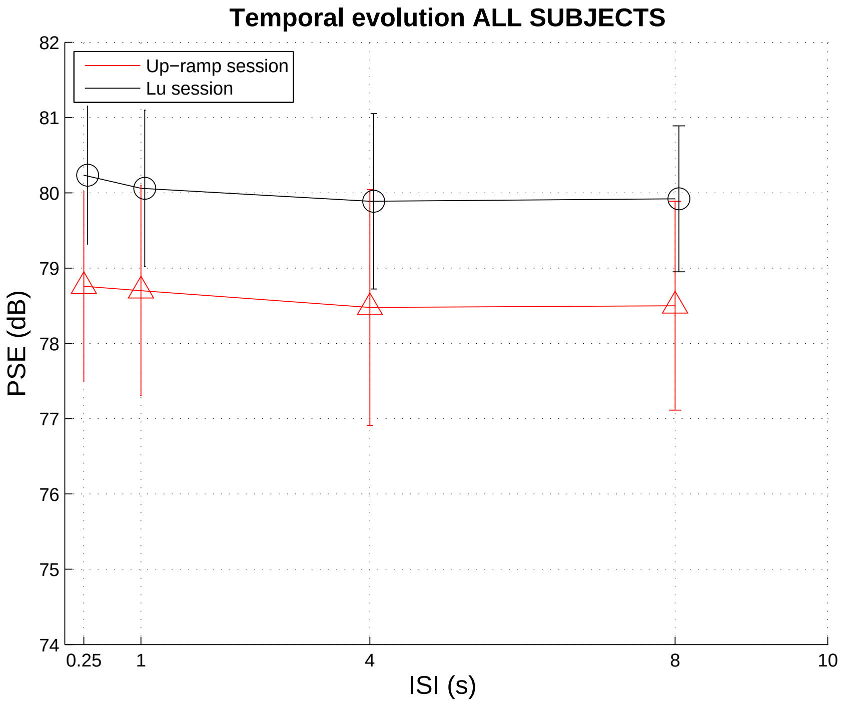


Figure 14: LU and Up-ramp sessions results - ALL SUBJECTS

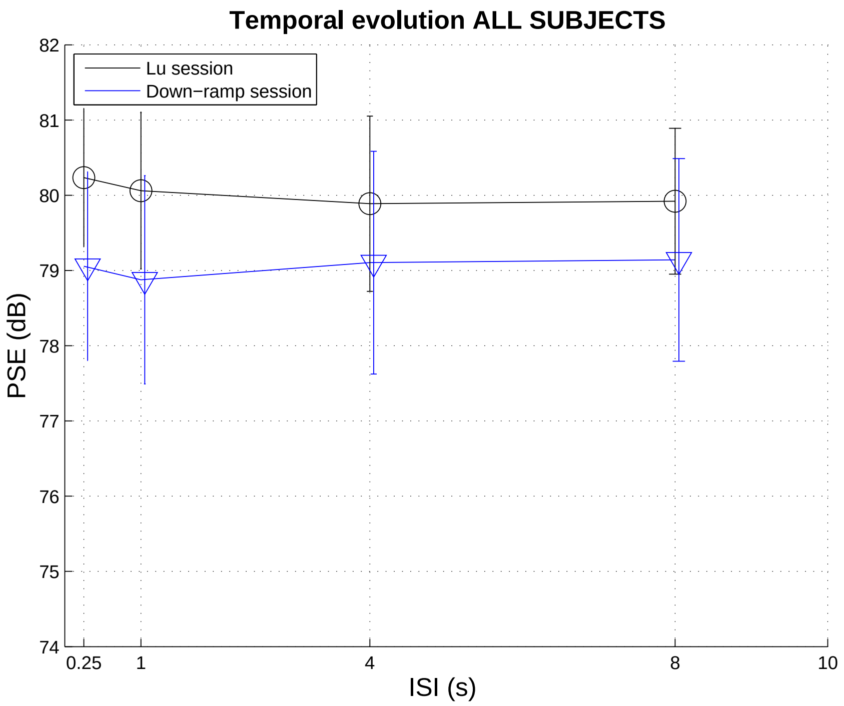
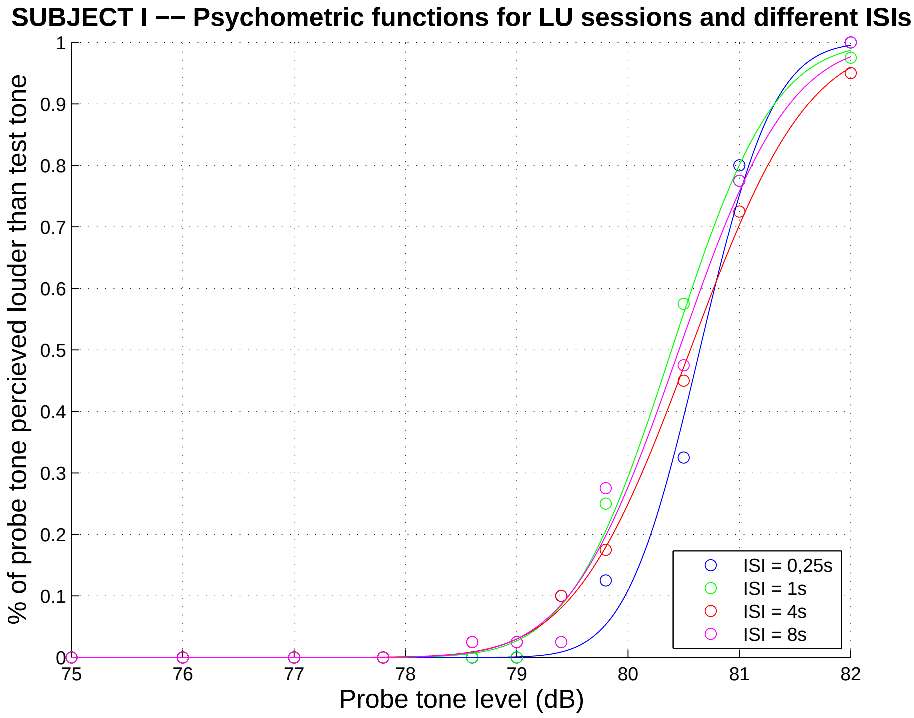


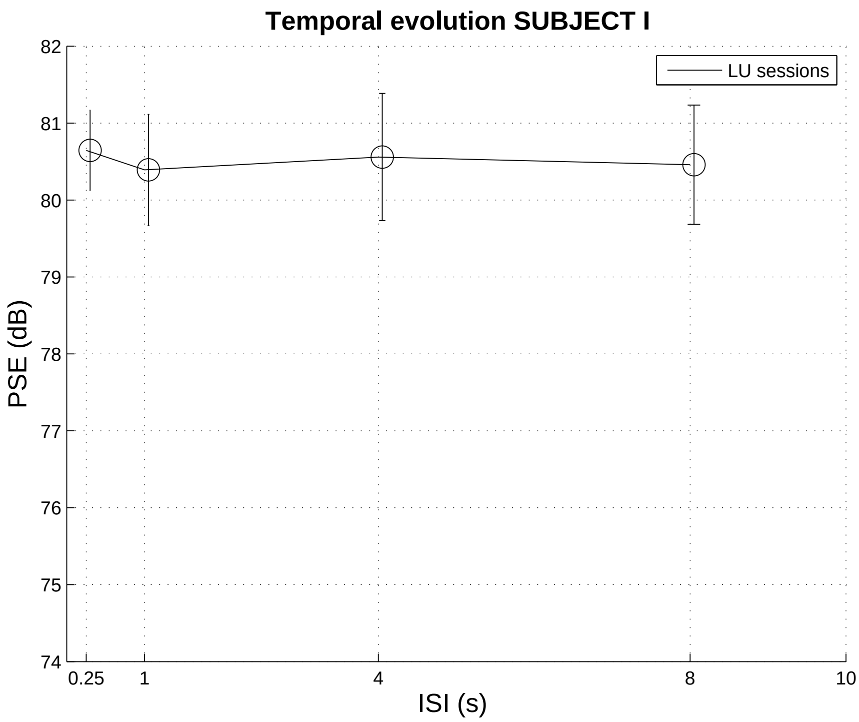
Figure 15: LU and Down-ramp sessions results - ALL SUBJECTS

