Multi-episodic Perceived Quality of an Audio-on-Demand Service

Dennis Guse^{*}, Oliver Hohlfeld[†], Anna Wunderlich^{*}, Benjamin Weiss^{*}, Sebastian Mller^{*} *Technische Universit Berlin[†]Brandenburg University of Technology

Abstract—Quality of Experience is traditionally evaluated by using short stimuli usually representing parts or *single* usage episodes. This opens the question on how the overall service perception involving *multiple* usage episodes can be evaluated a question of high practical relevance to service operators. Despite initial research on this challenging aspect of multiepisodic perceived quality, the question of the underlying quality formation processes and its factors are still to be discovered.

We present a multi-episodic experiment of an Audio-on-Demand service over a usage period of 6 days with 93 participants. Our work directly extends prior work investigating the impact of time between usage episodes. The results show similar effects — also the recency effect is not statistically significant. In addition, we extend prediction of multi-episodic judgments by accounting for the observed saturation.

Index Terms-Perceived quality, QoE, Audio streaming

I. INTRODUCTION

Traditional research on perceptual Quality of Experience (QoE) investigate short time-scales spanning from several seconds up to several minutes and involving only judgments of single interaction. For these, it has been shown that later parts of the stimuli as well as the worst performance have a higher impact on post-experience (i. e., retrospective) judgments [1]. These two effects are denoted as recency effect and peak effect, which are well-known from research on recall (e. g., [2]). For predicting retrospective QoE judgments, it has been shown that a weighted average with a higher weighting on more recent momentary judgments or performance performs sufficiently. In this regard, *multi-episodic perceived quality* investigates the formation process of a subjective quality impression for a service or system that is used repeatedly.

However, the underlying formation process of perceived quality over several usage episodes (i. e., multi-episodic perceived quality) is not well understood—especially considering usage periods of days, months, or even years. Following [3], a *usage episode* is defined as *a distinct and self-contained interaction by a user with a service or system to achieve his or her goal(s)*. Investigating and understanding the formation process of multi-episodic perceived quality is of high practical relevance to service operators as telecommunication services are prone to performance fluctuations (e. g., varying network conditions). These fluctuations may be perceived by a user and therefore affect his/her instantaneous quality as well as episodic and multi-episodic quality.

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This especially includes cloud-based multi-media services (e. g., Audio-on-Demand (AoD) and Video-on-Demand (VoD) streaming services that have become popular Internet applications). Research on multi-episodic perceived quality could show that a recency effect occurs (e. g., [3], [4]) as well as a duration neglect [5]. Despite these first initial findings, the formation process remains far from being understood—rooted also in the high complexity to perform multi-episodic experiments given their duration and the between-subject design.

In this paper, we aim to better understand this formation process using an AoD service. That is, if effects observed on multi-episodic perceived quality in one session can also be observed when the usage is extended to multiple usage episodes. Our experiment involves 93 participants using the AoD service twice per-day over 6 days. We complement our study by also by applying the Net Promoter Score (NPS) to investigate the impact on customer loyalty [6]. While it is of questionable reliability [7] and not well-established the QoE domain, it is popular in marketing and user retention analyses, e.g., as an AoD service might apply in practice.

Structure. We first review related work in Section II on which we base our study. We describe our hypotheses and research design in Section III and then discuss the study results in Section IV. Finally, we conclude the paper and give an outlook on future work towards understanding multi-episodic QoE.

II. RELATED WORK

Multi-day experiments. Research on multi-episodic perceived quality emerged in 2011 with multi-day experiments. A first experiment evaluated Skype calls performed on a daily basis over 12 days [8]. Each pair of subjects performed two video telephony calls per day while solving one task per call. This task-driven approach was selected to create a realistic usage situation as well as a comparable usage behavior (i.e., one Short Conversation Scenario (SCS) [9]). Episodic judgments (i.e., perceived quality of one usage episode) were directly collected after finishing each call. Multi-episodic judgments (i.e., all so far experienced usage episodes) were collected after the 2nd, 7th, and 12th day. Within each multiepisodic condition two performance levels limiting the overall transmission bandwidth were applied: High Performance (HP) and Low Performance (LP). Although the results were rather limited this experiment showed that multi-episodic perceived quality can be assessed successfully in a field experiment by applying a between-subject design—which we therefore adopt in this experiment. The results show that episodic judgments are reduced for LP usage episodes. Moreover, the results indicate that also subsequent episodic judgments are negatively affected even if these were presented in HP. Interestingly, a slight increase for episodic judgments was observed over the usage period. With regard to the formation process of multi-episodic judgments the results are rather limited. This is most likely due to the limited impact of LP usage episodes. Similar results were found for a VoD service [10]. They further observed discrepancies between episodic judgments of LP usage episodes and the final multi-episodic judgment. Precisely, they observed that for a service providing mainly severely LP usage episodes, episodic judgments are more positive than multi-episodic judgments. However, the results are limited by the number of participants as well as that the defined performance levels could not be achieved.

