

**COMMITTEE T1-TELECOMMUNICATIONS  
STANDARDS CONTRIBUTION**

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**STANDARDS PROJECT:** Analog Interface Performance Specifications for Digital Video  
Teleconferencing/Video Telephony Service

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**SUBJECT:** The Impact of One Way Delay on Video Conferencing Quality

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**SOURCE:** Bellcore

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**KEYWORDS:** one way delay, video conferencing, video

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**ABSTRACT:** This is a proposed contribution to ITU-T Study Group 12 which addresses that portion of Question 22 dealing with global audio/video quality evaluation by subjective means. We are seeking review and comment from T1A1.5 prior to submitting it to ITU-T as a Bellcore contribution. This contribution reports on a study that was conducted to examine the impact of one way delay on video conferencing quality. The results of this study indicate that end-user acceptance of video conferencing services will vary as a function of one way delay. It was found that one way delays of 150ms or greater produce a substantial degradation in the quality of service. This paper recommends that national and international standards bodies develop methods and procedures for audio/video delay performance characterization. This would allow industry suppliers of video codecs to provide delay performance data to their customers.

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## STUDY GROUP 12 - CONTRIBUTION

**Source\*** : Bellcore

**Title:** The Impact of One Way Delay on Video Conferencing Quality

**Abstract:** This contribution reports on a study that was conducted to examine the impact of one way delay on video conferencing quality. The results of this study indicate that end-user acceptance of video conferencing services will vary as a function of one way delay. It was found that one way delays of 150ms or greater produce a substantial degradation in the quality of service. This paper recommends that national and international standards bodies develop methods and procedures for audio/video delay performance characterization. This would allow industry suppliers of video codecs to provide delay performance data to their customers.

### 1. Introduction

Delay in the transmission or processing of audio/video information during interactive video conferencing can be very disruptive to the participants involved. In order to assure customer satisfaction with video conferencing services, the effects of delay must be understood and accounted for in the design and implementation of these new services. In the first quarter of 1996, Bellcore conducted a study to investigate the impact of differential delay (i.e., lip sync) on video conferencing quality<sup>[1],[2]</sup>. Although differential delay was the principal variable investigated, two one way delay test conditions of 0 and 400msec were also introduced in order to simulate different transmission and processing conditions. The differential delay variable was varied through it's range at both the 0 and 400 msec one way delay conditions. Analysis of the test data revealed a significant degradation in quality with the addition of one way delay.

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Based on the above finding concerning one way delay, a second one way delay study was planned and performed. The purpose of this contribution is to document the results of this second study. This work is in support of ITU-T Study Group 12, Question 22/12, which focuses on the audiovisual quality in multimedia services and is planned to be a contribution to both T1A1.5 and ITU-T.

The next section describes the method and procedure. Section 3 discusses the results of the study. Conclusions are discussed in Section 5.

## **2. METHOD AND PROCEDURE**

### **2.1 Apparatus**

In this study two video conferencing stations were configured using two test rooms in Bellcore's New Technology Performance Laboratory. These rooms are 17 by 12 feet with sound dampened walls. Ambient lighting, monitor settings, and sound levels were adjusted to levels which were agreed to be comfortable by the laboratory staff. A 6 by 3 foot conference table was centered in front of a conferencing system and the conferencing participants sat at a distance of 6 times the picture height of the monitor.

Each room was equipped with an oak console which housed a Sony DXC-151A CCD color video camera, a Sony PVM-2530 25" color monitor, a Panasonic WS-A10E-K speaker, and a Coherent 3000 echo cancelling system (see Figure 1). There was no video codec used in the experiment. The study used uncompressed video and audio channels throughout the testing. This configuration approximates the upper limit of the performance quality of a high quality conferencing system employing compression and the external conferencing components listed above. The video output from the CCD camera and the audio output from the microphone were input to a Prime Image Pipeline video/audio delay generator located in the main laboratory. This apparatus inserts delay independently in both the audio and video channels. The delay generator was verified for accuracy by using AT&T's procedure for measuring visual channel delay<sup>[3],[4]</sup>. Next, the audio and video signals were routed from the delay generator to the experimenter's console where they were monitored. Finally, the signals were routed to the other conference room for display and audio amplification in the conferencing console. Participants used a Fujitsu palmtop computer with a GUI (graphical user interface) interface and a stylus to provide service quality ratings. The experimenter was able to see and hear both participants during the sessions.