.1.3 Psychometric functions for each subject

Results of LU sessions

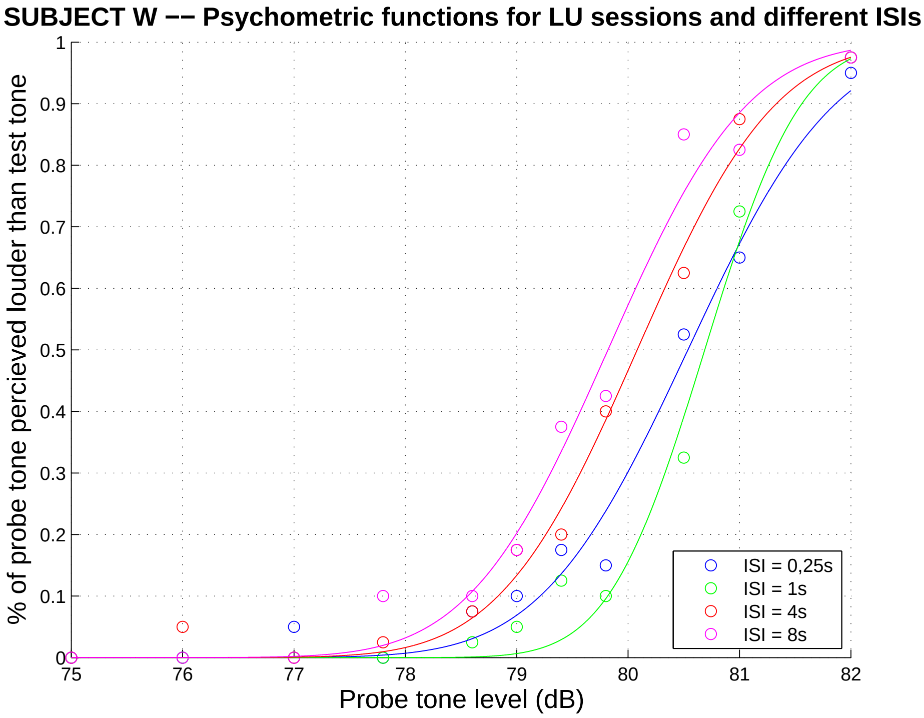


(a) Raw data and Psychometric functions

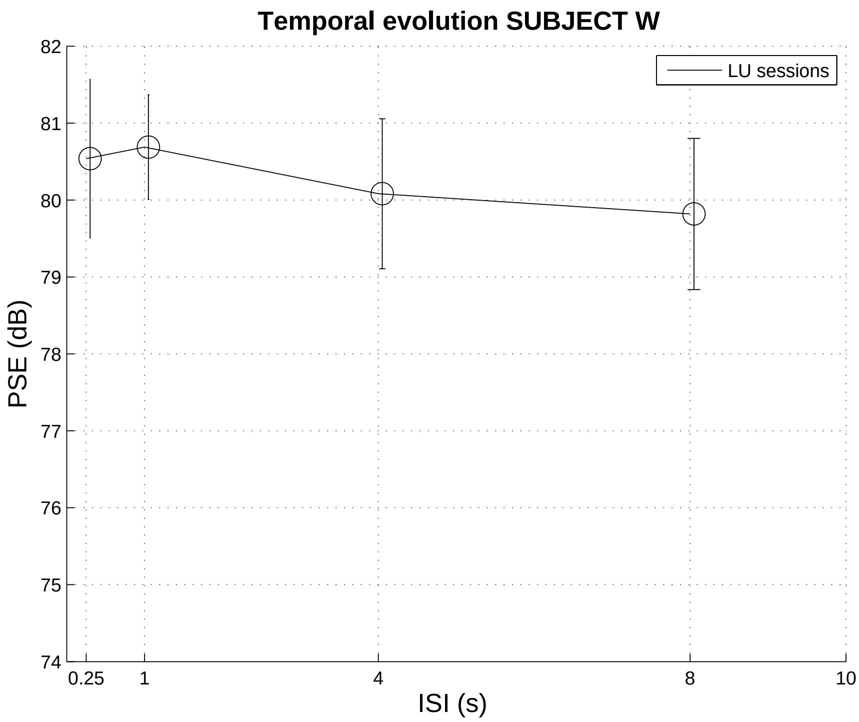


(b) PSE function

Figure 16: Results of LU sessions - SUBJECT I

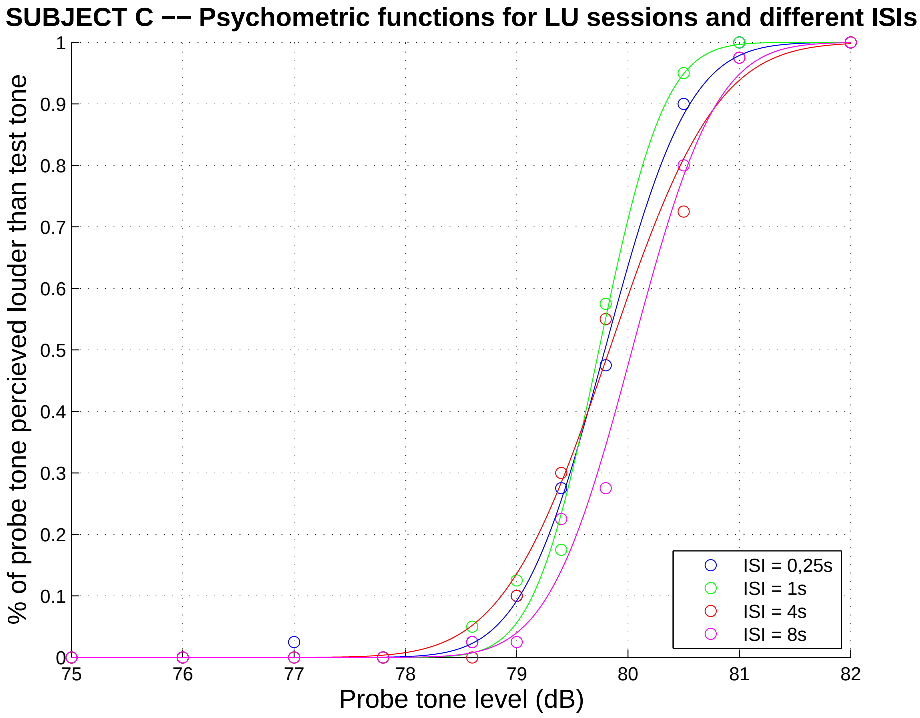


(a) Raw data and Psychometric functions

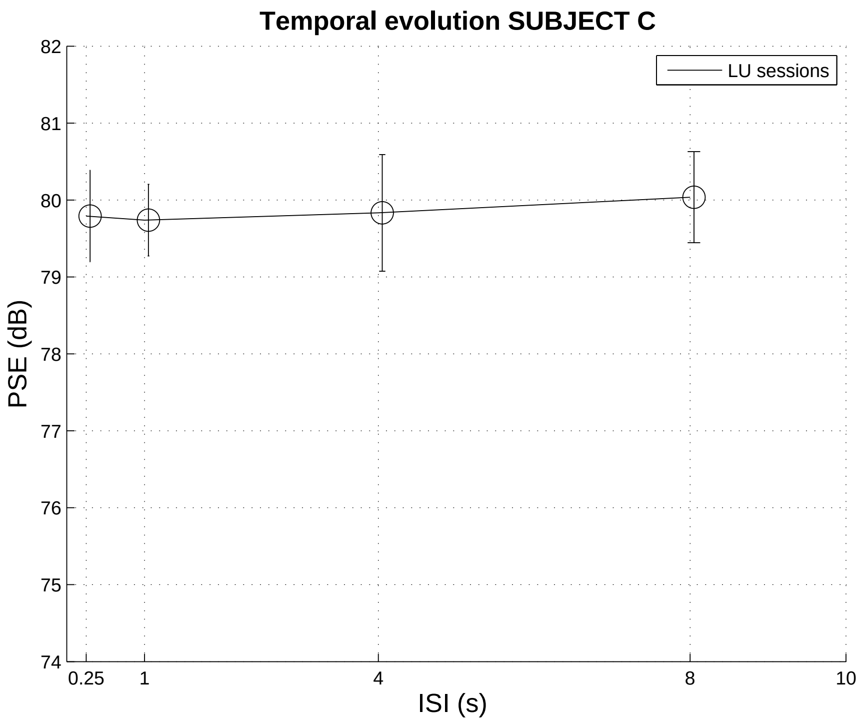


(b) PSE function

Figure 17: Results of LU sessions - SUBJECT W

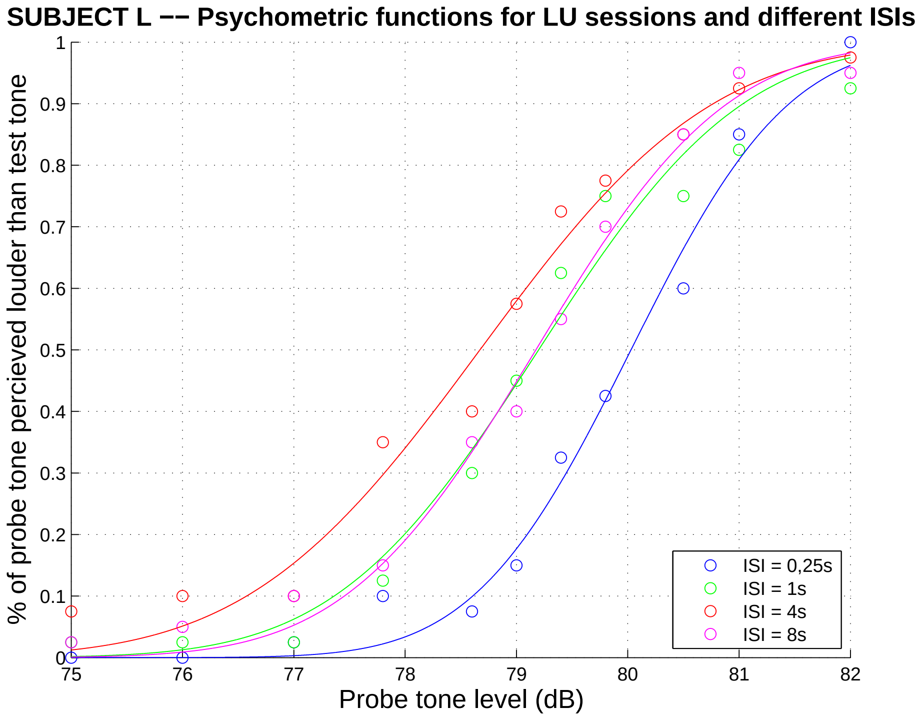


(a) Raw data and Psychometric functions

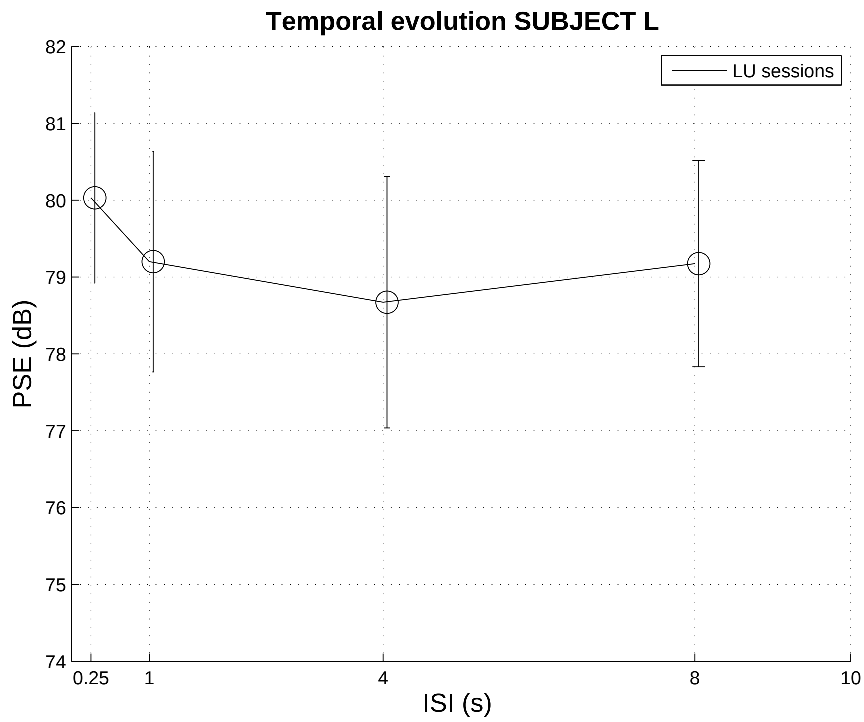


(b) PSE function

Figure 18: Results of LU sessions - SUBJECT C



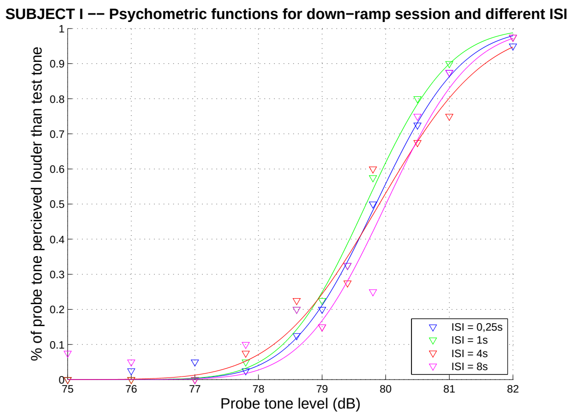
(a) Raw data and Psychometric functions



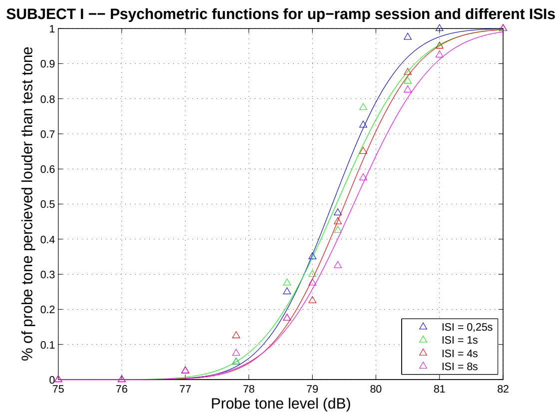