Subsequently, an experiment with a service bundle consisting of an AoD service and a VoD service over a usage period of 15 days [10] was conducted. Combining their results with [8] and [10], they presented initial models for predicting multi-episodic judgments based upon episodic judgments. They could show that a *linear moving average* outperforms a *windowed average*. Accounting for a peak effect resulted in decreased prediction performance.

Overall, the results of multi-episodic perceived quality over usage periods spanning several days is rather limited. One reason might be that such experiments require to be conducted outside of the laboratory. Thus, the usage environment is uncontrolled and often an elaborate technical setup necessary. Also, the required between-subject design increases the effort. Session quality. Multi-episodic perceived quality was further investigated in *individual sessions* (i.e., continuous use of the same service with multiple usage episodes). This complements multi-day experiments as it is not yet known if and how the time between usage episodes affects multi-episodic judgments. In [5], an AoD service was used to determine if the duration of a LP usage episode affects a subsequent multi-episodic judgments. It was observed that the duration of one LP usage episode does not affect the episodic and multi-episodic judgment. Subsequently, [3] conducted two experiments with overall 205 participants to investigate the impact of the usage situation in case of speech telephony. Both experiments consisted of six usage episodes that needed to be solved subsequently. In the first experiment, a pair of participants needed to solve one SCS per usage episode together. The second experiment, was conducted by each participant alone simulating a 3rd-party listening situation. Here, recordings of the first experiment were used and participants needed to transcribe all information necessary to solve the SCS. Here, the effects of presenting more LP usage episodes as well as presenting more HP usage episodes subsequently were investigated. Most notably, the results indicate that the usage situation has a very limited impact on episodic and multi-episodic judgments. Increasing the number of LP usage episodes resulted in a reduction of the subsequent multi-episodic judgment while remaining well above the episodic judgments of LP usage episodes. This indicates that previously experienced usage episodes still affect

this judgment and that the formation process is not a pure average. Also a positional impact could be observed in both experiments: increasing the number of HP usage episodes following LP usage episode(s) before a multi-episodic judgment limits the observed reduction.

Takeaway: Despite first findings, the formation process of multi-episodic perceived quality remains far from being understood. While initial work in one session found some interesting insights, multi-day experiments so far remained mainly inconclusive. In this paper, we address this issue by extending [3] from one session to multiple days while using a similar experimental design.

III. EXPERIMENT

The goal of this experiment is to investigate if the effects observed on multi-episodic perceived quality in one session can also be observed if the usage period is extended to multiple days. This complements prior work and enables to improve prediction models for multi-episodic perceived quality.

A. Design

Our multi-episodic perceived quality experiment also follows a between-subject design (i. e., only one multi-episodic condition was presented to each participant) in which participants use an AoD service twice per day. We chose a usage period of 6 days to be able to investigate a higher number of multi-episodic conditions compared to prior work. To directly embed our experiment into related work, we follow the experimental design of [3].

We choose an AoD service for two reasons. First, AoD is a popular Internet service (e.g., offered by popular apps such as Spotify or Audible). Second, an AoD service enables a simple technical setup in which the experiment can be conducted by each participant alone. That is, no interaction (and thus no coupling) with other participants-as in typical interaction experiments-is needed. This reduces the experimental complexity, avoids social effects, and reduces the effort to conduct the experiment for the participants. We used an *audio book* as content to i) keep the experiment interesting for participants and *ii*) enable us to verify that the content was consumed. We chose the audio book City of the Beasts from Isabel Allende as it was used in [5]. While participants could not chose the content, it limits the effort to prepare the experiment and omits differences in content as source for noise. This audio book was cut into individual, self-contained parts of 6..8 min length. One part was presented in each usage episode. This should enable participants to focus on the content while limiting their effort. The content was presented in it's chronological order.

