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SERIES P: TELEPHONE TRANSMISSION QUALITY, TELEPHONE INSTALLATIONS, LOCAL LINE NETWORKS

Audiovisual quality in multimedia services

Dimension-based subjective quality evaluation for video content

Recommendation ITU-T P.918

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Recommendation ITU-T P.918

Dimension-based subjective quality evaluation for video content

Summary

Recommendation ITU-T P.918 presents guidelines for undertaking subjective experiments for the quality of experience (QoE) assessment of perceptual video quality dimensions. In addition to scores for the overall video quality, the methodology yields scores for five perceptual dimensions. Each perceptual dimension scores are based on the ratings of the amount of degradation present in one system/test condition. The method is designed to be used with naïve subjects. The dimension scores can be used to provide diagnostic information on what may cause the degradation.

The perceptual dimensions are described in this Recommendation as well as the method to conduct a subjective experiment. Furthermore, information is provided about possible test environment and setup, participant instructions, and test material.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T P.918	2020-01-13	12	11.1002/1000/14153

Keywords

Multi-dimensional quality assessment, subjective testing, video quality evaluation.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Dimension-based subjective quality evaluation for video content

1 Scope

This Recommendation describes a subjective test methodology, which can assess and diagnose the video quality based on underlying perceptual quality dimensions.

Traditional quality tests, as described in [ITU-T P.800] and [ITU-T P.910], provide valid methods for the overall video quality but do not give insights into reasons for possible quality losses.

This Recommendation describes a test methodology that not only yields overall quality scores for video but specifically allows participants to rate five underlying perceptual quality dimensions for video and video transmission in general. The perception-based assessment of video QoE is important when planning and implementing services, as well as for the development of instrumental quality prediction models, especially when the service on hand is aimed for usage by humans.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T P.800] Recommendation ITU-T P.800 (1996), *Methods for subjective determination of transmission quality*.

[ITU-T P.806] Recommendation ITU-T P.806 (2014), *A subjective quality test methodology using multiple rating scales*.

[ITU-T P.910] Recommendation ITU-T P.910 (2008), *Subjective video quality assessment methods for multimedia applications*.

[ITU-T P.911] Recommendation ITU-T P.911 (1998), *Subjective audiovisual quality assessment methods for multimedia applications*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 direct scaling: The rating of perceptual dimensions by a test participant without any additional mathematical procedure, like principal component analysis (PCA) or multidimensional scaling (MDS).

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ACR Absolute Category Rating

DIC Discontinuity

FRA Fragmentation

LUM Suboptimal Luminosity

MDS Multidimensional Scaling

MOS Mean Opinion Score

NOI Noisiness

PCA Principal Component Analysis

QoE Quality of Experience

SD Semantic Differential

UCL Unclearness

VQD Video Quality Dimensions

5 Conventions

None.

6 Introduction to video quality analysis

To provide information about the quality of transmitted video, ITU-T recommends several different experimental designs. The approach presented here targets assessing perpetual dimensions to give a deeper insight into possible quality loss. The recommended method refers to a passive perception scenario and gives additional information about the overall video quality mean opinion scores (MOS) absolute category rating (ACR) experiments, as recommended in [ITU-T P.800].

To identify the video quality relevant perceptual dimensions, a pairwise similarity experiment with a subsequent multidimensional scaling (MDS) and a semantic differential experiment with a subsequent principal component analysis (PCA), were analyzed. Applying both test paradigms in separate experiments [b-Schiffner1] resulted in the set of perceptual dimensions for transmitted video given in Table 1.

Table 1 – Overview of the five identified and proposed perceptual video quality dimensions

VQD	Name	Description	Example impairment
I	Fragmentation (FRA)	Fallen apart, torn and disjointed	Packet loss
II	Unclearness (UCL)	Unclear and smeared image	Low coding bitrate
III	Discontinuity (DIC)	Interruptions in the flow of the video	Buffer delay and limitations
IV	Noisiness (NOI)	Random change in brightness and colour	Quantization, Circuit noise
V	Suboptimal luminosity (LUM)	Too high or low brightness	Over- and under-exposure

7 Test methodology

7.1 Dimension rating scales

The subjective method provides a means for quantifying five quality relevant perceptual dimension in a passive video consuming setting, by directly rating the five quality descriptive scales. It is referred to as *Direct Scaling* of the perceptual video quality dimension. The rating scales are based on Likert-Scale [b-Möller] and are shown in Figure 1.

Each dimension scale is dedicated to one particular dimension. The names of the dimensions are used as the titles, and antonym pairs are used to describe the range of the scales (see Figure 1). This enables direct quantification of separate scores for each perceptual dimension. The dimension scales consider degradations. On the right side of each scale, the material can be regarded as optimal for that respective property. Thus, the dimension scales can be regarded as unipolar. A detailed description of the usage and a potential test introduction is given in Appendix A.

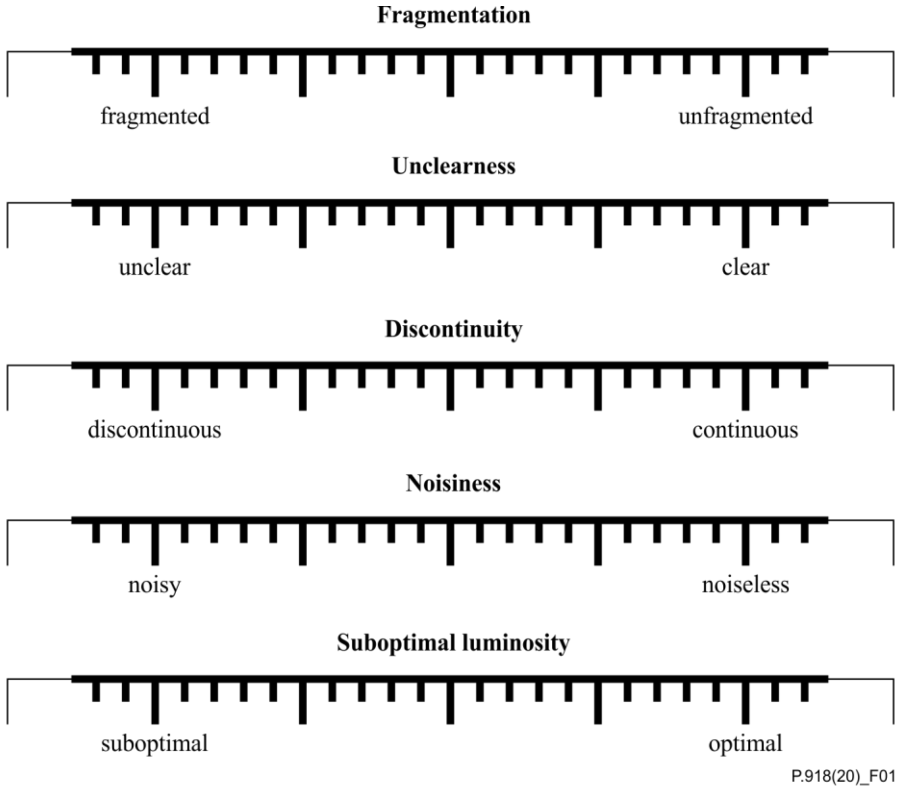


Figure 1 – Rating scales for the direct assessment of the quality dimensions, scale titles, and labels

7.2 Quality rating scales

In addition to the dimension rating scales, the overall video quality scores are obtained via a continuous seven-point scale, as depicted in Figure 2.