## **2.2 Procedures**

### **2.2.1 Participants**

A total of 24 people participated in this study. Participants were run in pairs, with one participant in each conference room. Each participant was paid to compensate for approximately 1 1/2 hours of their time.

### **2.2.2 Instructions**

At the start of a session, each participant was seated in one of the test rooms. First, instructions were given on how to use the GUI based voting system. A practice screen was provided for selecting and entering votes by touching a stylus on the GUI screen. Once the subjects indicated that they were comfortable with the voting procedure, the experimenter read the instructions provided in Appendix A.

The participants were told that the purpose of the study was to determine how well people can use video conferencing to communicate and that they would be using different types of video conferencing services to see each other while conversing. They were told that they would be engaged in a problem solving task which would require them to converse for two minutes, then they would be asked to indicate their satisfaction with the different types of video conferencing services by using the palmtop to vote on a nine-point rating scale (see Figure 2).

### **2.2.3 Experimental Design**

One way delay was defined as the delay which was introduced into the audio/video channel. One way delays of 0, 150, 300, 450, 600 and 750ms were used in the study. One way delay was inserted, in equal amounts, to each of the conference room audio/video outputs by setting the delay feature of the pipeline delay generators to one of the settings listed above.

## **2.3 Experimental Procedure**

A experimental session consisted of four practice trails and eighteen experimental trials. The eighteen experimental trials were broken down into 3 blocks of 6 delay conditions of either 0, 150, 300, 450, 600 or 750ms. A different random order of the test conditions was used in each block and session. At the start of a trial, the participants were given a choice of two items that might be of use to them if stranded in the desert. They were then instructed to converse about the two choices. After two minutes, the experimenter activated the laboratory microphone and requested their selection between the two items presented.

The choice was then logged into the control computer, audio communication terminated, and color bars displayed on the participant's monitor. The experimenter then requested the participants to please rate their satisfaction with the video conferencing service. Once both participants responded, the next trial was presented.

After all the trials were presented, the participants were debriefed. Generally, they commented that they had noticed the one way delay and that it affected their ratings.

### 3. Results

A two-way repeated measures Analysis of Variance<sup>[5]</sup> (ANOVA) was performed on the rating data. The independent variables were the six levels of One Way Delay, and Block of Trials. Recall that during the eighteen experimental trials, each of the six levels of delay was presented once in each successive block of six trials. The ANOVA found a significant effect for one way delay ( $p < .001$ ) block of trials ( $p < .001$ ) and the interaction between these two variables ( $p < .005$ ).

Since the presence of a significant interaction can affect the interpretation of the two main effects, it will be discussed first. The interaction is shown in Figure 3. An interaction is present to the extent that the three lines in Figure 3, representing the mean opinion scores for the six delay conditions, are statistically significantly non-parallel. Although the difference in means between blocks is largest for a delay of 450 ms, no reasonable explanation is obvious. In addition, the results for the other delay conditions likewise fail to exhibit any evident pattern. Until additional empirical data are available, this two-way interaction will be considered an artifact.

A significant main effect for block of trials was also obtained. As can be seen from Figure 4, the mean opinion rating decreased across the three blocks of trials. This result has several possible explanations. For example, participants might gradually rate the conditions poorer across the experiment as a result of fatigue, boredom, etc. On the other hand, it could reasonably be hypothesized that participants were not sensitive to delay early in the experiment, but with experience noticed it and found it annoying. Such a hypothesis was given attention since for the most part our participants had little, if any, experience with video conferencing. If this hypothesis was correct, it would suggest that people with experience in video conferencing might be much less tolerant of one way delay than the participants in our study. A follow-up pilot study was conducted using Bellcore employees who video conference regularly. Generally, these people rated the delay conditions much the same as did the study participants. With the caveat that the following comment is based on a small sample and must be considered anecdotal, several pilot study participants volunteered during the debriefing sessions that they noticed that delay varied across the study, but that it had little effect on their ratings since it was always less than what they experienced in actual video conferences.