(b) PSE function

Figure 19: Results of LU sessions - SUBJECT L

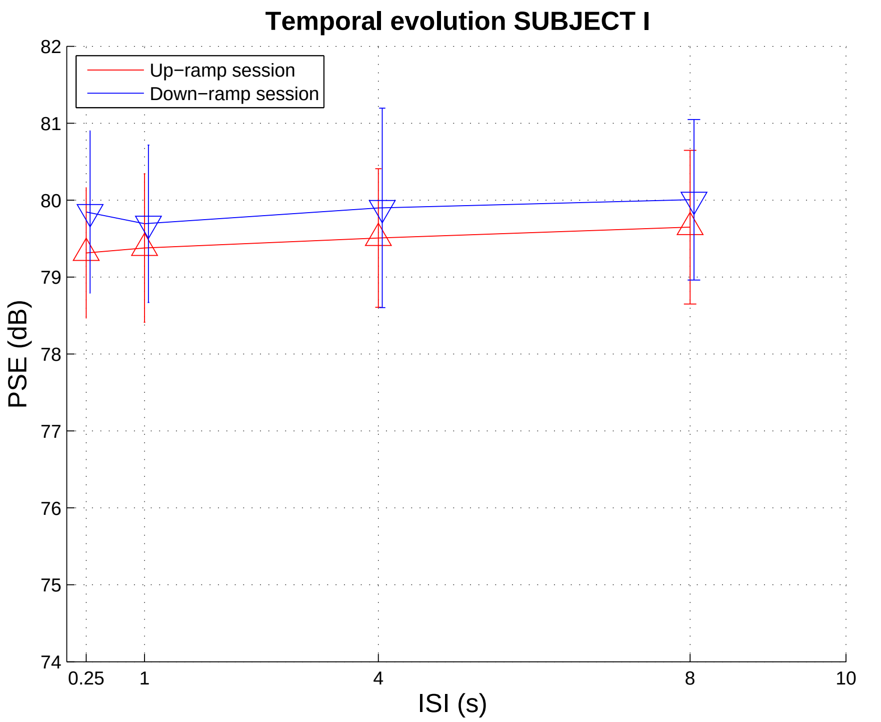
Results of up-ramp and down-ramp sessions



(a) Psychometric functions for down-ramps

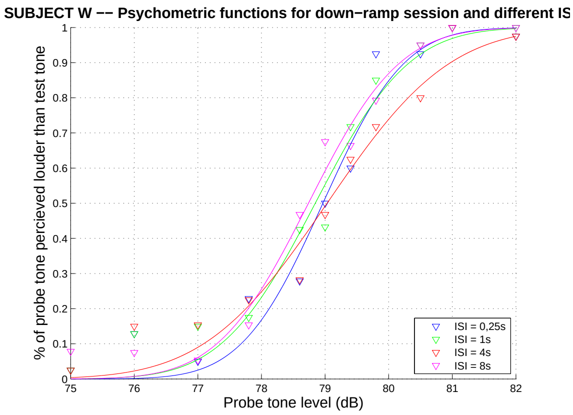


(b) Psychometric functions for up-ramps

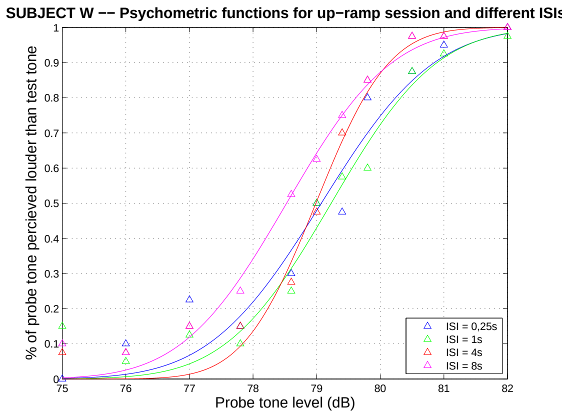


(c) PSE function

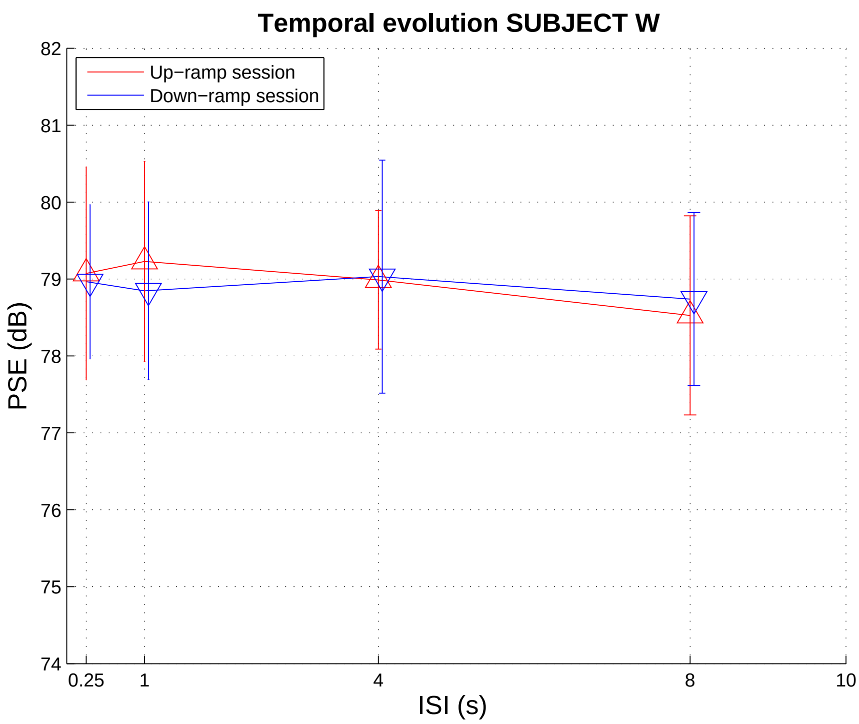
Figure 20: Results of UP-RAMP and DOWN-RAMP sessions - SUBJECT I



(a) Psychometric functions for down-ramps

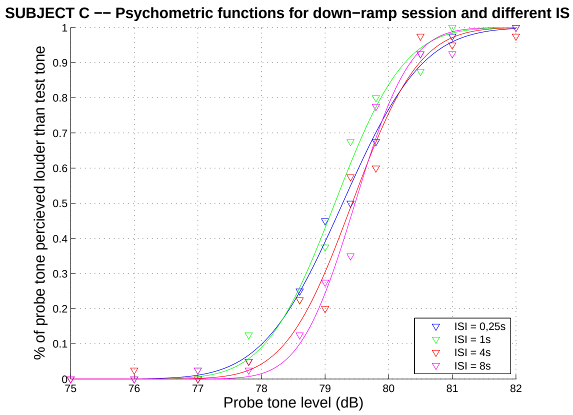


(b) Psychometric functions for up-ramps

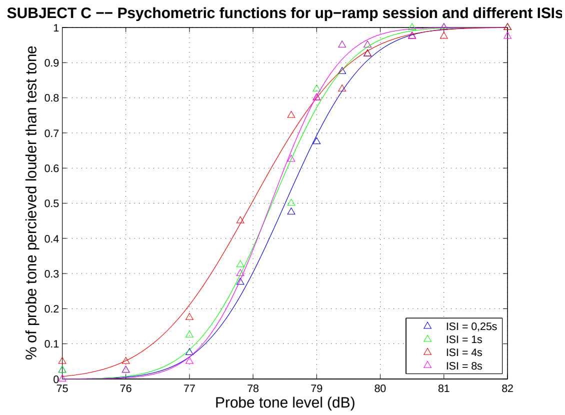


(c) PSE function

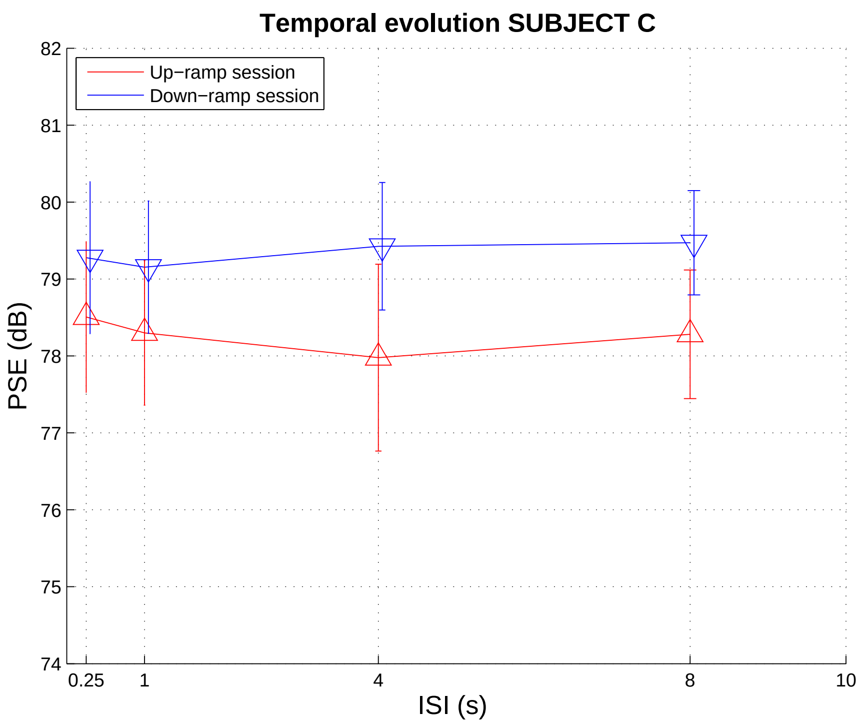
Figure 21: Results of UP-RAMP and DOWN-RAMP sessions - SUBJECT W