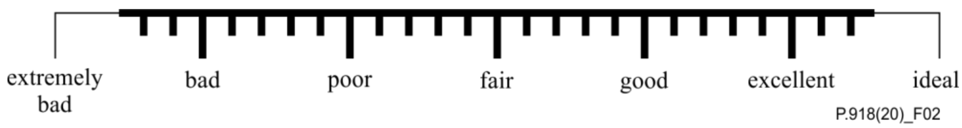


Figure 2 – 7-point continuous quality scale with labels: extremely bad, bad, poor, fair, good, excellent and ideal

7.3 Test design and rating scheme

The method, in general, follows common paradigms for subjective quality tests according to [ITU-T P.800], [ITU-T P.910] and[ITU-T P.911].

As denoted in [ITU-T P.911], different experimental designs, such as complete randomized design, Latin, Graeco-Latin and Youden square designs, replicated block designs, etc. (see [b-Kirk]) can be used, the selection of which should be driven by the purpose of the experiment. However, the effect of repetitions of the same or comparable video samples on motivation, rating behaviour, and fatigue has to be considered in the process of devising a test plan.

The method consists of two parts, the first one being the overall video quality rating task, and the second is the dimension rating task. The participant views the video sample and is allowed to re-watch it as often as necessary, but a least once. Subsequent to that, the participant rates the overall video quality as a first step afterwards all perceptual video dimensions are rated. Each scale should be presented one at a time to reduce the influence the scales could have on each other. It is further recommended to vary the order of the dimension scales for each test participant to eliminate the influence of order effects.

7.4 Instructions and training

A detailed written description of the test method is given to the test participants. This should ensure that every participant has an equal level of knowledge (see Appendix I). First, the instructions should give a brief description of the test and they should explain the rating scales and provide information on how they are used. In addition to the scale labels and antonym pairs, a brief explanation of the dimensions and additional adjectives should be given to facilitate a better understanding of the process for the the test participants.

After reading the written instructions, the test participants should be presented with example video material to familiarize themselves with the degradations, the video content, the rating task and the user interface. It is recommended to use at least six test samples for the training phase, one reference and five representing each of the video degradation dimensions. The video samples for the training part should be the same for all test participants.

8 Test environment

In general, [ITU-T P.910] and [ITU-T P.911] should be used. If the specific case requires it, for example, in mobile gaming applications, a deviation may be necessary.

8.1 Participants

The method makes use of naïve participants since no prior knowledge is required. Each participant should be tested for vision impairments (e.g., Snellen Chart and Ishihara Test). It is possible that vision deficiency may have a negative effect on the rating behaviour, therefore participants with vision deficiency should be excluded from the test results. A minimum number of 24 test participants is required. However, the actual number of participants depends on the test purpose and the targeted confidence interval for a specific (e.g., 90%, or 95%, or 99%) significance level, as well as the characteristics of the test material.

8.2 Test material

The selection of the test material depends on the test purpose. The method was developed using material typical for video telephony ("*Head and Shoulder*" scene) and was successfully tested. Furthermore, the method was successfully used in a broader video setting [b-Schiffner 2] and in a gaming context.

8.3 Data analysis and reporting of the results

The report must contain a summary of the results. Therefore, as a minimum, mean ratings, standard deviations (Stdev) and/or confidence intervals (CI95) for all tested conditions should be included. Along with the results, details of the experimental set-up and the constitution of the participants (e.g., gender, age) should be reported.

If the experimenter expects gender effects, it should be analyzed and reported.

The results can be organized and presented, for example, as in the model in Table 2.

Table 2 – Model for presentation of data analysis and reporting of results

Condition	No./Rates	Quality	FRA	UCL	DIC	NOI	LUM
Condition I							
Stdev							
CI95							
Condition II							
Stdev							
CI95							
Condition III							
Stdev							
CI95							
…	…	…	…				

The classical techniques of analysis of variance should be used to evaluate the significance of the test parameters. Depending on the experimental design, further methods could be appropriate.

Appendix I

Test instructions for the video quality – Video dimension test

(This appendix does not form an integral part of this Recommendation.)

Assessment of the video quality and video properties

Thank you for taking part in this experiment! Please, switch off your mobile phones now and take the time to read the instructions completely.

You are now participating in an experiment to evaluate the quality and the properties of video samples that may contain different degradations. During the experiment, you will be presented with a series of video samples representing excerpts from video-telephone calls. After each presentation, you will perform two tasks, first the assessment of the overall video quality followed by the assessment of specific video properties.

The rating scales are detailed below. It is very important that you familiarize yourself with the definition and use of the scales. The experiment will start with a set of six practice trials to familiarize yourself with the type of degradation, the assessment task and the computer program. If you have any questions, please contact the test supervisor.

The computer program will guide you through the experiment. Please continue until the experiment reaches the end. Once completed, please come out of the experiment room and report it to the experimenter.

Please make the assessment intuitive. In this experiment, which is purely subjective, there are neither correct nor false answers. Only your personal impression is important for the study.

Again, should you have any questions, please do not hesitate to ask the experiment supervisor.

Thank you for your participation!

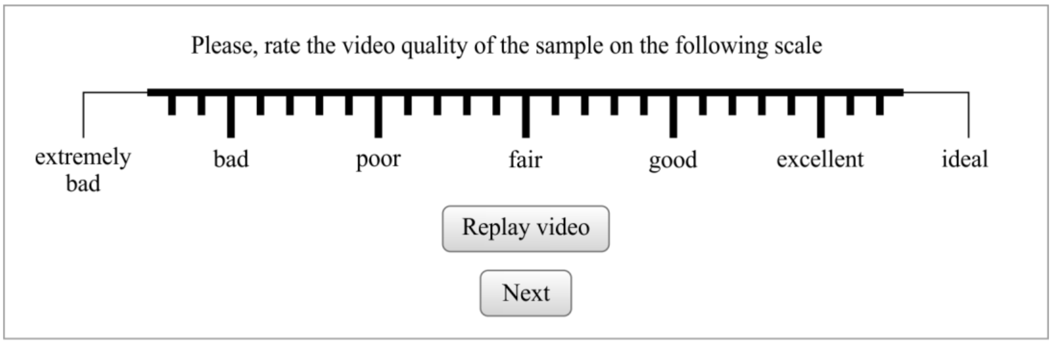
Assessment of video quality

After each presentation of a video sample, you will be asked to rate the overall quality of the sample you have just seen on a scale ranging from bad to excellent, as illustrated below.