The main effect for one way delay is shown in Figure 5. A one-way repeated measures ANOVA was performed to allow an analysis of the differences between the mean opinion

scores (MOS) for the delay conditions. The independent variable in this analysis was the mean rating score for each participant for each delay condition averaged across the three blocks of trials. As is to be expected, an ANOVA found a significant relationship between overall MOS and delay ( $p < .001$ ). Tukey's HSD test was applied to the results of the ANOVA to test for significant differences between the overall mean scores. The differences between the means are shown in Table 3-1. Differences that are greater than .65 MOS units are significant at .05 level and are indicated by a single asterisk. Differences greater than .77 MOS units are significant at the .01 level and are indicated by double asterisks.

**Table 3-1.** Differences in mean opinion scores as a function of amount of end-to-end delay.

	MOS <sub>0</sub>	MOS <sub>150</sub>	MOS <sub>450</sub>	MOS <sub>600</sub>	MOS <sub>300</sub>	MOS <sub>750</sub>
MOS <sub>0</sub> = 7.78	-	0.89**	1.07**	1.17**	1.18**	1.50**
MOS <sub>150</sub> = 6.89		-	0.18	0.28	0.29	0.61
MOS <sub>450</sub> = 6.71			-	0.10	0.11	0.43
MOS <sub>600</sub> = 6.61				-	0.01	0.33
MOS <sub>300</sub> = 6.60					-	0.32
MOS <sub>750</sub> = 6.28						-

\*  $P < .05$

\*\*  $p < .01$

## 4. Conclusions

The results of this study indicate that end-user acceptance of video conferencing services will vary as a function of one way delay. It was found that one way delays of 150ms or greater produce a substantial degradation in the quality of service. Due to the impact of one way delay on user satisfaction with video conferencing quality, it is recommended that national and international standards bodies develop methods and procedures for audio/video delay performance characterization. This would allow industry suppliers of video codecs to provide delay performance data to their customers.

## REFERENCES

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3. A. C. Morton, "Visual Channel Delay and Frame Rate Measurement - Initial Measurements using the Prototype System," contribution to ITU-T, Study Group 12 - Working Party 2, document number COM 12-075, 1995.
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Figure 1: Differential Delay Configuration