(a) Psychometric functions for down-ramps

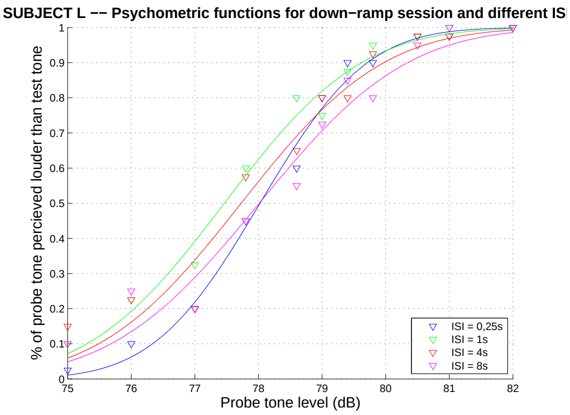


(b) Psychometric functions for up-ramps

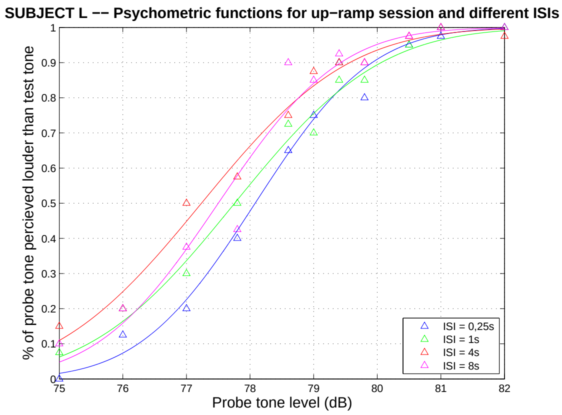


(c) PSE function

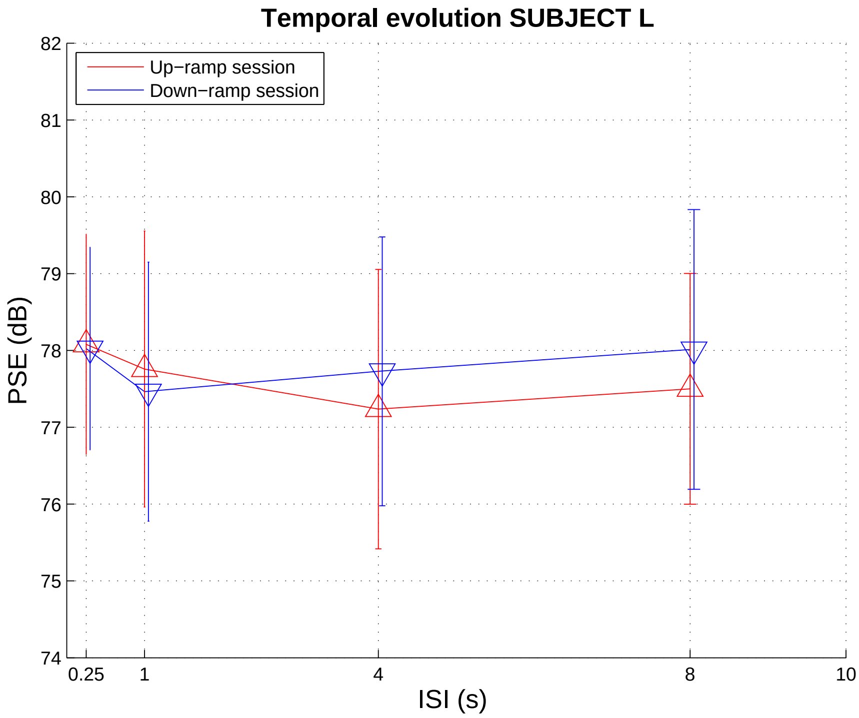
Figure 22: Results of UP-RAMP and DOWN-RAMP sessions - SUBJECT C



(a) Psychometric functions for down-ramps



(b) Psychometric functions for up-ramps



(c) PSE function

Figure 23: Results of UP-RAMP and DOWN-RAMP sessions - SUBJECT L

.2 Raw Results of Experiment 2

We did the geometric mean of answers for each stimulus. Up-ramp, down-ramp and constant stimuli ratings are plot on a same figure for each subject. Ramps are plot with the abscissa which corresponds to their loudest part (e.g the mean rating for the 65-80 dB up-ramp is plot at 80 dB abscissa).