To enter your rating, click on the corresponding point on the displayed scale using the mouse. You can refine your rating if necessary, as well as see the video sample again by clicking on the "Replay video" button. Once you are satisfied with your evaluation, click the "Next" button to proceed with the next rating task.

Please do not take into account the thematic content of the video sample in your evaluation.

Note that this is a video only experiment, the sound is muted.



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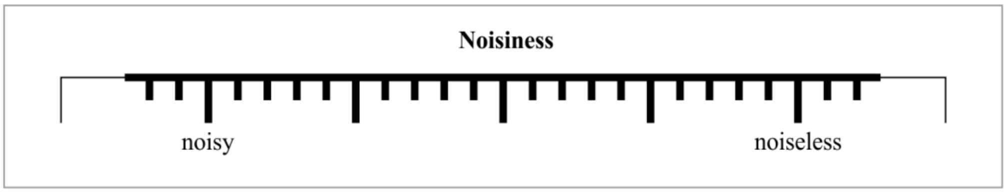
Assessment of video properties

After evaluating the overall quality, you will be tasked to assess the same video on five different properties described below. Note that the order in which the video property scales will be presented to you may differ from the order below.

1) Noisiness

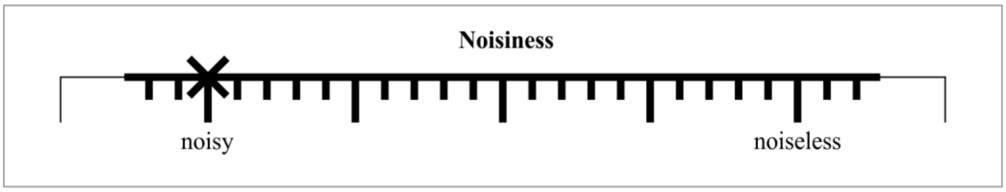
The "Noisiness" scale, ranging from "noisy" to "noiseless", refers to the amount of noise present in the video. The "Noisy" attribute could be described with terms like "noise" or "flickering", and the "noiseless" attribute as "not noisy" or "not flickering".

The scale is as follows:



P.918(20)_FI.2

If you feel the video sample is very noisy put the cross at the following position:



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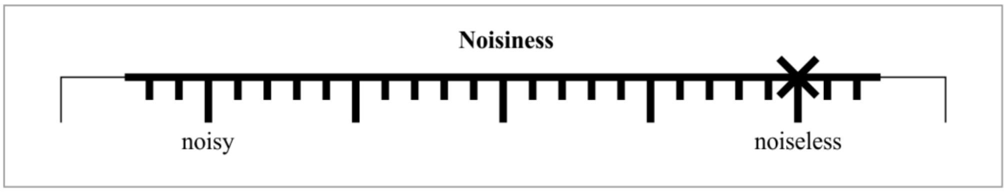
If you cannot detect any noise, place the cross in the "noiseless" position:



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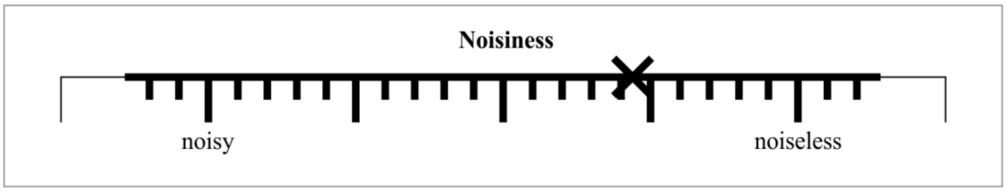
You can use the entire range of the scale to describe the degree of degradation. If you think the degree of degradation is only moderate, you could move the slider into this area:



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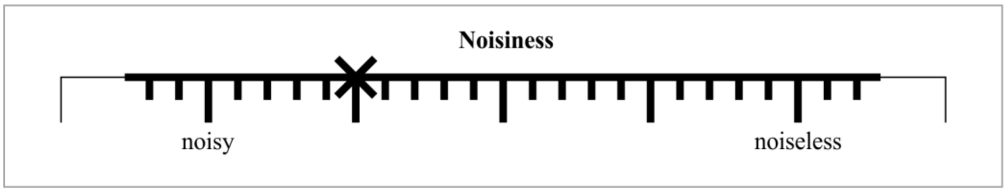
Perhaps the sample is **clearly** noisy, but not quite as extreme; then your evaluation might look as follows:



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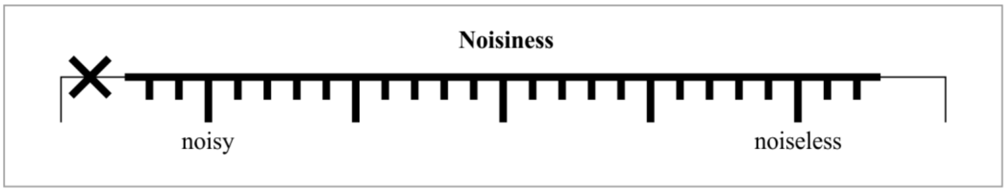
In principle, you can also use the spaces in between the markers, if necessary. In particular, you can use the "overflow areas" beyond the terms, if the terms for the assessment are not sufficient for you, e.g.,:

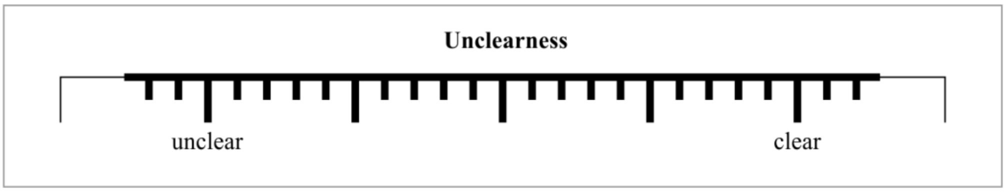


P.918(20)_FI.7

2) Unclearness

The "Unclearness" scale, ranging from "unclear" to clear", refers to how blurred, unclear, or washed out a video picture is. The term "unclear" could also be described as "muddy", "contrast weak" or "unsharp". The term "Clear" could be described as "clean", "contrasting" or "sharp".