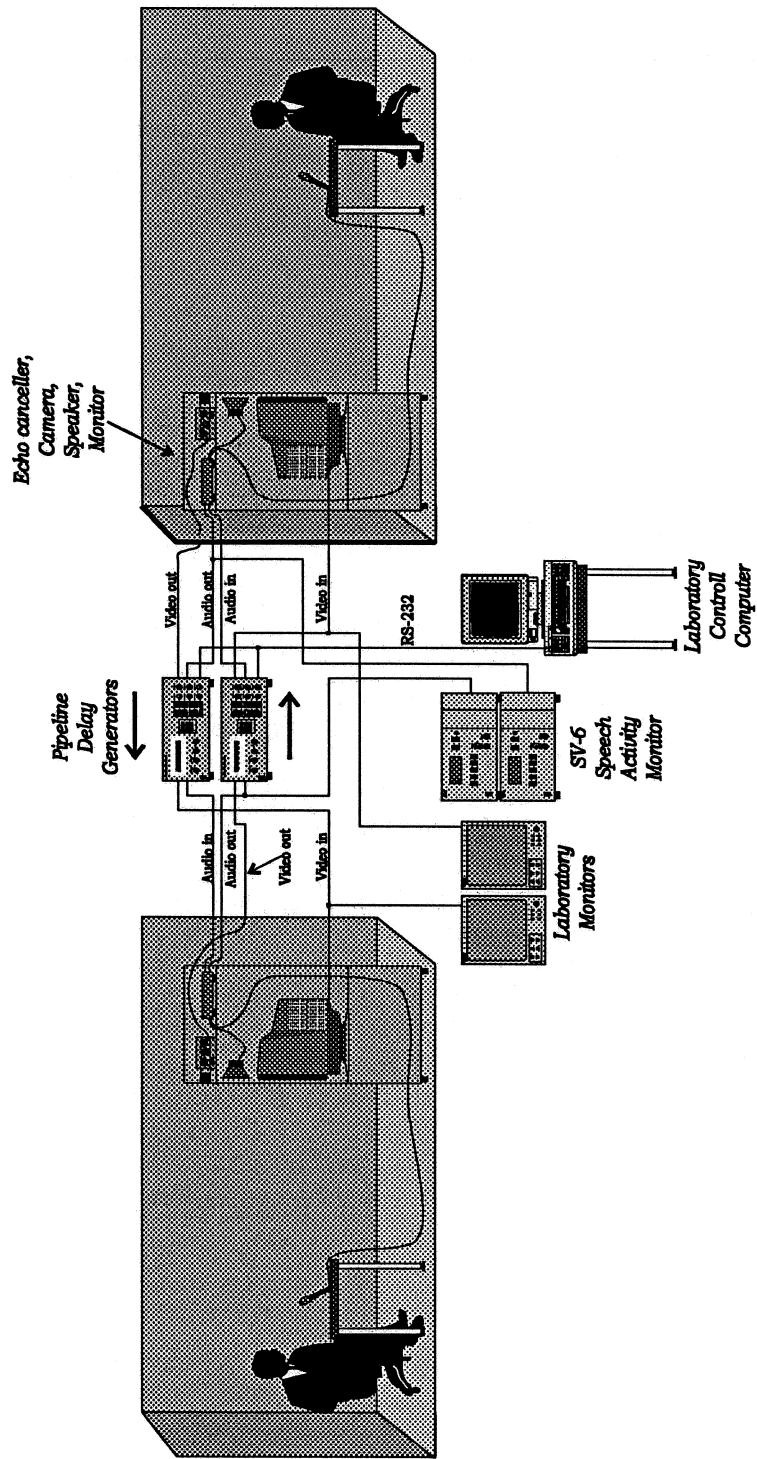




Figure 2: Handheld Computer GUI Screen

9 Point Scale	
<input type="radio"/> 9 Excellent	
<input type="radio"/> 8	
<input type="radio"/> 7 Good	
<input type="radio"/> 6	
<input type="radio"/> 5 Fair	Confirm Your Response
<input type="radio"/> 4	
<input type="radio"/> 3 Poor	<input type="button" value="Done"/>
<input type="radio"/> 2	
<input type="radio"/> 1 Unsatisfactory	