In line with prior work, two performance levels HP and LP were applied. HP denotes the highest performance, yielding only very limited to no perceptible degradations. LP denotes the worst performance and is expected to provide a severely lower perceived quality. For HP, the source material (CD, 44.1 kHz, stereo) was encoded with MP3 (192 kbit/s). The bitrate was selected to produce no audible impairments. For

 TABLE I

 OVERVIEW ON MULTI-EPISODIC CONDITIONS.

Condition	Episodic performance				
Condition	1-3	4	5	6	
C0	HP	HP	HP	HP	
C1	HP	LP	HP	HP	
C3	HP	HP	HP	LP	
C4	HP	LP	LP	HP	
C5	HP	HP	LP	LP	
C6	HP	LP	LP	LP	
C8	HP	LP	HP	LP	

LP, the content was encoded with LPC-10¹. This codec was also used in prior work (e. g., [3], [5]) as it provides a severe degradations while providing speech intelligibility. We remark that the LP encoding is *unrealistic* for any multi-media streaming service. However, other quality degradation types beyond our scope (e.g., stalling) are expected in practice, yielding also quality fluctuations (LP/HP). We added the LP encoding as reference to prior work that used the same encoding to study the quality formation process of multi-episodic judgements. Participants used their own computer and pair of headphones to access the AoD service via the Internet using a HTML5capable web browser. The system was implemented using [11]. To exclude Internet-induced artifacts, the audio content was *preloaded* prior to starting each usage episode.

We apply the following hypotheses to evaluate multiepisodic judgments in one session [3].

- (*H1*) increasing the number of LP usage episodes leads to a higher reduction in multi-episodic judgments.
- (*H2*) presenting HP usage episodes after LP usage episodes limits the reduction in multi-episodic judgments.
- (*H3*) presenting HP usage episodes between LP usage episodes leads to a higher reduction than presenting the LP usage episodes consecutively.

Based upon the three hypotheses, seven multi-episodic conditions were created. Performance was only varied between days. Following [3], the first three days were presented in HP to provide a common baseline for the between-subject design. LP episodes were only presented from the 4...6th day.

The multi-episodic conditions are shown in Table I. C1 and C3 present either the 4th or the 6th day in LP. C4, C5, and C8 present two days between the 4th and the 6th day in LP. C6 presents all usage episodes on these three days in LP. C0 (HP only) was explicitly skipped in this experiment as [3] did not find evidence that the multi-episodic judgments would be affected. Also, the effect of a slight increase over the usage period reported by [8] was rather small and was observed over a usage period of 14 days. Therefore, we use the multi-episodic judgment after the 3rd day as C0.

For the investigation of **H1**, the results of C0, C3, C5, and C6 can be compared. **H2** can be evaluated by comparing the results of C1 and C3 as well as C4 and C5. Finally, **H3** can be evaluated by comparing the results of C8 with C3 and C5.

¹The LPC-10 encoded content was re-encoded with MP3 (192 kbit/s) for the actual transmission and reproduction.)



Fig. 1. Continuous 7-point scale defined in [12].

B. Procedure

Introductory session. The experiment started with a introductory session. The goal was to explain the experimental procedure and to collect demographic data. Subsequently, a short training presenting short stimuli of typical audio degradations was conducted. Finally, two usage episodes with the AoD service needed to be conducted to show participants how to use the service.

Experiment. The multi-episodic part of this experiment began the day after the introductory session. Here, the usage episodes needed to be conducted daily between 7 am and 1 pm as well as 3 pm and 10 pm, respectively. In line with prior work, judgments were taken on the 7-point continuous category rating scale (see Figure 1). Episodic judgments were taken after every usage episode and multi-episodic judgments after the second usage episode of the 3rd day and the 6th day.

Control questions. As participants could not be supervised during the experiment, we presented two content-related questions after every usage episode. For every questions the correct answer out of three options needed to be selected. This allows to evaluate if a participant had experienced the content. This was inspired by cheating prevention approaches for crowdsourcing [13].

Final assessment. On the day after the 6th day usage period, a debriefing was conducted with every participants. Here, also the NPS was assessed asking how likely it would be that the provided service would be recommended to friends or colleagues (0 *not likely at all* until 10 *extremely likely*).

C. Participants

The experiment was conducted in Berlin from September until November 2015 with 57 female and 38 male participants aging from of 18 to 33 years ($\mu = 25.8$, $\sigma = 4.0$). Participants were required to have normal hearing capabilities. Also they needed to comply with the defined schedule and complete all questionnaires. As a reminder, participants were informed by email, when a usage episode should be conducted. Successful participation was compensated with 20 EUR.