The scale should be used in the same way as for the "Noisiness" scale (see above).



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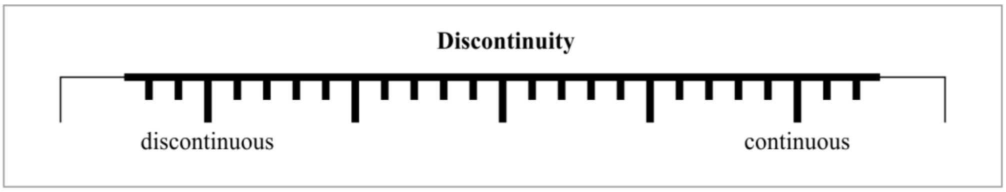
3) Discontinuity

The "Discontinuity" scale, ranging from "discontinuous" to "continuous", refers to the smoothness of the video. "Discontinuous" could be described with terms like "jerky" or "wobbly", whereas the term "continuous" could be described as "constant", "smooth" or "stable".

The scale should be used in the same way as for the "Noisiness" scale (see above).



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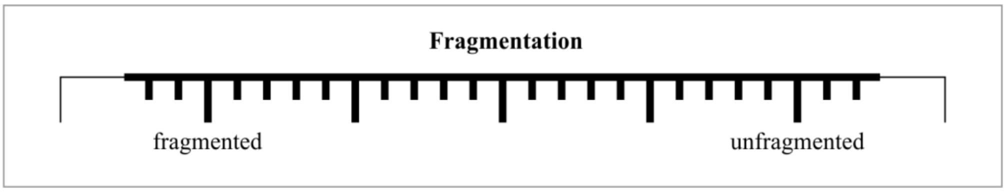
4) Fragmentation

The "Fragmentation" scale, ranging from "fragmented" to "unfragmented", refers to how much the video breaks into individual parts or fragments. The term "fragmented" could be described as "blocky" or "dismembered", and the term "unfragmented" could be described with the terms such as "non-blocking" or "contiguous".

The scale is used in the same way as for "Noisiness" (see above).

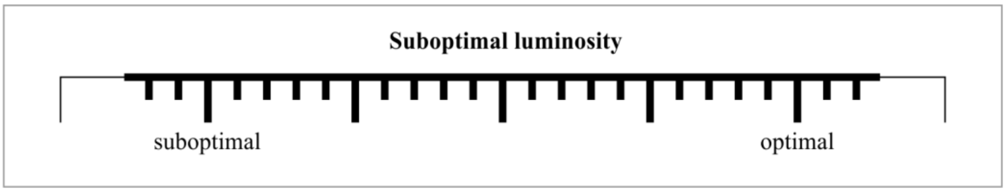


P.918(20)_FI.10

5) Suboptimal Luminosity

The "suboptimal luminosity" scale, ranging from "suboptimal" to "optimal", refers to how much the brightness of the pictures deviates from the optimal luminosity. When the luminosity is judged too dark or too light, it should be referred as suboptimal.

The scale is used in the same way as for "Noisiness" (see above).



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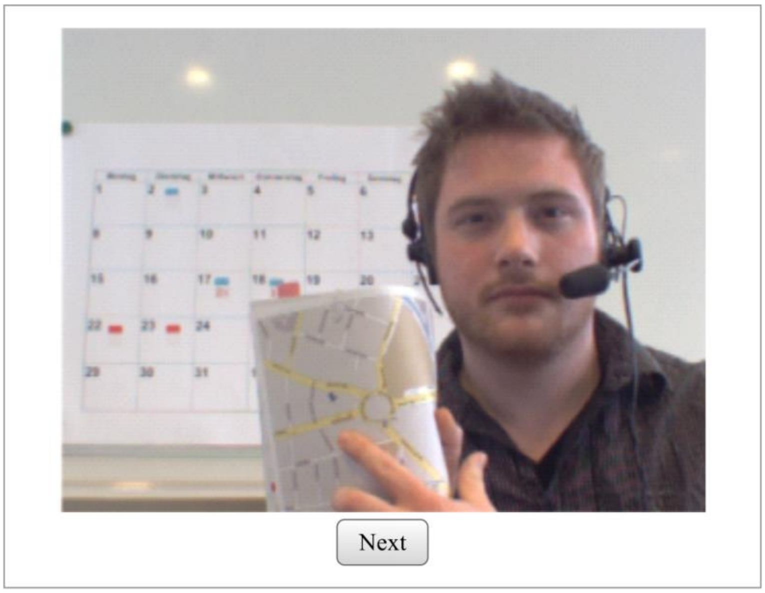

Example of the video player screen

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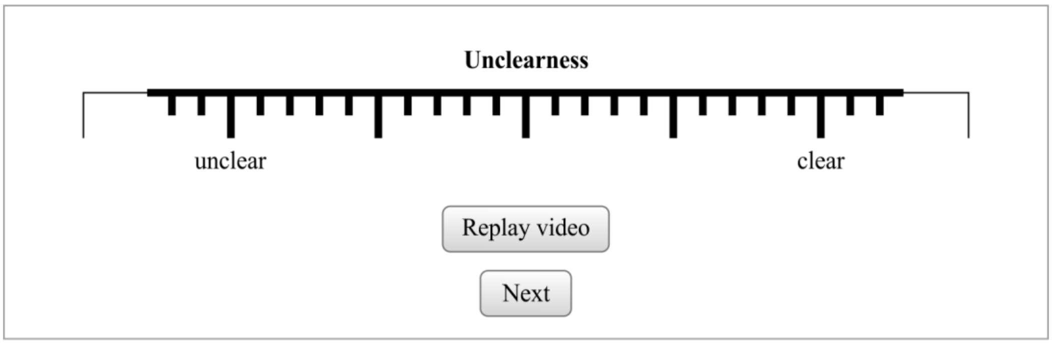

Example of video properties scale:

P.918(20)_FI.13

Appendix II

Results of an evaluation experiment – Investigating the video quality and the five perceptual video quality dimensions.

(This appendix does not form an integral part of this Recommendation.)

The subjective test described in this appendix was conducted to evaluate the test methodology. Each of the 47 naïve test participants were tested for normal eyesight and were fully instructed and trained.

The experiment comprised 43 test conditions, of which the impairments are shown in Table II.1.