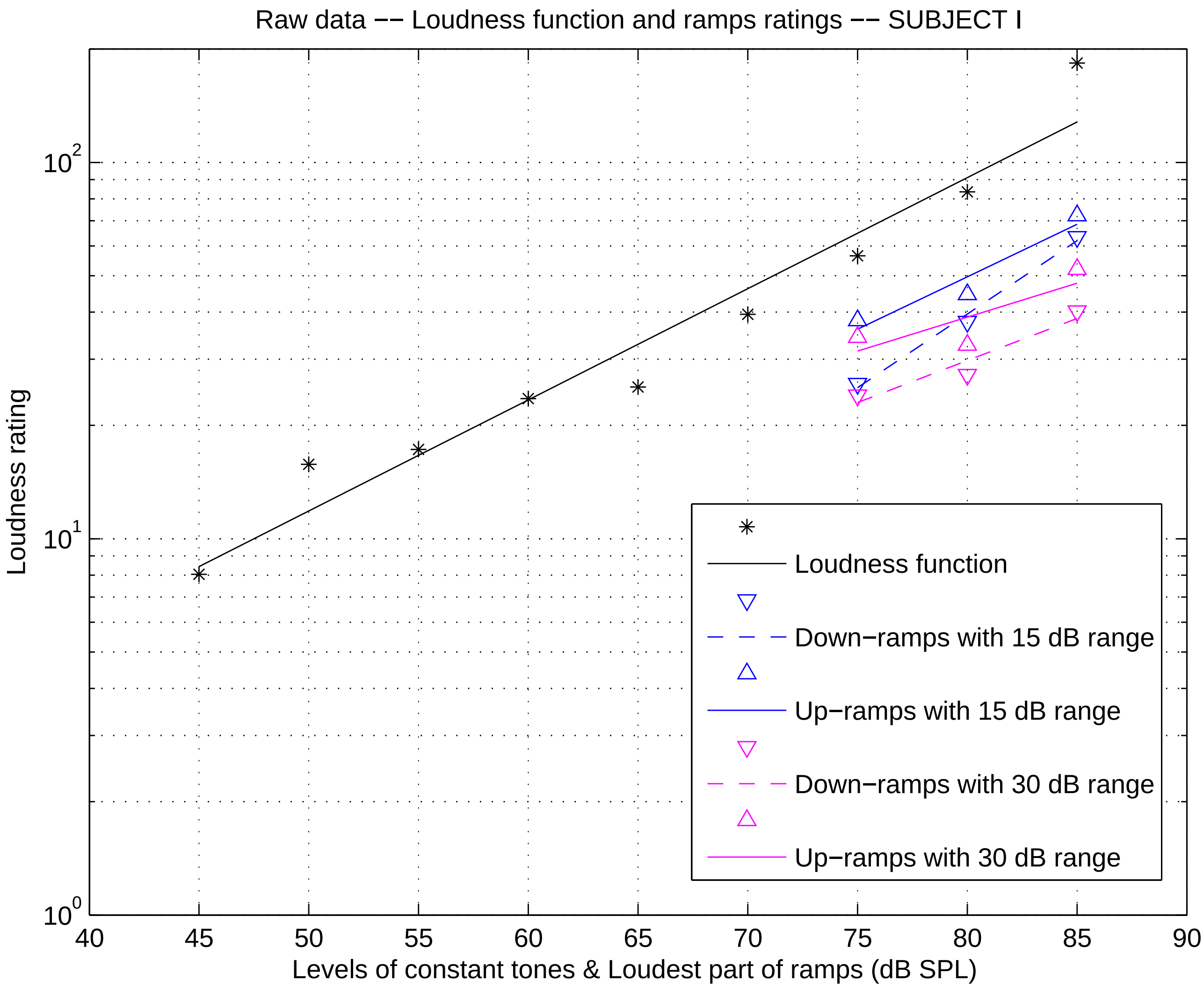


Figure 24: Raw global loudness ratings - SUBJECT I

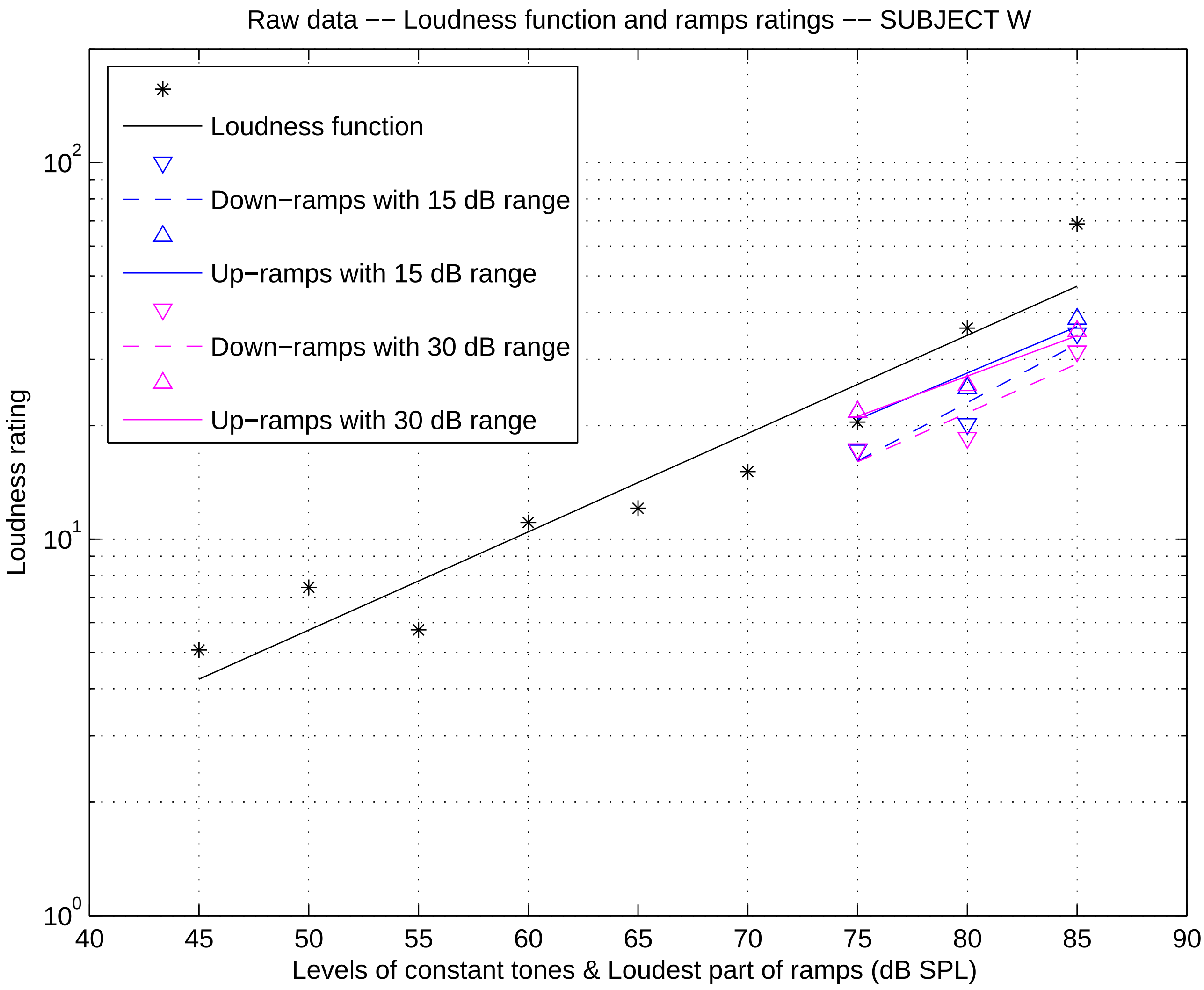


Figure 25: Raw global loudness ratings - SUBJECT W

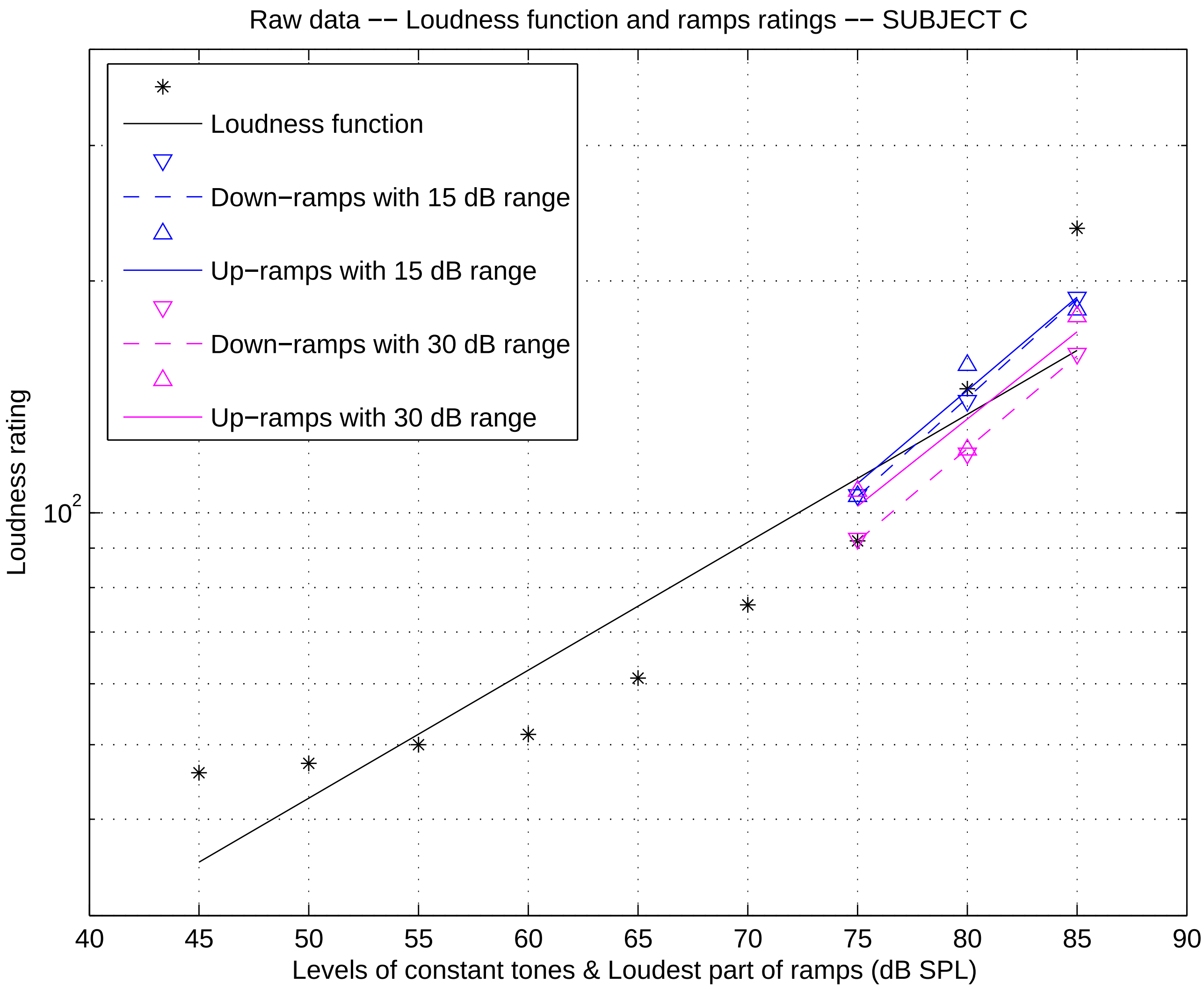


Figure 26: Raw global loudness ratings - SUBJECT C

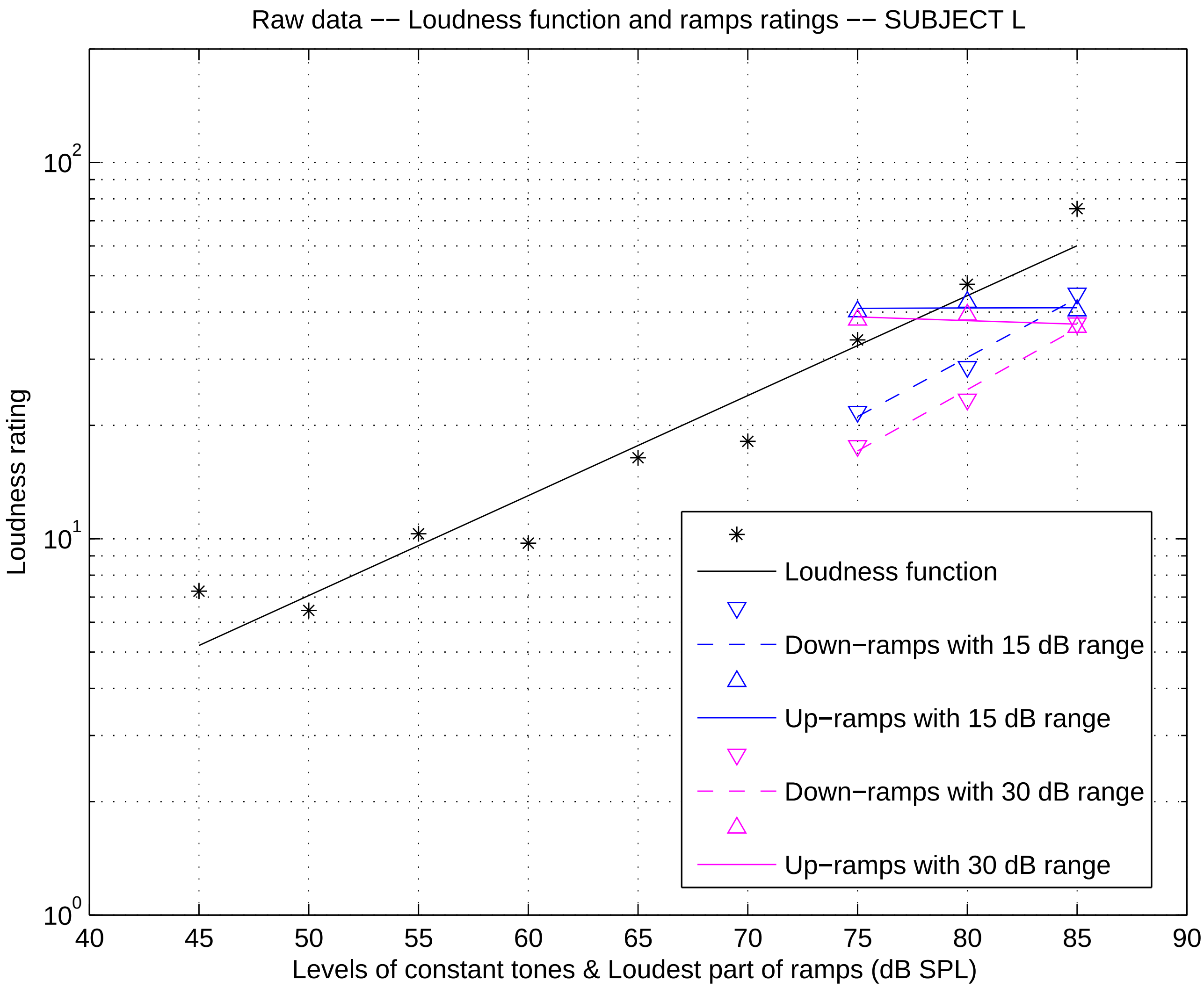


Figure 27: Raw global loudness ratings - SUBJECT L

.3 Standardized Results of Experiment 2

As there was no given scale for this experiment, subjects could use any scale they wanted. In order to compare ratings between subjects, a standardization of these results is necessary. Standardized answers have been calculated so the mean rating for each subject is 2 for the 50 dB constant stimuli.