IV. RESULTS

We next present the results of our experiment. First, the participants are screened for inconsistent judgments and error rate of the content-related questions is evaluated. Second, the potential impact of the between-subject design is evaluated. Then, the multi-episodic judgments are evaluated with regard to the three investigated hypotheses.

A. Plausibility Checks

For the evaluation of consistent judgments, we use the episodic judgments and evaluate these individually. We consider a participant to be inconsistent if more than two episodic

TABLE II NUMBER OF PARTICIPANTS AND EPISODIC JUDGMENTS PER MULTI-EPISODIC CONDITIONS. REPORTED AS MOS WITH STANDARD DEVIATION IN BRACKETS.

Condition	LP days	Participants	HP	LP
C0	-	-	-	
C1	4	16	4.5 (0.9)	1.3 (0.8)
C3	6	14	4.7 (0.7)	1.3 (0.8)
C4	45	13	4.5 (0.7)	1.3 (0.5)
C5	56	18	5.0 (0.8)	0.9 (0.5)
C6	46	14	4.6 (0.6)	1.2 (0.7)
C8	4 and 6	15	4.5 (0.6)	1.2 (0.7)

judgments exceed the $1.5 \times$ *interquartile range* of the performance levels. None of the participants fulfilled this criteria. With regard to the content-related questions, we assume that participants should at least answer 50% correctly. Otherwise, a participant did not seem to follow the experimental instructions and thus would be excluded from further data evaluation. Out of the 24 questions, participants answered on average 20.8 questions ($\sigma = 2.7$) correctly. One participant was excluded.

B. Between-subject Design

Given that a between-subject design is applied, we next investigate if this affects the episodic judgments between multi-episodic conditions. We show the Mean Opinion Score (MOS) per multi-episodic condition in Table II). For episodic judgments of HP, a significant difference is found (H(5) =33.4978, p < 0.001). The post-hoc test shows that C5 is different to all other conditions (p < 0.05) and that C3 is different to C4 and C8 (p < 0.02). For LP, differences between conditions are also found (H(5) = 18.2748, p = 0.0026). The post-hoc test shows that C5 is different than C1, C4, and C8 (p < 0.05). It must be noted that episodic judgments of C5 resulted in the highest MOS for HP and in the lowest MOS for LP. This is unexpected but not unlikely due to the betweensubject design considering the number of multi-episodic conditions. A detailed analysis did not reveal reason(s) for this and we therefore presume that this does not prevent comparision between multi-episodic conditions.

For the multi-episodic judgment after the 3rd day, no significant differences between conditions are observed (H(5) = 5.2111, p = 0.3907). This indicates that as long as only HP episodes were presented, the between-subject design did not affect multi-episodic judgments. **Takeaway:** The between-subject design did not appear to affect the multi-episodic evaluation.

C. Multi-episodic Judgments

We next evaluate the three hypotheses stated in Section III-A using the final multi-episodic judgments.

H1 (increasing number of LP usage episodes). We first investigate if increasing the number of LP episodes *before* a multi-episodic judgment results in a decrease of this judgment (i.e., a reduction in perceived quality is reported). This hypothesis is evaluated by comparing C0, C3, C5, and C6 (i.e., 0-3 LP usage episodes). Table III shows both multi-episodic

TABLE III H1: MULTI-EPISODIC JUDGMENTS AFTER THE 6TH DAY. REPORTED AS MOS WITH STANDARD DEVIATION IN BRACKETS.

Condition	LP episode(s)	Multi-episodic judgment
C0	(HP only)	4.7 (0.6)
C3	6	3.6 (0.6)
C5	56	2.5 (1.0)
C6	46	2.4 (0.7)

judgments. C0, C3, C5, and C6, are significantly different (H(3) = 68.3657, p < 0.001). A post-hoc test finds that C0 is significantly different to all other conditions (p < 0.001). Also, C3 and C5 (p = 0.002) as well as C3 and C6 are significantly different (p < 0.001). For C5 and C6, no significant difference is found (p = 0.366).