Table II.1 – Description of the impairments in the test material for the experiment (single impairments and combination impairments)

Video impairment – Single	Description
Reference	Unimpaired material
RISV Artificial Blurring ITU-Filter	All frames impaired (filter setting 1,3,6 from ITU-T P.930)
RISV Artificial Blurring Filter7	All frames impaired (own filter setting)
RISV Artificial Jerkiness X	Frames Jerkiness (3, 6, 9, 12, 18 frames holded)
RISV Artificial NoiseQ X%	Salt and Pepper Noise (1, 3, 6, 9, 15% pixel/frame)
H.264 Bitrate xxkbps	H.264-Codec 2-pass coding (28, 56, 128, 256 kbps)
RISV Artificial Blockiness	AxA Block size (2, 5, 8, 11 pixel)
Packet Loss x.x%	H.264-Codec, Traffic Control, NetEm 0.3, 0.6, 1.2, 1.8% random packet loss rate
Luminance Impairment I (darker)	Luminance reduced –25, –50, –75 (underexposure)
Luminance Impairment II (lighter)	Luminance raised +25, +50, +75 (overexposure)
Video impairment – Combination	**Description**
Blurring + Noise	ITU-Filter 1 + 9% Noise
Blurring + Packet Loss	ITU-Filter 6 + 0.6% Packet Loss
Lum-Imp. I + Packet Loss	Luminance reduced –50 + 1.2% Packet Loss
Lum-Imp. I + Blurring	Luminance reduced –50 + ITU-Filter 1
Lum-Imp. II + Noise	Luminance raised +50 + 9% Noise
Jerkiness + Blurring	6 Frames + ITU-Filter 1
Jerkiness + Lum-Imp. II	9 Frames + Luminance raised +50
Jerkiness + Packet Loss	9 Frames + 0.6% Packet Loss
Noise + Jerkiness	9% Noise + 6 Frames
Noise + Packet Loss	9% Noise + 1.2% Packet Loss

Results – Video quality rating

In Figures II.1 and II.2, the quality ratings for single impairments and impairment combinations are shown. The expected rating behaviour can be observed here.The stronger the impairment, the lower the quality rating. The 95% confidence interval for the quality rating ranged from 0.06 – 0.16, with an average value of 0.12.

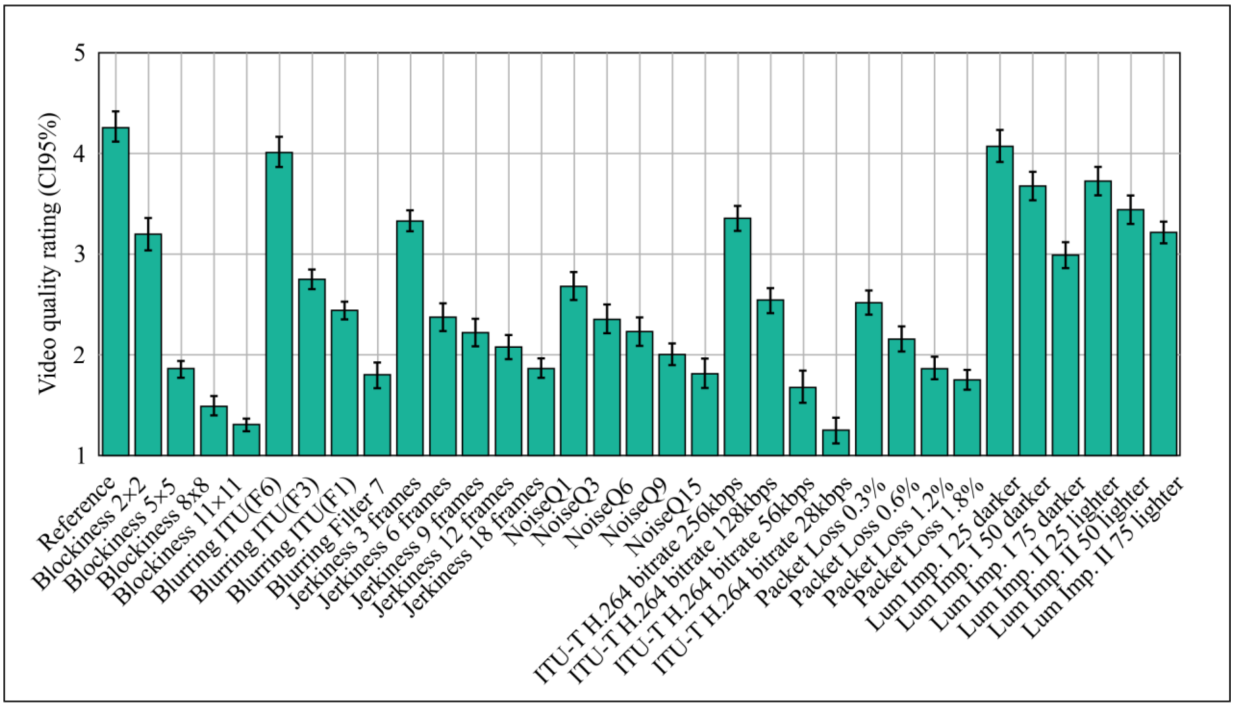

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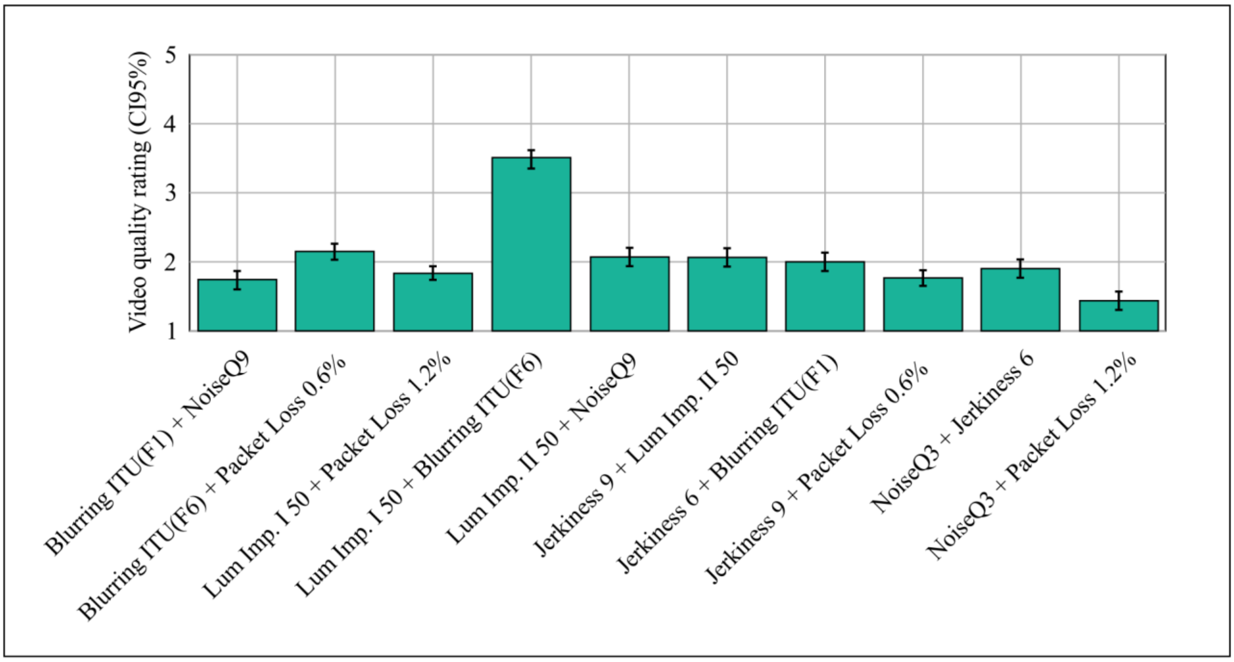
Figure II.1 – Results of the quality ratings for the single impairments (Confidence interval – CI95%)