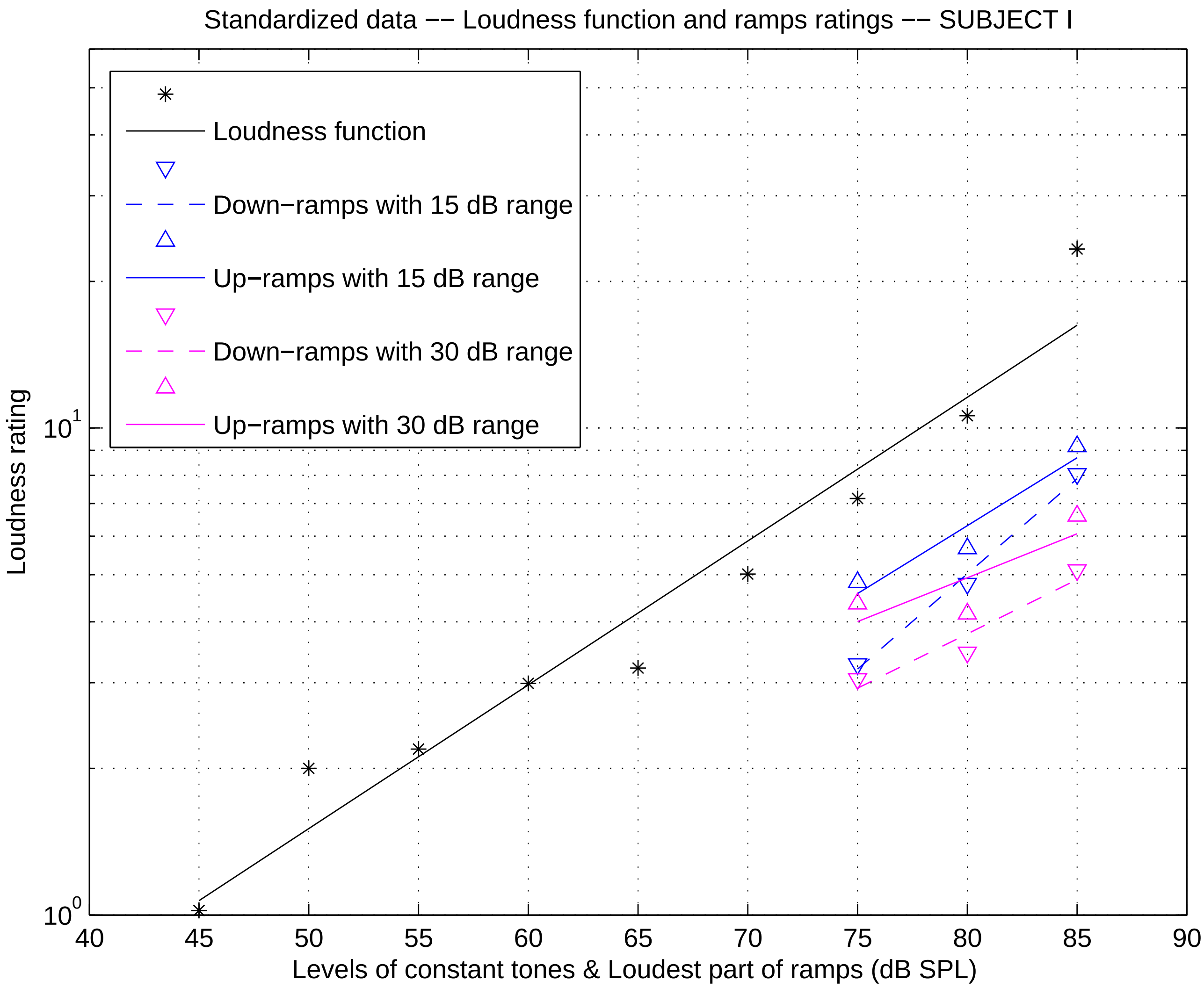


Figure 28: Standardized global loudness ratings - SUBJECT I

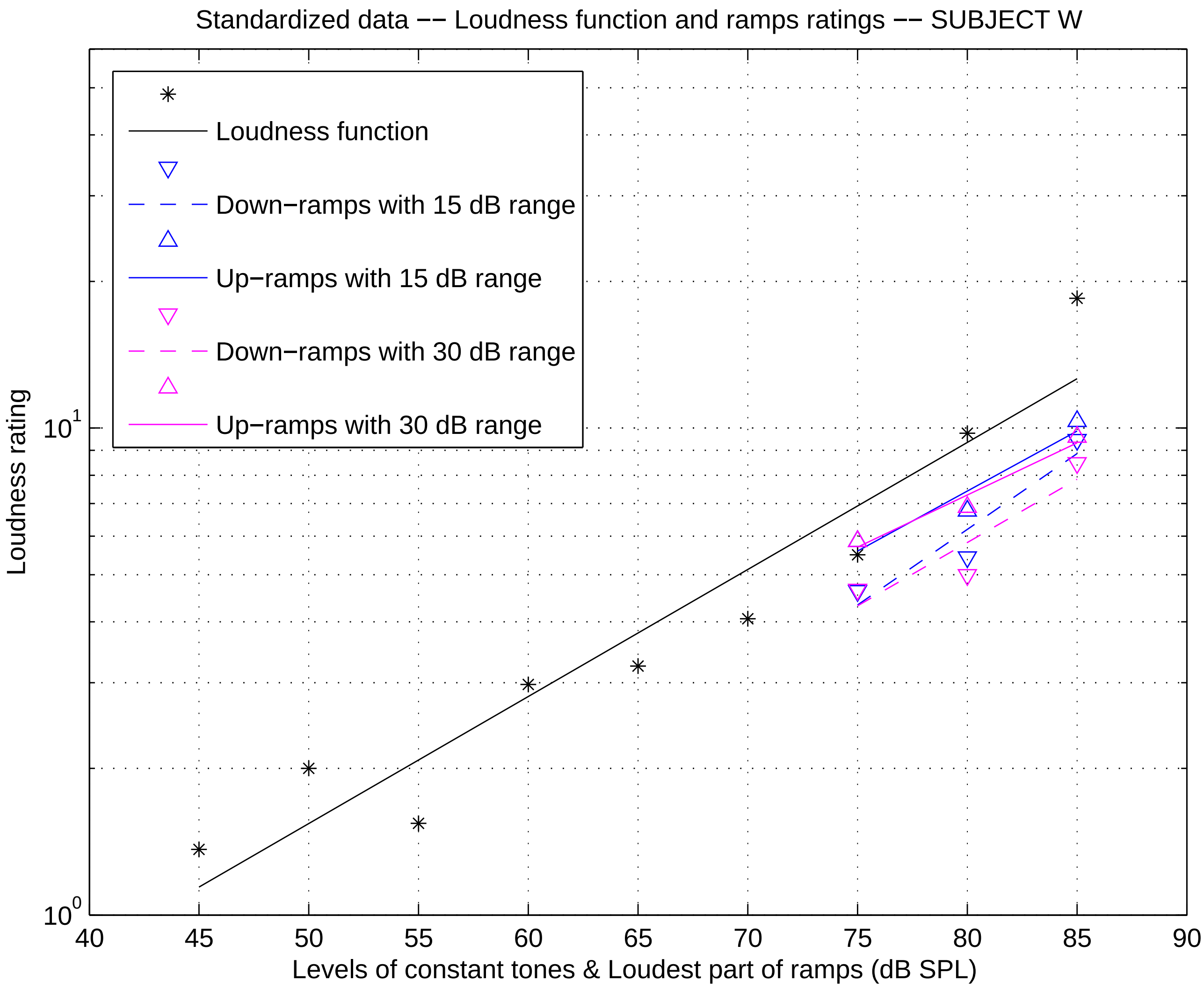


Figure 29: Standardized global loudness ratings - SUBJECT W

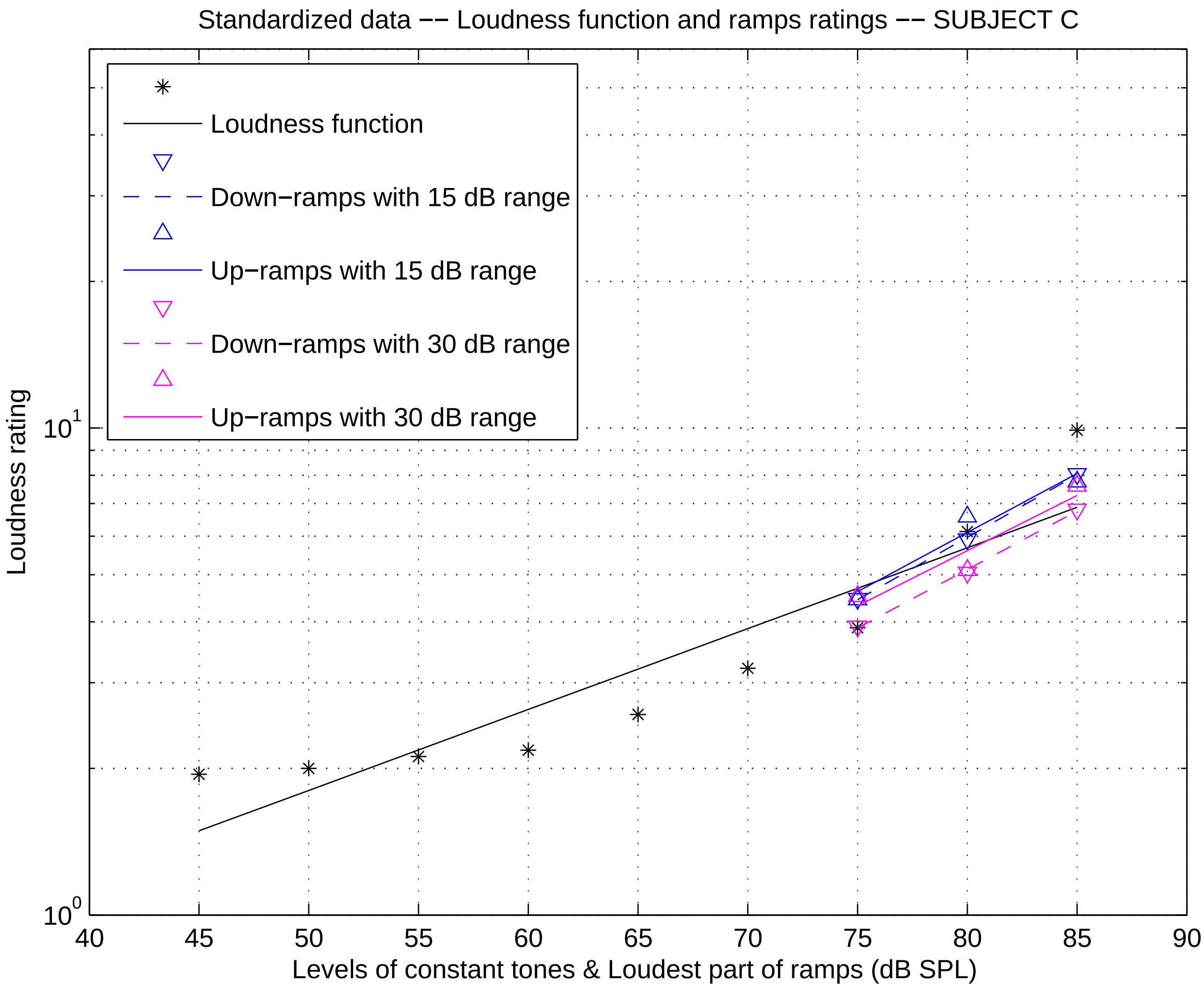


Figure 30: Standardized global loudness ratings - SUBJECT C

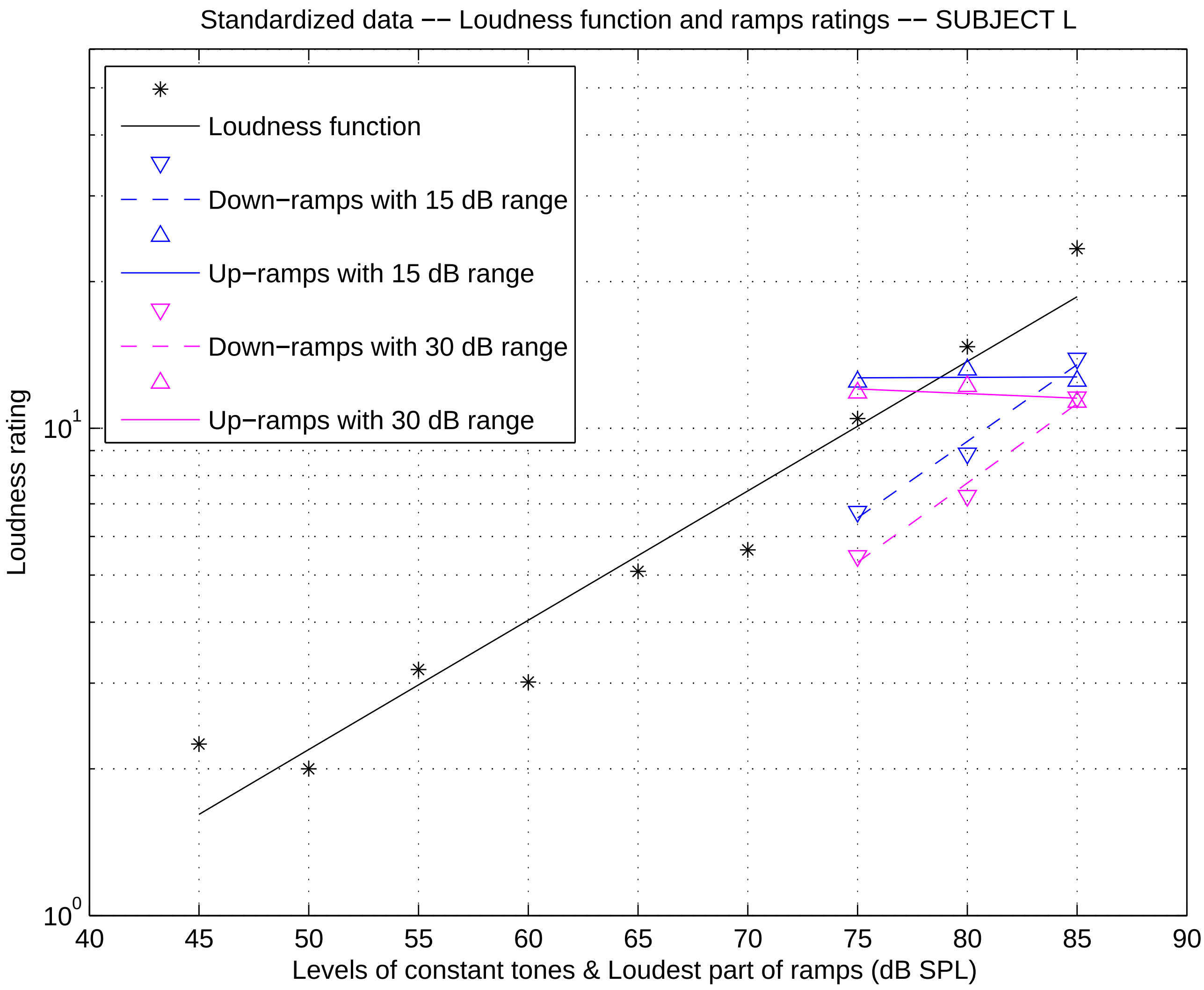


Figure 31: Standardized global loudness ratings - SUBJECT L

.4 Questionnaires

NOM NAOUR Date 15/09/2010

Prénom Isabelle

Questionnaire n°1 sur l'expérience Psycho-acoustique

1. Quelle a été l'évolution de votre perception au cours de l'expérience ?

Une « certaine habitude » est apparue. Le sujet avait l'impression de certaines « sessions identiques ». Les 3 types de sessions ont été distingués par le sujet directement. Le sujet a mentionné la difficulté supérieure des sessions croissantes et décroissantes à cause de la différence de nature des sons et de leurs « durées différentes ».

2. Comment avez-vous fait votre jugement pour comparer les 2 sons dans chaque session ?

Pour les sessions type Lu : «pas de problème, c'était facile ». Pour les autres le « jugement a été fait par rapport au niveau le plus fort du premier son ».

3. Avez-vous associé certains sons avec une image virtuelle pour faciliter la comparaison ?

« Non, pas du tout ».

4. Quand vous ne saviez pas « Quel son était le plus fort », comment avez-vous répondu ?

☒ AU HASARD ☐ LE PREMIER SON ☐ LE SECOND

Le sujet pense que « certains sons étaient identiques » dans les sessions de type Lu.

5. Pensez-vous avoir changé votre façon de juger entre différentes sessions ?

☐ OUI ☒ NON ☐ JE NE SAIS PAS

6. Si oui, pouvez-vous expliquer ?

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NOM NAOUR Date 15/09/2010
Prénom Isabelle

Questionnaire n°2 sur l'expérience Psycho-acoustique

PARTIE 1 : Questions sur les sessions 1 à 15

1. Dans la première partie de l'expérience (écoute des 2 sons puis réponse à la question « Quel son était le plus fort ? »), lors de l'écoute des *sons augmentant en intensité (écoute son A)*, comment les avez-vous comparés aux seconds sons ?

   ☒ EN ME BASANT SUR LA PARTIE DU SON LA PLUS FORTE ☐ EN CHERCHANT UNE MOYENNE ☐ SANS REFLECHIR

2. Si vous deviez juger la difficulté de **cette tâche**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
   ☐ ASSEZ FACILE ☐ TRES FACILE

3. Dans la première partie de expérience (écoute des 2 sons puis réponse à la question « Quel son était le plus fort ? »), lors de l'écoute des *sons diminuant en intensité (écoute son B)*, comment les avez-vous comparés aux seconds sons?

   ☒ EN ME BASANT SUR LA PARTIE DU SON LA PLUS FORTE ☐ EN CHERCHANT UNE MOYENNE ☐ SANS REFLECHIR