As a result, **H1** can only be partly accepted as the multiepisodic judgment decreased, but only for up to two LP usage episodes. The underlying reason for the observed saturation could not be derived from this experiment. *Takeaway:* We find that increasing the number of LP days directly before the multi-episodic judgment negatively affects this judgment. Here, we observe a reduction of approximately 1 pt per LP usage episode for up to two episodes. No further decrease can be observed in case of three LP days. It must be noted that the multi-episodic judgment remains 1 pt higher than the episodic judgments of LP usage episodes.

H2 (increasing number of HP usage episodes after LP). We next evaluate the presence of a recency effect (i. e., if presenting HP usage episodes after LP usage episodes limits the reduction in multi-episodic judgments). This hypothesis is investigated by comparing C1 vs. C3 (i. e., one day LP) and C4 vs. C5 (i. e., two days LP). Table IV shows the final multi-episodic judgment. With regard to the final multi-episodic judgment neither C1 and C3 (W = 138.50, p = 0.136, one-sided) nor C4 and C5 (W = 151.00, p = 0.087, one-sided) are significantly different. Takeaway: Unlike prior work which observed a recency effect on shorter usage periods, we did not find clear indications. As a service provider, LP usage episodes should thus be avoided as the subsequent HP usage episodes do not make up for prior LP experiences.

H3 (consecutive vs. non-consecutive LP usage episodes). Finally, we evaluate if HP usage episodes between LP usage episodes lead to a higher reduction than presenting the LP usage episodes consecutively. That is, do users prefer performance switches between usage episodes or rather continuous presentation of similar performing usage episodes. This hy-

TABLE IV H2: MULTI-EPISODIC JUDGMENT AFTER THE 6TH DAY FOR. REPORTED AS MOS with standard deviation in brackets.

Condition LP episode(s) Mult	i-episodic	judgment
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	1 1	1 5 6
C1	4	4.1 (0.7)
C3	6	3.6 (0.6)
C4	45	3.0 (1.1)
C5	56	2.5 (1.0)

 TABLE V

 H3: MULTI-EPISODIC JUDGMENT AFTER THE 6TH DAY. REPORTED AS

 MOS with standard deviation in brackets.

Condition	LP episode(s)	Multi-episodic judgment
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C4	45	3.0 (1.1)
C8	4 and 6	2.7 (0.4)
C5	56	2.5 (1.0)

pothesis can be evaluated by comparing C4 and C5 with C8. C4 and C5 present each two days LP consecutively, whereas C8 presents the 4th and the 6th day in LP. Table V shows the final multi-episodic judgment for these conditions. These conditions are not significantly different (H(2) = 2.3809, p = 0.3041). As a result, H3 must be rejected. In fact, the slight improvement in the multi-episodic judgment of C8 compared to C5 might be explained by a recency effect. Takeaway: Performance switches between usage episodes do not seem affect the formation process.

State of the art. Our results are in line with single-session results in prior work that investigated multi-episodic use in one sessions of one hour [3]. This indicates that the time between usage episodes in the studied experiments might only have a limited impact on multi-episodic judgments. We infer that it is very beneficial to investigate first multi-episodic perceived quality in one or more sessions of multiple usage episodes each. Then these findings can be verified and extended in multi-day experiments. This will also enable to create prediction models for multi-episodic perceived quality.

D. Net Promoter Score

The NPS assesses how likely it would be that the provided service would be recommended to friends or colleagues (0 not likely at all to 10 extremely likely). It thereby divides participants into promoters (9-10 pt), passives (7-8 pt), and detractors (0-6 pt) to determine the growth and churn of users of (non-technical) services. The NPS results are in shown in Figure 2. C1 and C3 (mainly passives) as well as C5, C6, and C8 (mainly detractors) achieve each a seemingly similar distribution while C4 stays between both groups. This indicates that the NPS is negatively affected if more LP usage episodes are present. Notably, also a saturation is indicated as C5 and C6 are seemingly similar. However, the results contain outliers and the overall correlation coefficient of the NPS with the final multi-episodic judgment is only 0.5. Takeaway: Multi-episodic judgments alone do not suffice to predict service recommendations captured by the NPS. We therefore assume that the NPS is affected by additional factors.

This highlights the need for future work to create holistic models capturing the overall service experience.