P.918(20)_FII.2

Figure II.2 – Results of the quality ratings for the impairment combinations (Confidence interval – CI95%)

Results – Video dimension rating

Single impairments

It was investigated whether the impairments trigger the relevant quality dimensions and how they are distributed over the scales. It can be seen that the whole range of the scales was used. The 95% confidence intervals on all dimension scales range between 0.07 – 0.31, with an average of 0.16.

It was observed that the test conditions representing a specific degradation dimension are rated on the intended scales, whereas the other test conditions did not lead to a lower rating on the respective scale. This holds for all dimension scales. As an example, the test conditions *Jerkiness, Noise, Luminosity Impairment I and II, and Blurriness* had no negative impact on the *Fragmentation* dimension ratings. The test conditions *Blockiness, Packet Loss,* and *Bitrate* had an apparent negative effect on the fragmentation rating. This was expected since all test conditions impair the unity of the image. *Blockiness* had the lowest negative impact, but still reduces the rating below 3. The bigger the blocks, the more fragmented the video image appears. The same is true when reducing the bitrate. This leads to more and more visible block-like artifacts in the video imagery. *Packet Loss* had the strongest impact on the ratings, where even relatively low packet loss rates introduced a significant drop in the rating due to typical artifacts such as "slicing" and "partly green-out" perceived as fragmented.

Figures II.3 to II.7 show how each of the single-impairment test conditions were rated on the five perceptual video quality dimensions.

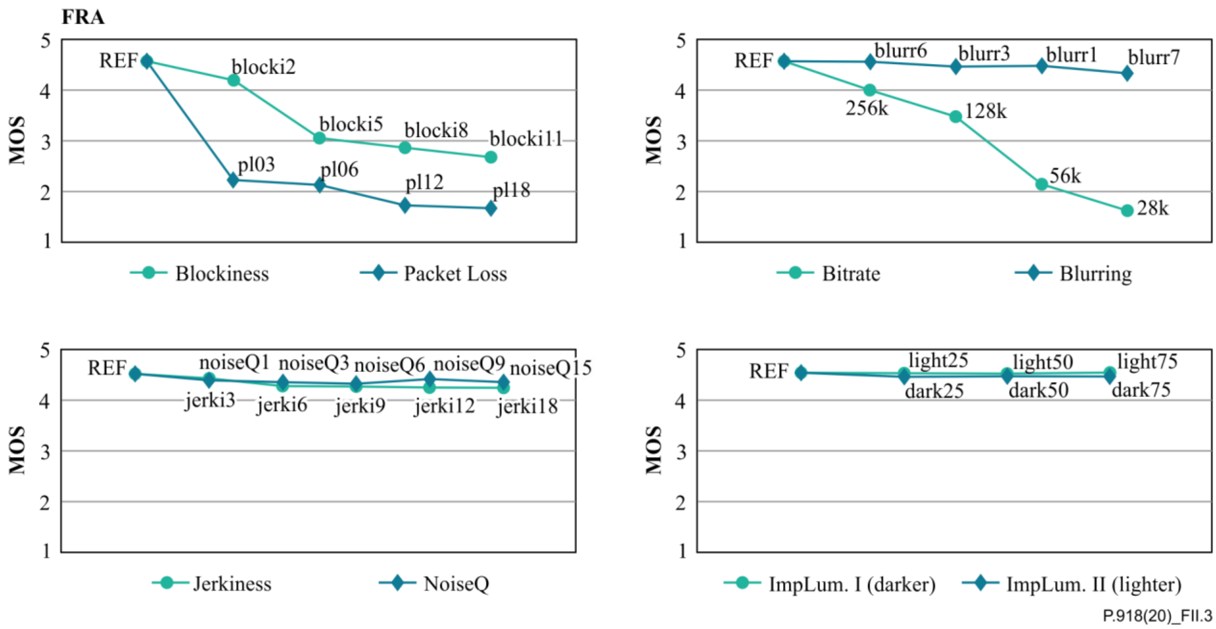


Figure II.3 – Ratings for the perceptual video quality dimension *Fragmentation* for all single-impairment conditions

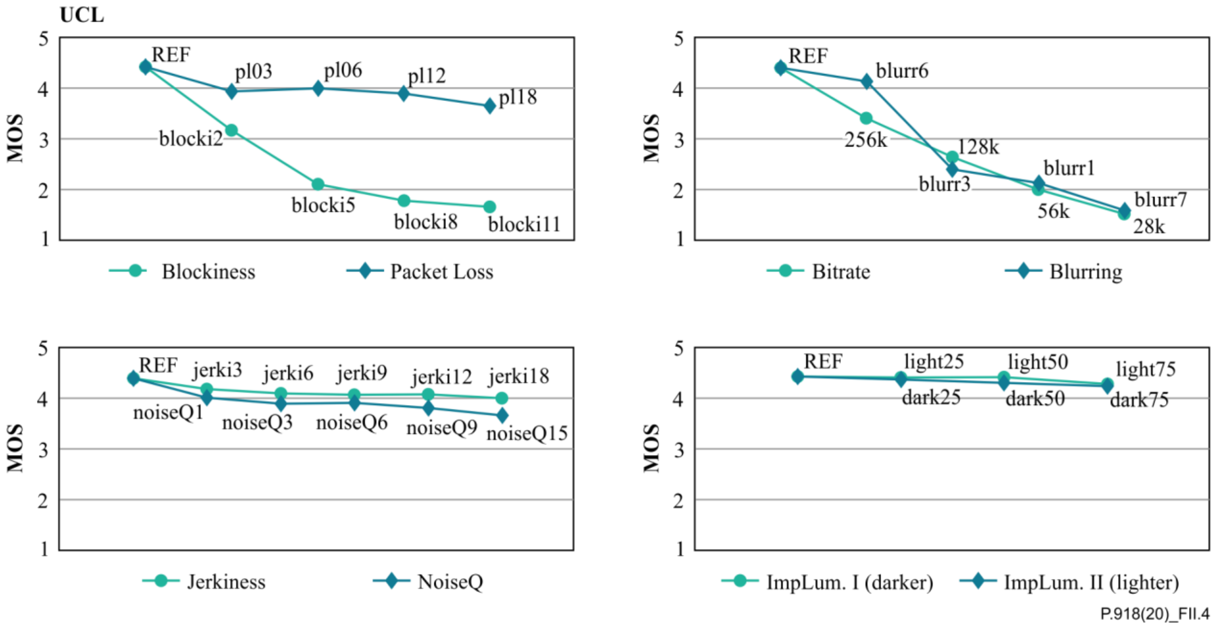


Figure II.4 – Ratings for the perceptual video quality dimension *Unclearness* for all single-impairment conditions