Figure 3. Mean Opinion Score as a Function of One Way Delay and Trial Block

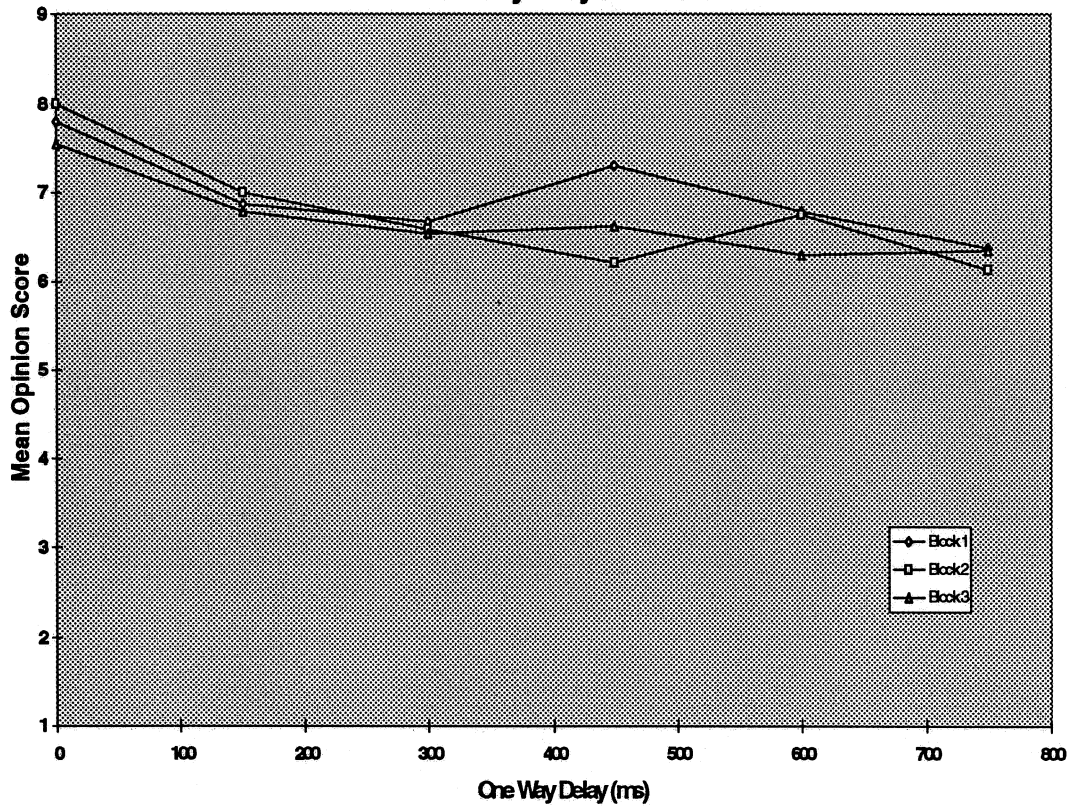


Figure 4. Mean Opinion Score as a Function of Trial Block

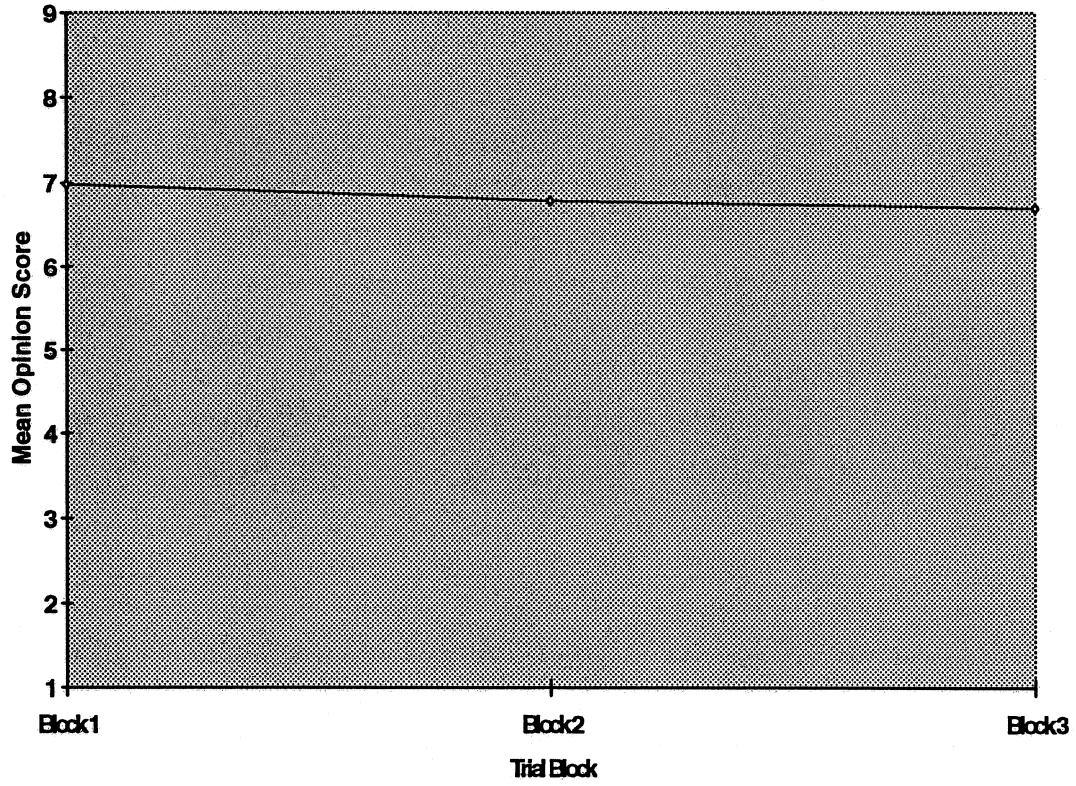
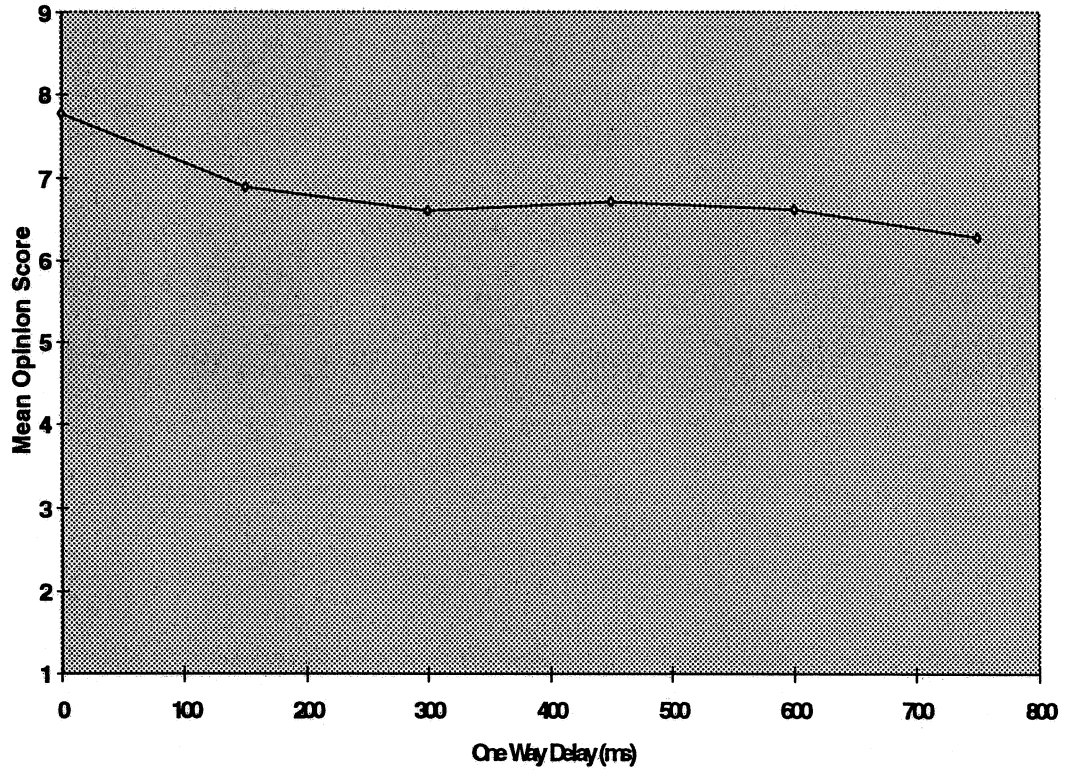