4. Si vous deviez juger la difficulté de **cette tâche**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
   ☐ ASSEZ FACILE ☐ TRES FACILE

5. Si vous deviez juger la difficulté de **la tâche pour les sessions type « 2 sons constants »**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☐ ASSEZ DIFFICILE ☐ INDIFFERENT
   ☒ ASSEZ FACILE ☐ TRES FACILE

NOM NAOUR… ×Date 17/09/10

Prénom …Isabelle……….

Questionnaire n°3 sur l'expérience Psycho-acoustique

Questions sur la session 16 uniquement

1. Dans la première partie de l'expéri ence (écoute des *sons constants*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
☐ ASSEZ FACILE ☐ TRES FACILE

2. Dans la deuxième partie de l'expérience (écoute des *sons augmentant en intensité*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
☐ ASSEZ FACILE ☐ TRES FACILE

3. Dans la deuxième partie de l'expérience (écoute des *diminuant en intensité*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
☐ ASSEZ FACILE ☐ TRES FACILE

NOM PRUNCK Date 15/09/2010

Prénom William

Questionnaire n°1 sur l'expérience Psycho-acoustique

1. Quelle a été l'évolution de votre perception au cours de l'expérience ?

Pas de difficulté avec les sons constants. « Beaucoup de mal avec les sons décroissants au départ ». « Du mal aussi avec des temps longs entre les sons au début ». Puis ensuite, ça a été, « ma mémoire s'est habituée ». Les sons croissants sont trompeurs car « on peut être influencé par la fin ».

2. Comment avez-vous fait votre jugement pour comparer les 2 sons dans chaque session ?

« J'avais deux méthodes. La premièrre, plus scientifique, où je faisais appel à ma mémoire pour une comparaison honnête. La deuxième s'était plus du *feeling* ».

3. Avez-vous associé certains sons avec une image virtuelle pour faciliter la comparaison ?

« Jamais ».

4. Quand vous ne saviez pas « Quel son était le plus fort », comment avez-vous répondu ?

☐ AU HASARD ☒ LE PREMIER SON ☐ LE SECOND

« Cétait mon référentiel. Sauf au début, pour les ¾ premières sessions, où je ne m'étais pas encore fixé de règle ».

5. Pensez-vous avoir changé votre façon de juger entre différentes sessions ?

☐ OUI ☒ NON ☐ JE NE SAIS PAS

« …elle s'est perfectionnée ».

6. Si oui, pouvez-vous expliquer ?

………
………
………
………
………

NOM PRUNCK Date 15/09/2010

Prénom William

Questionnaire n°2 sur l'expérience Psycho-acoustique

PARTIE 1 : Questions sur les sessions 1 à 15

1. Dans la première partie de l'expérience (écoute des 2 sons puis réponse à la question « Quel son était le plus fort ? »), lors de l'écoute des *sons augmentant en intensité (écoute son A)*, comment les avez-vous comparés aux seconds sons ?