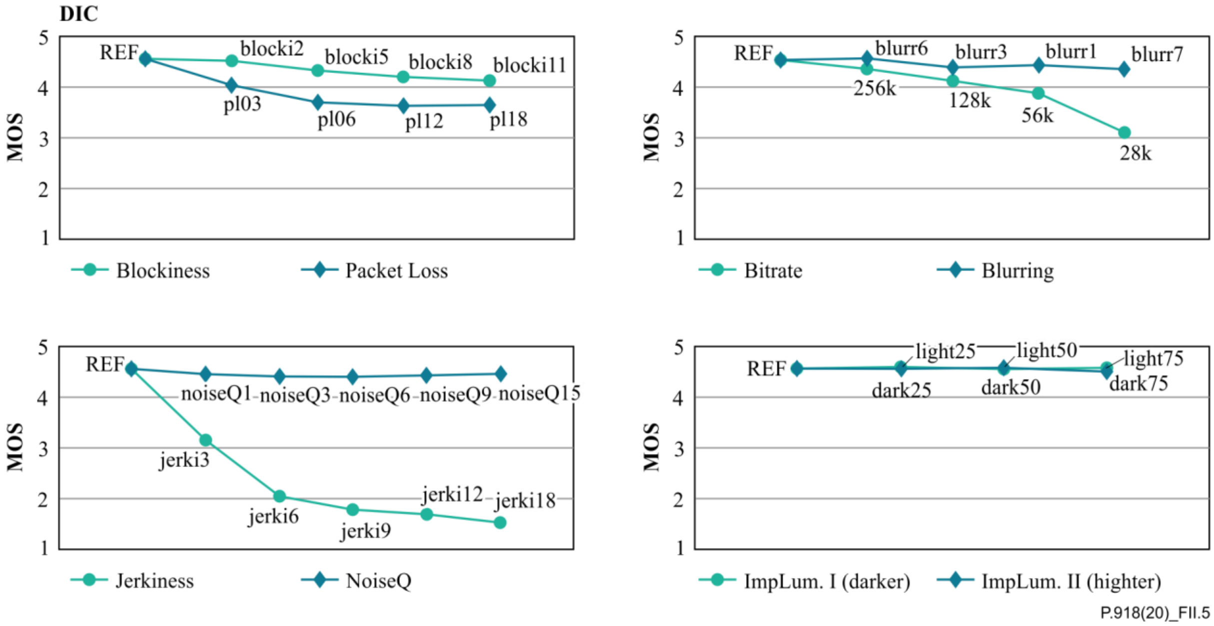


Figure II.5 – Ratings for the perceptual video quality dimension *Discontinuity* for all single-impairment conditions

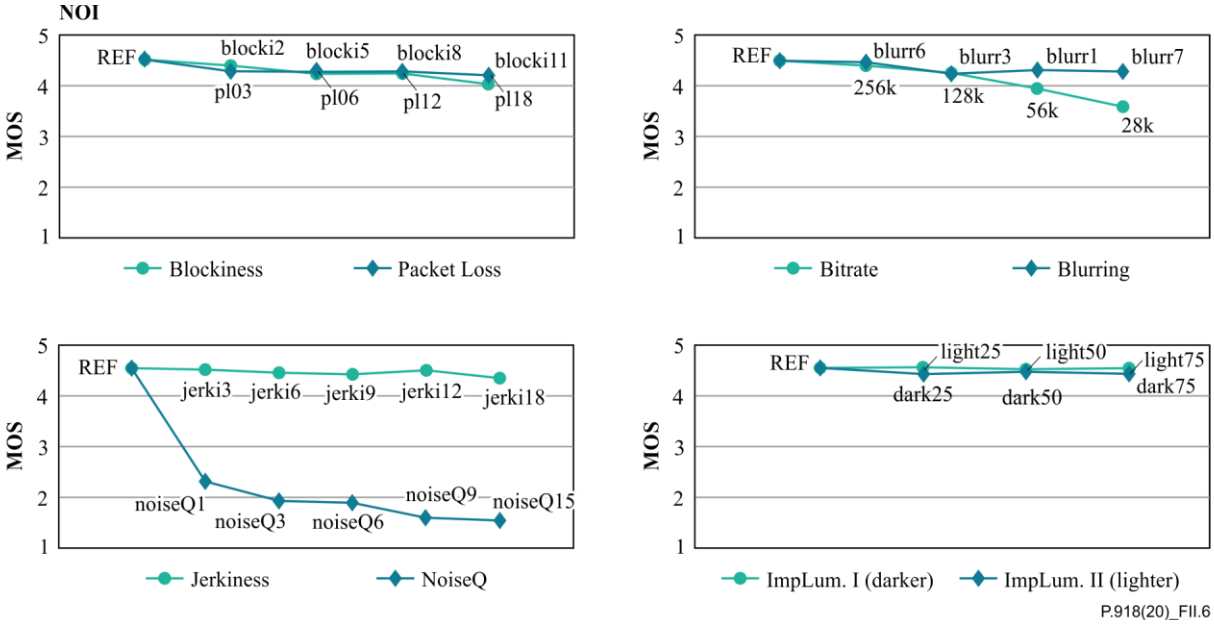


Figure II.6 – Ratings for the perceptual video quality dimension *Noisiness* for all single-impairment conditions