Figure 5. Mean Opinion Score as a Function of One Way Delay



### **Appendix A. Instructions to Participants**

**In this study we are investigating how well people can use video conferencing to communicate.. You will use different types of video conferencing services see each other while conversing.**

**In the study you will talk to each other for about two minutes. During the conversational period you will engage in a problem solving task used by such groups as the Explorer scouts. Then you will be asked to indicate your satisfaction with the different types video conferencing services using a nine-point rating scale. As demonstrated a few moments ago, you will use the stylus and response box on the table in front of you to provide your rating..**

**In the problem solving task, you should pretend that the two of you are the only survivors of a light plane crash in the Sonora Desert in the southwestern United States. Although neither of you are injured, shortly before the crash the pilot indicated that the plane was 65 miles off course, and 70 miles north of the nearest town. This is cause for concern since the weather report indicated daytime temperatures of 110 degrees, which means ground temperatures in excess of 130 degrees. The immediate area is quite flat, and except for some occasional cactus, appears to be rather barren. You are dressed in light weight clothing -- short sleeved shirts, pants, socks and street shoes.**

**You should assume that you are the actual people in the situation, and that you have decided to stick together. In the first two minute period you will decide whether the wisest decision is to stay with the plane and wait for possible rescue, or attempt to walk to the town. Then in the following two minute periods you will be given a choice of two items that might be of use to you. Use the two minutes to decide which of the two items would be of most use in increasing the chances of your survival.**

**If you agree on a decision before the two minutes is up, consider whether the item that was not selected might be of use in some manner that you have not considered. If you do not converse with each other for the full two minute period, you may find it difficult to rate your satisfaction with each service..**