   - [x] EN ME BASANT SUR LA PARTIE DU SON LA PLUS FORTE « Pendant les 2/3 1ères sessions »
   - [x] EN CHERCHANT UNE MOYENNE « Ensuite ».
   - [ ] SANS REFLECHIR

2. Si vous deviez juger la difficulté de **cette tâche**, quel qualificatif donneriez-vous ?

   - [ ] TRES DIFFICILE
   - [ ] ASSEZ DIFFICILE
   - [ ] INDIFFERENT
   - [x] ASSEZ FACILE
   - [ ] TRES FACILE

3. Dans la première partie de expérience (écoute des 2 sons puis réponse à la question « Quel son était le plus fort ? »), lors de l'écoute des *sons diminuant en intensité (écoute son B)*, comment les avez-vous comparés aux seconds sons?

   - [ ] EN ME BASANT SUR LA PARTIE DU SON LA PLUS FORTE
   - [x] EN CHERCHANT UNE MOYENNE
   - [ ] SANS REFLECHIR

4. Si vous deviez juger la difficulté de **cette tâche**, quel qualificatif donneriez-vous ?

   - [ ] TRES DIFFICILE
   - [x] ASSEZ DIFFICILE (« au début »)
   - [ ] INDIFFERENT
   - [x] ASSEZ FACILE(« ensuite »)
   - [ ] TRES FACILE

5. Si vous deviez juger la difficulté de **la tâche pour les sessions type « 2 sons constants »**, quel qualificatif donneriez-vous ?

   - [ ] TRES DIFFICILE
   - [ ] ASSEZ DIFFICILE
   - [ ] INDIFFERENT
   - [ ] ASSEZ FACILE
   - [x] TRES FACILE (« difficulté apprivoisée au fur et à mesure »).

NOM PRUNCK Date 17/09/10

Prénom …William…….

Questionnaire n°3 sur l'expérience Psycho-acoustique

Questions sur la session 16 uniquement

1. Dans la première partie de l'expérience (écoute des *sons constants*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☐ ASSEZ DIFFICILE ☐ INDIFFERENT
   ☒ ASSEZ FACILE ☐ TRES FACILE

2. Dans la deuxième partie de l'expérience (écoute des *sons augmentant en intensité*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
   ☐ ASSEZ FACILE ☐ TRES FACILE

3. Dans la deuxième partie de l'expérience (écoute des *diminuant en intensité*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☐ ASSEZ DIFFICILE ☒ INDIFFERENT
   ☐ ASSEZ FACILE ☐ TRES FACILE

NOM CARION Date 22/09/2010

Prénom Charlotte

Questionnaire n°1 sur l'expérience Psycho-acoustique

1. Quelle a été l'évolution de votre perception au cours de l'expérience ?

« Les sessions m'ont paru se ressembler » . « Je pense qu'il y aura un problème de cohérence entre mes réponses ». Le sujet a mentionné des problèmes de « concentration ». La difficulté de comparaison lui a semblé s'accroître pour les ISI les plus longs.

2. Comment avez-vous fait votre jugement pour comparer les 2 sons dans chaque session ?

« Je me basais sur la partie la plus forte du 1er son plutôt que d'essayer de faire une moyenne ».

3. Avez-vous associé certains sons avec une image virtuelle pour faciliter la comparaison ?

« Non, absolument pas».

4. Quand vous ne saviez pas « Quel son était le plus fort », comment avez-vous répondu ?

☒ AU HASARD ☐ LE PREMIER SON ☐ LE SECOND

Le sujet pense que « certains sons étaient identiques » dans les sessions de type Lu.

5. Pensez-vous avoir changé votre façon de juger entre différentes sessions ?

☐ OUI ☒ NON ☐ JE NE SAIS PAS

6. Si oui, pouvez-vous expliquer ?

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NOM CARION Date 22/09/2010

Prénom Charlotte

Questionnaire n°2 sur l'expérience Psycho-acoustique

PARTIE 1 : Questions sur les sessions 1 à 15

1. Dans la première partie de l'expérience (écoute des 2 sons puis réponse à la question « Quel son était le plus fort ? »), lors de l'écoute des *sons augmentant en intensité (écoute son A)*, comment les avez-vous comparés aux seconds sons ?

   - [x] EN ME BASANT SUR LA PARTIE DU SON LA PLUS FORTE
   - [ ] EN CHERCHANT UNE MOYENNE
   - [ ] SANS REFLECHIR

2. Si vous deviez juger la difficulté de **cette tâche**, quel qualificatif donneriez-vous ?

   - [ ] TRES DIFFICILE
   - [ ] ASSEZ DIFFICILE
   - [x] INDIFFERENT
   - [ ] ASSEZ FACILE
   - [ ] TRES FACILE

3. Dans la première partie de expérience (écoute des 2 sons puis réponse à la question « Quel son était le plus fort ? »), lors de l'écoute des *sons diminuant en intensité (écoute son B)*, comment les avez-vous comparés aux seconds sons?

   - [x] EN ME BASANT SUR LA PARTIE DU SON LA PLUS FORTE
   - [ ] EN CHERCHANT UNE MOYENNE
   - [ ] SANS REFLECHIR

4. Si vous deviez juger la difficulté de **cette tâche**, quel qualificatif donneriez-vous ?

   - [ ] TRES DIFFICILE
   - [x] ASSEZ DIFFICILE
   - [ ] INDIFFERENT
   - [ ] ASSEZ FACILE
   - [ ] TRES FACILE

5. Si vous deviez juger la difficulté de **la tâche pour les sessions type « 2 sons constants »**, quel qualificatif donneriez-vous ?

   - [ ] TRES DIFFICILE
   - [ ] ASSEZ DIFFICILE
   - [ ] INDIFFERENT
   - [x] ASSEZ FACILE
   - [ ] TRES FACILE

NOM CARRION Date 24/09/10

Prénom Charlotte

Questionnaire n°3 sur l'expérience Psycho-acoustique

Questions sur la session 16 uniquement

1. Dans la première partie de l'expérience (écoute des *sons constants*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☐ ASSEZ DIFFICILE ☒ INDIFFERENT
   ☐ ASSEZ FACILE ☐ TRES FACILE

2. Dans la deuxième partie de l'expérience (écoute des *sons augmentant en intensité*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
   ☐ ASSEZ FACILE ☐ TRES FACILE

3. Dans la deuxième partie de l'expérience (écoute des *diminuant en intensité*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
   ☐ ASSEZ FACILE ☐ TRES FACILE

NOM ENGLE………… Date 15/09/2010

Prénom Liam…………….

Questionnaire n°1 sur l'expérience Psycho-acoustique

1. Quelle a été l'évolution de votre perception au cours de l'expérience ?

Un certain abrutissement au fil des expériences. Parle de l'apparition d'une certaine habitude, qui fait que l'on devient « meilleur ». Les 3 différents types de sessions ont été retrouvées après discussion.

2. Comment avez-vous fait votre jugement pour comparer les 2 sons dans chaque session ?

Pour les sessions croissantes et décroissantes, le sujet a fait une « moyenne dans sa tête ». « Je ne voulais pas me laisser influencer par la partie la plus forte ».

3. Avez-vous associé certains sons avec une image virtuelle pour faciliter la comparaison ?

« Non ».

4. Quand vous ne saviez pas « Quel son était le plus fort », comment avez-vous répondu ?

☒ AU HASARD ☐ LE PREMIER SON ☐ LE SECOND

Mais souvent « je donnais la même réponse que pour le son qui précédait celui où je ne savais pas quoi répondre ».

5. Pensez-vous avoir changé votre façon de juger entre différentes sessions ?

☐ OUI ☒ NON ☐ JE NE SAIS PAS

6. Si oui, pouvez-vous expliquer ?

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NOM ENGLE Date 15/09/2010
Prénom Liam

Questionnaire n°2 sur l'expérience Psycho-acoustique

PARTIE 1 : Questions sur les sessions 1 à 15

1. Dans la première partie de l'expérience (écoute des 2 sons puis réponse à la question « Quel son était le plus fort ? »), lors de l'écoute des *sons augmentant en intensité (écoute son A)*, comment les avez-vous comparés aux seconds sons ?

☐ EN ME BASANT SUR LA PARTIE DU SON LA PLUS FORTE ☒ EN CHERCHANT UNE MOYENNE ☐ SANS REFLECHIR

2. Si vous deviez juger la difficulté de **cette tâche**, quel qualificatif donneriez-vous ?

☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
☐ ASSEZ FACILE ☐ TRES FACILE

3. Dans la première partie de expérience (écoute des 2 sons puis réponse à la question « Quel son était le plus fort ? »), lors de l'écoute des *sons diminuant en intensité (écoute son B)*, comment les avez-vous comparés aux seconds sons?

☐ EN ME BASANT SUR LA PARTIE DU SON LA PLUS FORTE ☒ EN CHERCHANT UNE MOYENNE ☐ SANS REFLECHIR

4. Si vous deviez juger la difficulté de **cette tâche**, quel qualificatif donneriez-vous ?

☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
☐ ASSEZ FACILE ☐ TRES FACILE

5. Si vous deviez juger la difficulté de **la tâche pour les sessions type « 2 sons constants »**, quel qualificatif donneriez-vous ?

☐ TRES DIFFICILE ☐ ASSEZ DIFFICILE ☐ INDIFFERENT
☒ ASSEZ FACILE ☐ TRES FACILE

Le sujet dit quand même que le silence entre les 2 sons le « perturbait » si trop important.

NOM ENGLE Date 21/09/10

Prénom …Liam…….

Questionnaire n°3 sur l'expérience Psycho-acoustique

Questions sur la session 16 uniquement

1. Dans la première partie de l'expérience (écoute des *sons constants*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☐ ASSEZ DIFFICILE ☐ INDIFFERENT
   ☒ ASSEZ FACILE ☐ TRES FACILE

2. Dans la deuxième partie de l'expérience (écoute des *sons augmentant en intensité*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
   ☐ ASSEZ FACILE ☐ TRES FACILE

3. Dans la deuxième partie de l'expérience (écoute des *diminuant en intensité*), si vous deviez juger la difficulté de **la tâche d'estimation par un nombre**, quel qualificatif donneriez-vous ?

   ☐ TRES DIFFICILE ☒ ASSEZ DIFFICILE ☐ INDIFFERENT
   ☐ ASSEZ FACILE ☐ TRES FACILE

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