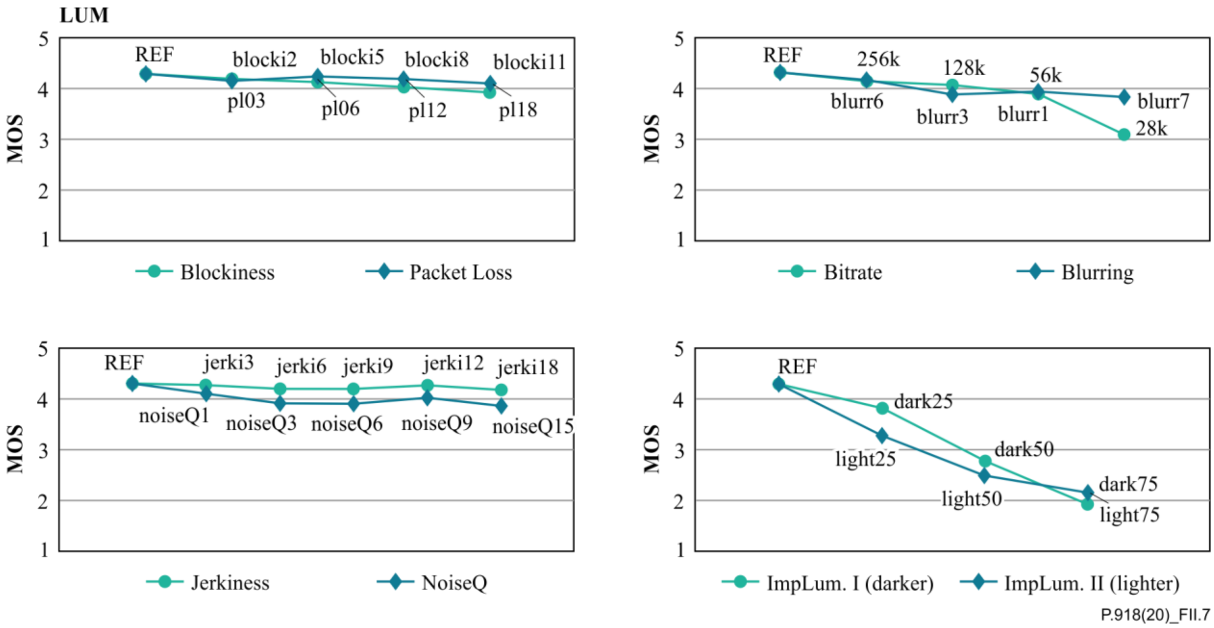


Figure II.7 – Ratings for the perceptual video quality dimension *Suboptimal Luminosity* for all single-impairment conditions

Impairment combinations

In this paragraph, the ratings for the different combination of degradations are investigated. The focus lies on examining whether the ratings for one particular type of impairment stay the same when combined with an additional impairment aimed to trigger another perceptual dimension. The results are shown in Figure II.8. In all the five sub-figures, the green line-graph is the baseline of the single impairment. The combined impairments are placed in the same categories as the accompanying single impairments. It was observed that even when a second impairment is present in the video, the ratings on the respective scale are almost identical with no significant differences. The only exception is when test condition *noiseQ9* is combined with conditions *light50* and *blurr1*. In this case, *noiseQ9* seems to mask some of the degradations, leading to a higher score than expected.

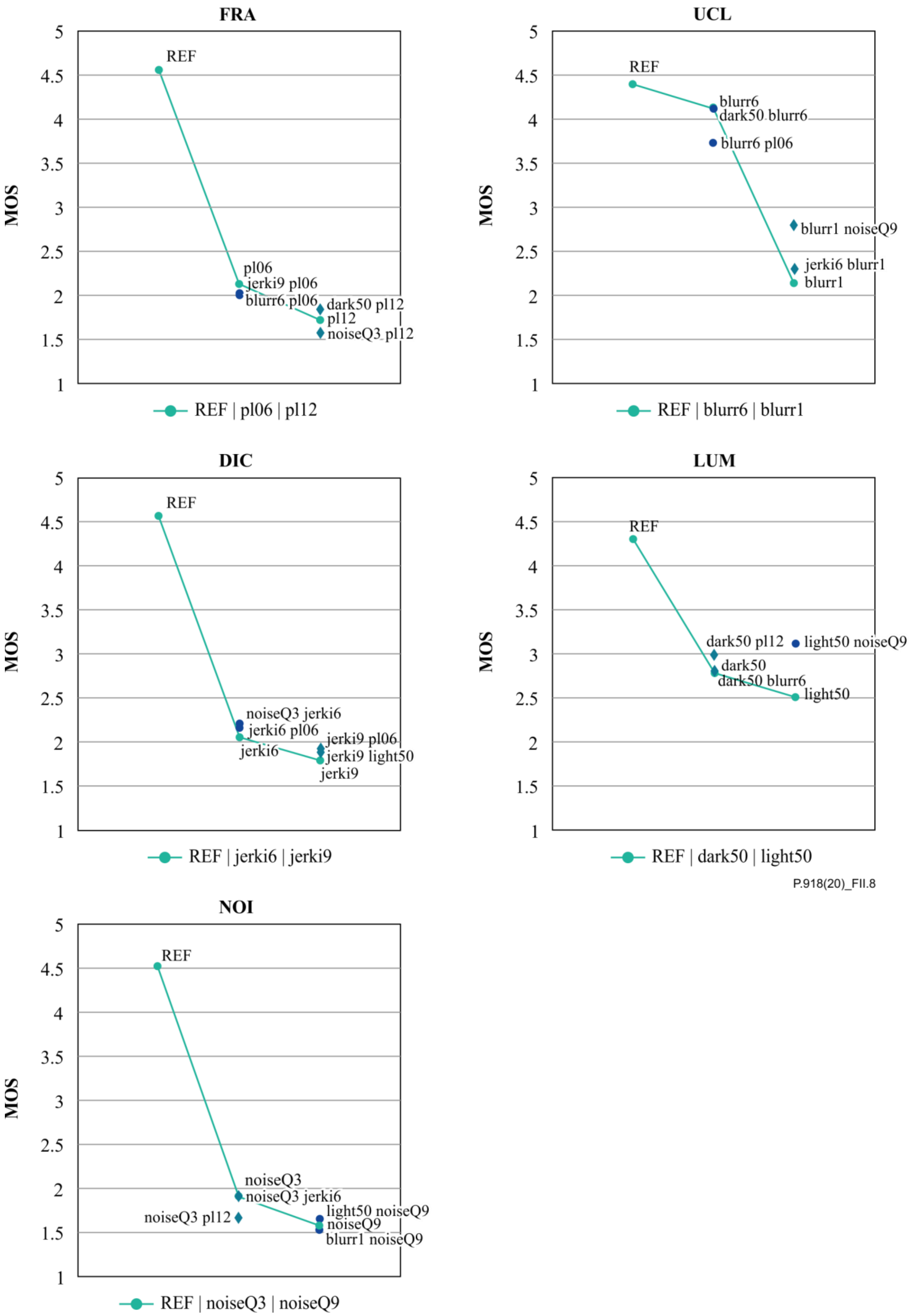


Figure II.8 – Ratings for the perceptual video quality dimensions for all impairment combinations

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