V. QUALITY PREDICTION

We now evaluate different approaches to predict the multiepisodic judgments based upon the episodic judgments. Guse et al. [3], [4] proposed to predict a multi-episodic judgment by computing the *weighted average* of prior episodic judgments. The influence of each usage episode e_i on the



Fig. 2. Boxplot of the NPS per multi-episodic condition.

overall multi-episodic quality m_n is expressed by its weight a_i . This was found sufficient considering the amount of data and noise. Using a weighted average also allows to account for a recency effect. We evaluate the a) window function (WF)² and b) linear window (LW). Both functions are parametrized by the window parameter w. For WF, it is limited to $w \in \mathbb{N}$ and $0 < w \leq n$.

$$WF: a_i = \begin{cases} 1, & \text{if } i - n + w > 0\\ 0, & \text{otherwise} \end{cases}$$
(1)

$$LW: a_i = \begin{cases} i - n + w, & \text{if } i - n + 2 * w > 0\\ 0, & \text{otherwise} \end{cases}$$
(2)

We evaluate the prediction accuracy by computing the Rootmean-square deviation (RMSD) of the episodic MOS (i. e., input) and multi-episodic MOS (i. e., output).

Prediction C0 (HP only). The prediction accuracy improves for an increasing w (cf., Figure 3). This is more prevalent for WF than for LW. WF achieves its minimal RMSD with w = 6(i. e., all prior episodes). WF provides only a marginal decrease for $w \ge 3$. **Takeaway:** The weighted average achieves a reasonable prediction accuracy while LW provides a slightly better, robust performance. This is in line with [3].

Prediction C1-C8. With regard to the prediction of the multi-episodic judgment of the 6th day, both weight functions perform differently (cf., Figure 4). While LF reaches a minimal RMSD at w = 4 (i. e., 0.15), WF not until w = 8 (i. e., 0.26). *Takeaway:* LF is preferable to WF, as a higher prediction

²Selecting w := n, this model type becomes the average over all prior episodic judgments as proposed by [8].



Fig. 3. Multi-episodic prediction accuracy for C0.



Fig. 4. Multi-episodic prediction accuracy for all conditions (except C0).

accuracy is achieved. Also, LF requires a smaller w while providing a higher robustness for choosing w.

Accounting for Saturation. In line with Guse et. al [3], a saturation could be observed although not taken into account for prediction. For C6, the multi-episodic judgment remained at the same level as C5 although an additional usage episode was presented in LP. Also it remained approx. 1 pt above the episodic judgment of LP. In fact, C5 and C6 only differ in the performance level of the 4th usage episode. As both were not judged differently, this suggests that this difference did not affect the formation process of the multi-episodic judgment. In case of C6, we prepose to adjust the episodic judgments of the LP usage episodes of the 4th day by the average of the HP usage episodes. Then the window function can be applied without further modification. For C6, this modification shifts the minimal RMSD from w = 9 to w = 6 for WF and for LW from w = 7 to w = 4 (see Figure 5). Also, the prediction performance of C6 (adjusted) and C5 resemble each other closely. Takeaway: This prefiltering approach for three consecutive LP usage episodes allows to account for the saturation as it increases prediction performance.

VI. CONCLUSION

We presented the results of a multi-episodic experiment of an AoD service. The primary goal was to extend the work on multi-episodic perceived quality in one session [3] to several days. For this reason, the same hypotheses and also a very similar experimental design was applied. We made three observations. First, increasing the number of LP usage episodes decreases the directly following multi-episodic judgment (**H1**). Here, the multi-episodic judgment reaches



Fig. 5. Multi-episodic prediction accuracy for saturation.

saturation showing that prior HP usage episodes are still accounted for. Second, we could not find a significant impact of a recency effect (H2) that was observed in prior work [3] on single sessions. Third, consecutive vs. non-consecutive presentation of LP usage episode did not seem to affect multi-episodic judgments (H3). This is, interestingly, in line with multi-episodic experiments in one session [3] indicating that the time between usage episodes has a limited impact on the multi-episodic formation process.

Future Work. Although our results are very promising, the formation process of multi-episodic perceived quality is still far from well understood. So far experiments forced participants to use service(s) in a certain manner by defining when and how to interact with them. Thus, intentionally preventing variation in usage behavior and interaction. However, in a normal setting a user has a motivation to interact with a service, sometimes a task, as well as a desired outcome and probably it's importance. Therefore, (temporary) failures of services might prevent a user from fulfilling his/her task and therefore the multi-episodic formation process. Also, the attribution of reduced service performance or failures might affect multi-episodic judgments (e.g., being in a remote area with limited mobile coverage). Moreover, it is still open how different modalities (e.g., audio, video), service types (e.g., web browsing), and service bundles are actually judged and how the formation process is determined.

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